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Instructor Expectations in a Project-based Undergraduate Mechanical Engineering Classroom

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Instructor Expectations in a Project-based Undergraduate Mechanical Engineering Classroom

by

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Dedication

This research is dedicated to all those brave souls implementing non-traditional learning strategies into the math, science, and engineering classroom

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I especially want to thank my research participants: “Dr. Austin,” “Bill,” “Barbie,” “Mary,” and “Sami,” as well as the other students in the course I observed for my research. I miss my weekly talks with Dr. Austin and wish him the best in his retirement.

Most of all I would like to thank my husband, Scott Marshall, for putting up with me for all these years (eight?) I have been in graduate school. This is the last degree. I’ll be sticking with art classes, at least for awhile.

Instructor Expectations in a Project-based Undergraduate Mechanical Engineering Classroom

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This study was inspired by my observations of the frustrations some students experienced in an undergraduate engineering course that used student-centered projects. This study first explored how the instructor conveyed his expectations of student learning behaviors, then how students perceived these behaviors, what learning behaviors the students engaged in, and finally, why the students engaged in those behaviors. The study lasted one semester and was predominantly qualitative using interviews with the instructor and four students in the course. These interviews were transcribed, summarized and then edited into individual narratives. Three surveys were also given to the entire class throughout the semester.

The results suggested that students are open to understanding new or non-traditional instructor expectations. However, understanding these new expectations did not guarantee that students would then engage in the associated learning behaviors. Understanding why students may not choose to engage in the learning behaviors that will satisfy their instructor's expectations was the most intriguing area for future research suggested by this study. The data gathered from the students suggested that personal achievement goals and motivational factors may be linked to the learning behaviors students choose. Future research into the interactions of achievement goals, motivation, and choices of learning behaviors in the engineering classroom is encouraged.

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Chapter 1: Introduction

My dissertation research topic was sparked by my observations of an upper level undergraduate engineering course that used very open-ended projects as well as from conversations with the professor for this course. This professor was integrating innovative instructional methods into the engineering classroom to encourage student-centered, self-directed learning. Because he was more interested in the processes students used to complete the project than the actual final product, the professor did not provide the students with an explicit checklist for what he wanted them to do for the project. He did, however, assign homework that structured the project and to some extent his expectations of the students. Still, many students seemed to either not understand what he wanted or, if they did understand, they were not comfortable with his expectations and seemed to still not know what to do. The instructor's expectations and his classroom pedagogical style were different from their previous experience which were mainly lecture-based classrooms with assigned homework problems from the textbook. Some students seemed thrilled with the freedom to pursue the project as they desired. Other students seemed terrified to proceed without specific directions, perhaps out of fear that their grade would suffer if they did not do exactly what the instructor expected of them. The instructor for this course described the situation:

> The students who are negative about it complain about the open-endedness, complain about the responsibility of taking on these things, are uncomfortable with any sort of ambiguity in the statement of the project or the problem. They keep saying "tell me what to do, tell me what to do" or afterwards saying "but you didn't' tell us to do that" or "you didn't", and you know, no matter what I say, I can't convince them that they can get a good grade doing what they think is best. (personal communication, March 26, 2002)

Student-centered vs. Teacher-centered Classrooms

I believed that what I observed in this classroom was due to the conflict of student-centered and teacher-centered approaches to education. The instructor was

trying to create a student-centered classroom while some of the students were still entrenched in the expectations of the teacher-centered classroom.

The teacher-centered classroom is the more traditional paradigm. My model of the teacher-centered classroom is shown in Figure 1. The teacher is at the center of the classroom essentially controlling the interactions between the student and the resources for learning. The decisions about learning as well as much of the responsibility for learning rest with the teacher. Improvements to the classroom are made in response to the question "How can the teacher better teach the material?"

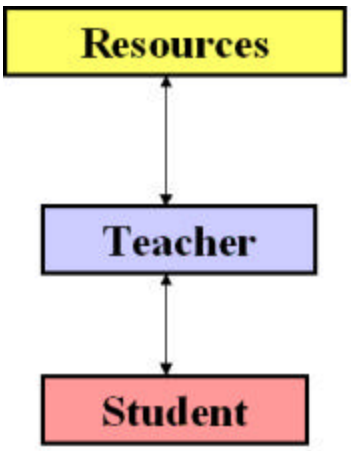


Figure 1: The teacher-centered classroom.

One of the characteristics of the project-centered classroom is that it is student-centered. I have shown my graphical interpretation of the student-centered classroom in Figure 2. Here, the student is at the center of the learning process. The teacher serves as another resource. The student is responsible for her own learning. She makes decisions about what to learn and pursues the necessary resources to do so. The teacher serves more as a tutor or facilitator, guiding the student about what resources to access. Improvements to the classroom are made in response to the question "How can the student better learn?"

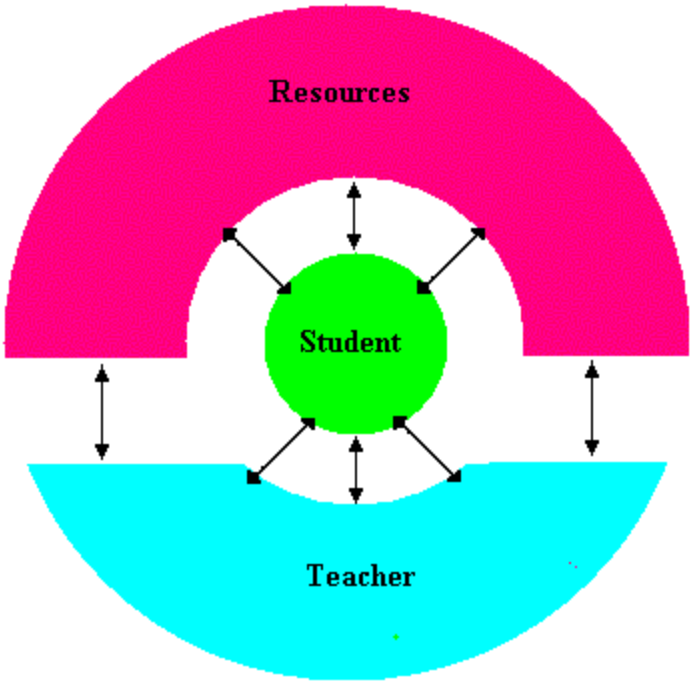


Figure 2. My model of the student-centered classroom

In the syllabus of the course for this study (see Appendix A), the instructor used the following quote (citing Felder and Brent, 1996, p. 1) to describe student-centered instruction (SCI) for his students:

> a broad approach that includes such techniques as substituting active learning experiences for lectures, holding students responsible for material that has not been explicitly discussed in class, assigning open-ended problems and problems requiring critical or creative thinking that cannot be solved by following text examples, involving students in simulations and role-plays, assigning a variety of unconventional writing exercises, and using self-paced and/or cooperative (team-based) learning…[SCI] provides students with opportunities to learn independently and from one another and coaches them in the skills they need to do so effectively.

Student Learning Behaviors

The teacher-centered and project-centered classrooms have different expectations for student learning behaviors. By student learning behaviors I refer to observable behaviors or actions the student engages in as part of their learning process.

In the traditional, teacher-centered classroom, these expectations may be very explicit: come to class, read these pages in the textbook, do these homework problems, write a report following this defined format. In the student-centered classroom, the student must frequently define the necessary learning behaviors, with guidance from the instructor. The expected learning behaviors may not be as explicit as those required for the traditional classroom. While the students may still be expected to attend class, read assigned pages in a text, and do homework problems, they may also be expected to utilize resources beyond the classroom such as the library, the Internet, their teammates, and even outside experts on the project. The students may be expected to define the content to be covered in class either by asking questions or even requesting that the professor discuss a certain topic. The students may also be responsible for managing the progress of their work or projects. This increase in student responsibility in the student-centered classroom may be met with resistance by the students.

In the project-centered classroom the instructor has a role or responsibility to develop a classroom environment that offers students the opportunities to engage in what the teacher believes to be the appropriate learning behaviors for developing and practicing the skills and learning the content necessary for achieving the desired learning outcomes of the course. The student's role is then to recognize those opportunities and engage in those behaviors to achieve the desired learning outcomes. But to engage in those behaviors the student needs to understand what those expected behaviors are. So, four things must happen as shown in Figure 3.

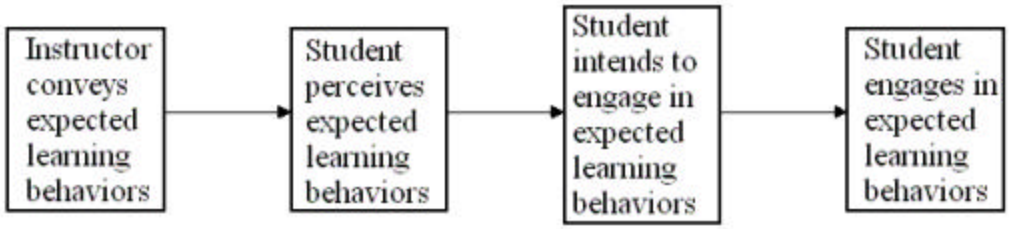


Figure 3. Necessary occurrences for students to engage in expected learning behaviors.

If the students don't understand what they need to do for success – defined here as achieving the desired student learning outcomes -- then they probably aren't going to be successful. Research indicates that students' learning behaviors are affected by what they believe they will be asked to do or what will be assessed (Marton & Säliö, 1976). So correctly understanding the instructor's expectations can be assumed to affect what learning behaviors student choose to engage in for the course.

Self-directed Learning

The project-centered course in this study used student-centered learning, one aspect of which is more self-directed learning on the part of the students. As already mentioned, many students resist this new role and even criticize the professor for not doing what they consider to be his job – lecturing to them and making them learn. They do not want to leave their "comfort zone in which the instructor tells them everything they need to know and then asks them to repeat it on a test" (Felder, Stice, & Rugarcia, 2000, p. 4). The instructor of the course offered this perspective on students' acceptance of the self-directed aspects of student-centered learning:

> Well you know, we've talked about whether a classroom should be instructor-centered or student-centered before and I think students have always espoused the idea it should be student-centered without giving any thought to what that really means. And then you give them the challenge of being the focus, of having some control over what's going on in the classroom and what needs to be accomplished and leave it up to them to raise questions and all of a sudden they're quite uncomfortable, a lot of them are. I get really upset when a student comes to me and says " Well, what do you want? What do you want me to do or want us to do?" And the only answer I can give them is to think, to be creative to the best of their abilities and do what they think is right. (personal communication, March 26, 2002)

For several semesters, students in the course of this study have spent most of the semester studying jet engines. In a traditional, lecture-based, teacher-centered classroom students would learn about jet engines by taking notes as the professor lectures, reading their textbook on jet engines, and then working homework problems that go along with the text they just read. Then about every four weeks or so they would then be tested on

what they had learned. The problems might not relate to any specific example in the real world but the problems would have a single correct answer. All assumptions would be stated in the problem statement. Also, all the information the student needs to solve the problem would typically be somewhere in that textbook. However, in this class, the students did not have a required text with problems at the end. There were books on reserve in the library which the students could also buy. The instructor wrote the homework problems. The students did not read a section in a book then work the problems at the end of that section they just read. They had to go to multiple sources and synthesize the material in order to answer the homework problems. Then as the problems become more complex, they had to make assumptions that affected their computer models of the engine. If their assumptions were different from their classmates' assumptions then the models would have different results, but different results didn't necessarily mean the models were incorrect. There was typically not a single right answer. The learning behaviors that may have guaranteed success in the traditional lecture-based classroom did not guarantee success in this student-centered classroom.

But adjusting to the student-centered classroom is not always easy. Negative feelings such as confusion, frustration and dissatisfaction can be considered a normal part of the transition to student-directed learning, or SDL (Lunyk-Child, Crooks, Ellis, Ofosu, O'Mara & Rideout, 2001). Taylor (as cited in Lunyk-Child et al., 2001) recognized that this transition begins with a "collapse of the learner's frame of reference" (p. 117). The learner must work through this disorientation to pass through the phases of exploration, reorientation and equilibrium.

ISSUES WITH OPEN-ENDEDNESS

Projects are often thought to promote deeper learning, to encourage higher-order thinking skills such as creativity and to allow students to build conceptual knowledge. A common characteristic of projects in the classroom is that they are open-ended. Open-ended assignments do not have one correct answer nor do they have one correct process for obtaining an answer. There may be multiple answers and multiple ways to obtain

these answers. Mathematics courses in the K-12 classroom frequently stress one correct answer, and in many cases, one correct process. Since strong mathematics skills are necessary for success in engineering courses, engineering students may enter college with a high school background strong in mathematics stressing the right answer. If so, then does this strong background in reaching a right answer interfere with adapting to open-ended assignments without one right answer?

Open-ended assignments can create challenges for both the instructor and the students. Since there is no one right answer and students have much more leeway to do things their own way, how does the instructor convey to the students what he expects them to accomplish? Under a broad definition of project, one option is to take away some of the open-endedness by defining very clearly what is expected of the students, perhaps with a checklist. This might be essential for students who are new to projects, especially if they are used to always having all expectations from them clearly defined, or if the instructor considers some tasks as essential for students to perform. The opposite extreme might be providing no checklist or examples, just an objective to be accomplished or a question to be answered. The students are then free to pursue the project as they consider appropriate. As I mentioned, in the course I observed the instructor does not provide checklists and this causes anxiety for many students who want more structure.

Projects

Open-ended projects require a different set of student learning behaviors than are called for in the traditional lecture-based engineering classroom. My research topic surfaced as a result of my perceptions of the frustrations that occur as students try to react to this new situation. Many of these students have mastered the student learning behaviors for successful outcomes expected in the traditional lecture-based engineering course. Unfortunately, the behaviors for success in this traditional environment may not be adequate for the project-based classroom. Projects require a deeper understanding of the material. With projects, surface learning strategies such as rote memorization are probably not adequate. Students must develop new learning behaviors that facilitate

deep learning. Students' anxiety levels may also influence how well they adapt to student-centered course. More anxious students may do better in teacher-centered classrooms while less anxious students might perform better in student-centered classrooms (Hancock, Nichols, Jones, Mayring, & Glaeser-Zikuda, 2000).

Because non-traditional learning activities such as projects are less tightly controlled than traditionally taught courses, the instructor might experience more difficulty defining his expectations for student learning behavior. Perhaps the problem is not so much that the expectations are less specific but that they are less familiar. Students may have difficulties accepting that these really are the expectations. For students who are products of classrooms stressing the one right answer, instructor expectations that stress anything else might not be just confusing. They might be unacceptable, or at least accepted with skepticism. Students may not be willing to engage in the necessary behaviors to meet such instructor expectations for fear that, despite what he says, the instructor is really seeking that one right answer. They may not have the trust in the professor or confidence in themselves to risk their grade, despite what the instructor says.

Conveying Instructor Expectations

So how does the instructor convey his expectations for student learning behaviors with projects when he wants the students to be creative and make their own decisions about what is needed to complete the assignment? Obvious and intended sources would include the course syllabus as well as what the instructor actually tells the students in and out of class, verbally and non-verbally. Non-verbal cues cannot be ignored. By college many students are going to be attuned to every subtle message the instructor gives, intentionally or not, about what is expected. A facial expression, a contradicting statement, and other students' stories from previous classes with this instructor - all contribute to the students' perceptions of what the instructor expects. The students are also going to be influenced by the fifteen or more years of formal education they have experienced prior to this course. But in the end the students must put all of these pieces of information together to create an understanding of what they think the

instructor wants them to do. Then each individual student, consciously or not, must decide whether or not to engage in these perceived desired behaviors.

The Gap

Even if the students accurately perceive what the instructor expects them to do, they still must decide to engage in those behaviors. In the class I observed the students were in a classroom environment new to them and being asked to engage in behaviors different from those they had used in previous classes. Many students appeared anxious and frustrated. At this point, what do they decide to do? Many factors can affect a student's choice of behaviors. Some of these factors might be due to influences outside of the classroom. For example, a student's prior experiences and self-efficacy beliefs influence a student's classroom behaviors. But these are not factors that an instructor can necessarily influence.

Nunan (1995) explored the "mismatch between the pedagogical intentions of the plans of the educational institution, curriculum, teacher and textbook, and the outcomes as realized through the skills and knowledge that learners take away from the instructional encounters" in the field of teaching English as a second language (p. 133). Nunan argued that

> the principal reason for this mismatch between teachers and learners, which gives rise to a disparity between what is taught and what is learned, is that there is a mismatch between the pedagogical agendas of the teacher and that of the learner. While the teacher is busily teaching one thing, the learner is very often focusing on something else (p. 134-135).

Nunan also cites research by Block in which the biggest contributor to this gap appeared to be student misconceptions or misperceptions of the rationale for performing learning activities. The teacher had a rationale but had not made it clear to the students. Nunan also cites his own previous research in which teaching preferences did not match the students' learning preferences. Today's students tend to prefer "concrete subjects and active methods of learning" while faculty "are predisposed to abstract subjects and passive learning." (Levine & Cureton, 1998, p. 129). For engineering students, a

"mismatch" between students' preferred learning styles and the traditional instructional styles of engineering instructors may negatively affect student learning outcomes (Felder & Silverman, 1988).

PURPOSE OF THE STUDY

The purpose of this study was to explore how the interactions between the instructor's and students' behaviors affected the students' learning behaviors in a project-based engineering classroom. Through interviews and surveys I sought to better understand the instructor expectations of the students, student understanding of these expectations, and how events in the course affected both instructor expectations and student understanding of these expectations.

RESEARCH QUESTIONS

The original proposal for this study defined four research questions to be explored within the context of a project-based, student-centered, undergraduate engineering classroom:

1. How does an instructor convey his expectations of student learning behaviors to his students?
2. How do the students then perceive his expectations for their behaviors?
3. What learning behaviors do the students then actually choose to employ?
4. Why do students choose those learning behaviors?

One of my basic beliefs that I brought to this study was that the only way the teacher can influence the students' learning outcomes is by influencing the students' behaviors (see Figure 4). Like the old saying "you can lead a horse to water but you can't make him drink", despite the teacher's best intentions the student may not exhibit the desired learning behaviors, possibly for reasons beyond the teacher's influence or control. While the teacher can influence the student's behaviors, ultimately the student must choose to engage in the necessary behaviors to achieve the desired learning outcomes. And I believe that all behaviors are a choice, not random or coincidental.

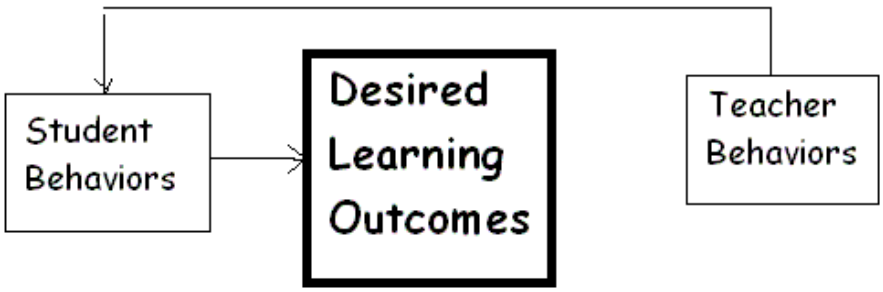


Figure 4. My simple model of the classroom interactions between student and teacher behaviors to achieve the desired student learning outcomes.

IMPORTANCE OF THIS STUDY

Many engineering classrooms are changing from teacher-centered to learner-centered where classroom improvements are not viewed so much in terms of how to better teach but how the student can better learn. This change is being driven in part by the new Accreditation Board for Engineering and Technology (ABET) criteria that require engineering educational programs to meet a set of student learning outcomes (Engineering Accreditation Commission, 2000). This change in accreditation focus was influenced by the demand from engineering employers for graduate engineers with not just technical knowledge but professional skills such as the ability to work in teams and make ethical decisions. The open-endedness of projects is perceived by some faculty and industrial representatives to provide students with opportunities to develop some of these desired professional skills.

ABET Criterion 2: Program Educational Objectives requires "a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program" (Engineering Accreditation Commission, 2000, p. 1). Implementing continuous improvement implies that feedback from formative assessment practices is then used to make changes to the classroom. Too often classroom improvement is sought by changing the more visible components of the classroom -- new textbooks, new seating arrangement, more technology, and working as part of a group. But these surface changes will offer little improvement if the real problems are with what I refer to as the structural foundation of the course. Students are

raised in the teacher-centered environment and know what is expected of them but do they have the same understanding of the student-centered environment? Won't it be easier for them to engage in the necessary behaviors if they understand the instructor's expectations (Parr & Valerius, 1999)? If the same philosophies and goals of the student-centered classroom are not understood and accepted by both instructor and students then the classroom environment will be compromised.

The engineering department that provided the course of focus for this study is currently integrating more projects into its curriculum with the belief that projects will enable students to both develop professional skills and reinforce technical content knowledge. These projects are typically offered in a more student-centered classroom. The results of this study were anticipated to be of immediate benefit to this department as it strives to successfully implement projects into its classrooms, especially those stressing student-centered pedagogies.

LIMITATIONS (DELIMITATIONS)

Some assumptions were made as a part of this study. These assumptions support an idealistic model and may not be reflective of the real-world classroom. Probably the most critical assumption was that the instructor's expected learning behaviors would lead to the desired student learning outcomes. A second critical assumption was that there were no other student behaviors that the student might engage in to achieve the same learning outcomes. And thirdly, the study assumed that the student had not yet achieved the desired learning outcomes prior to the course so they needed to perform these expected behaviors to achieve the desired results.

TERMINOLOGY

expected learning behaviors – The behaviors the instructor expects the students to engage in to succeed in the course. This term is being used broadly. It is not intended to imply behaviorist learning beliefs such as a stimulus-response classroom.

instructor/teacher– The person responsible for developing and communicating the learning activities/plan and then monitoring/ensuring that these are carried out as planned.

open-ended problem – A problem that has multiple solutions and multiple paths for obtaining the solutions.

project – The use of an open-ended assignment that requires the students to integrate existing knowledge as well as acquire new necessary knowledge for completing the assignment. Projects result in an artifact while problems do not necessarily result in an artifact.

problem-based learning – An open-ended learning strategy that uses a driving question based upon a real-world application as the framework for student-directed learning

project-based learning – An open-ended learning strategy where the student(s) create an artifact while addressing a real-world problem.

PBL – Project-based or problem-based learning. The project or problem provides the framework that supports the learning activities.

student-centered – The classroom activities and resources used are driven by the student's needs for learning. Similar to student-directed learning.

teacher-centered – The classroom activities are driven by the teacher's focus on teaching and control of resources used.

SUMMARY

Assuming that the only way a teacher can influence a student's learning outcomes is by influencing the student's learning behaviors, then instructors must clearly convey their expectations for their students' learning behaviors. Students must then clearly receive or perceive these expectations and then engage in these expected behaviors. But when engineering students used to a traditional, teacher-centered classroom enter a student-centered classroom, both instructor and student may experience frustrations due to differing expectations. This research studied the interaction between the instructor and students' behaviors as they sought to convey and understand expectations for student learning behaviors performing a project in a student-centered, undergraduate engineering classroom.

Chapter 2: Literature Review

My initial interest in this research topic was sparked by my observations of an apparent gap between instructor expectations and students' perceptions of, understanding of, and even acceptance of, those expectations. Little published research appears to exist relating to such a gap between instructor's expectations and students' perceptions of those expectations and the students' subsequent behaviors. In reviewing the literature for my study, I searched for theory that might account for student and teacher behaviors in the classroom thus indirectly illuminating my research topic.

THE GAP

Why is there, or is there, a gap between what the instructor expects and what students perceive the instructor expects, particularly for open-ended assignments? Poor communication comes to mind very quickly as one possible reason. Parr and Valerius (1999) suggest that the "disconnection" between faculty expectations of student behaviors and students' actual behaviors might be due to "a lack of clear communication by faculty of expectations, differences in educational goals between faculty and students, student misunderstandings of expectations, or students consciously choosing not to engage in certain desired behaviors" (p. 11 of 15 of full text article from Expanded Academic ASAP database). One of the most common forms of communicating an instructor's expectations in the college classroom is the course syllabus. The syllabus could even be considered as a contractual agreement (Smith & Razzouk, 1993). It is typically handed out the first day of class. Students review it then either drop the course or choose to remain enrolled, thus accepting the terms of the syllabus. However, research has indicated that students may not carefully read the syllabus or even use it as the instructor intends (Smith & Razzouk, 1993). Many of the business students in a study (Smith & Razzouk, 1993) were unable to recall important information from their course syllabus including course objectives, evaluation procedures, and their daily assignment although knowledge of the syllabus did seem to improve as the semester went along.

Nunan (1995) believes that the gap between what he intended for his students to do and their actual outcomes was mainly due to a difference in agendas and occurred at "the level of the learning process" (p. 140). The differing agendas were due to the teacher being focused upon teaching while the students were focused upon something else. Nunan (1995) believes a learner-centered classroom in which learners "are aware of the goals and the content of the curriculum, learning program or pedagogical materials" (p. 136) is the way to lessen the gap between teachers and students. Block (as cited in Nunan, 1995) believes that students and teachers all enter the classroom with their own "preoccupations" regarding with what is going on and why. Block proposed that the gaps in the classroom were in part due to students' misperceptions about why they were being asked to perform classroom tasks.

Hiemstra (2001) looked at the differences between what instructors believed their business students learned from writing reports and their students' beliefs of what they learned as a result of the task. Both the instructors and students agreed that the students did improve their writing skills from the experience. However the instructors reported more improvement in student writing skills than did the students. This difference might be attributable to the instructors' more realistic and more objective perspectives. The influence of grades and not understanding the assignment may have influenced some students' perceptions of improvement while not receiving the desired grade may have lowered some students' perceptions of improvement.

Pollio and Beck (2000) describe a gap between instructors' and students' perceptions of the value the other places on grades and learning. When students believe the instructor values grades over learning, they may ask about what will be on the test but won't remain after class to ask questions. Similarly, instructors who believe their students value grades over learning will use grades as motivators. But the reality appears to be that both instructors and students value learning over grades. The problem is that there is no dialogue between the two sides. Pollio and Beck (2000) propose that each side view the situation from the other's perspective and develop a supportive, not adversarial, relationship.

Winter and Yackel (2000) refer to misalignments between the instructor and students' points of view in the mathematics classroom. For instance, evaluative misalignment occurs when "there is a significant difference between the instructor's and student's ideas of what evaluation actually means or the criteria that should be used to make evaluative decisions" (p. 298). Misalignments can result in disruptive classroom behaviors when the instructor and students have differing views about who has the controlling authority in the classroom (Winter & Yackel, 2000). These misalignments between instructor and students may be affected by the instructor's prior classroom experience, especially with student-centered courses. Expert instructors and novice instructors may have different beliefs about what are appropriate student learning behaviors and thus enter the classroom with different expectations of their students.

One gap or "mismatch" that has been noted in the engineering classroom is between students' preferred learning styles and their instructor's teaching styles (Felder & Silverman, 1988). Learning styles refer to how students receive and process information in the classroom. For instance, most engineering students have been shown to be sensors. Sensors like facts, data and experimentations. Most engineering instructors are intuitors who like principles and theories. Engineering students who are intuitors appear to receive higher grades, perhaps because they are not victims of this mismatch between teaching and learning styles (Felder & Silverman, 1988).

BEHAVIORAL THEORIES

I looked at two theories that provide support for describing student behaviors in the classroom. The first was the theory of planned behavior which considers three constructs that affect an individual's intended behaviors. The second theory I looked at was Eccles' expectancy-value of motivation theory which proposes students' beliefs and expectancies about tasks are related to their achievement on those tasks.

Theory of Reasoned Action/Theory of Planned Behavior

The theory of reasoned action (TRA) (Norwich & Jaeger, 1989) proposes that an individual's intention to perform a behavior is the most "immediate determinant" of

whether or not that individual will engage in the behavior (p 315). This intention to perform a behavior is a function of both attitude and subjective norms. Attitude and subjective norms depend upon the individual's underlying beliefs relative to the task. Attitude is dependent upon the individual's beliefs in the potential outcomes of the task and subjective norms are dependent upon the individual's perceptions of others' approval or disapproval of behaviors necessary for performing the task. But the theory of reasoned action did not allow for situations of incomplete volitional control (Ajzen, 1991) so the theory of planned behavior (TPB, shown in Figure 5) adds a third element to the theory of reasoned action -- perceived behavioral control (Brown, 1999). Perceived behavioral control refers to the individual's perceived degree of personal control over his or her own behavior. Therefore, a person's intent to perform a behavior depends upon the individual's own personal attitude towards the behavior, what the individual thinks others think about the behavior (subjective norms) and how easy or hard the individual perceives the behavior will be to perform (perceived behavioral control) (Burak, 2002). Self-identity has been proposed as a fourth potential influence on behavior but appears to be more an indirect influence on intention to perform a behavior (Terry, Hogg, & White, 1999).

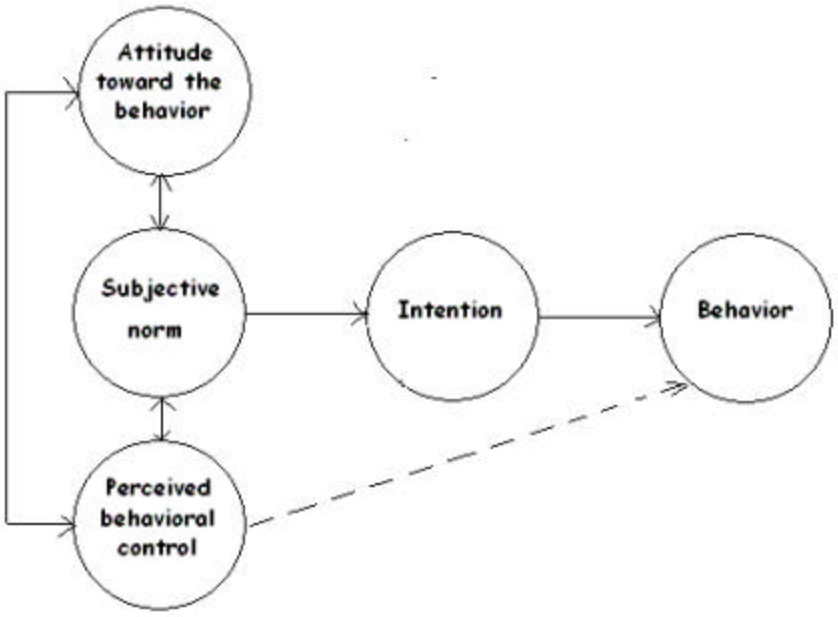


Figure 5. The Theory of Planned Behavior according to Ajzen (1991)

Attitudes

Attitudes refer to the individual's beliefs related to the behavior including evaluation of the potential outcomes of the behavior. While attitudes are students' own beliefs, instructors can influence how students perceive the task thus affecting their attitudes.

Students' attitudes toward a task may be dependent upon their perceptions of the attainment value the task has with respect to achieving their future goals, or its perceived instrumentality. In evaluating a classroom task, students will make decisions based upon the anticipated results. If they believe the task is relevant and helps them reach goals, then they may be more likely to intend those behaviors. If they do not think they can be successful with the task then they may be less likely to engage in the task.

Students develop proximal subgoals when their future goals seem too far off (Miller, DeBacker, & Greene, 1999). These subgoals create a framework towards achieving future goals. Those tasks with intrinsic value provide students with enjoyment and satisfaction from performing the task while those tasks that provide students with extrinsic value provide students with rewards and recognition. Eccles (as cited in Townsend & Hicks, 1997) proposes that task value is determined by positive or beneficial factors -- intrinsic, utility and attainment values -- and negative or cost factors – amount of effort, loss of valued alternatives. Students must weigh the costs versus the benefits of a task and then determine what resources to devote to it.

Subjective Norms

While attitude might be considered to come from how a student values or views a task, subjective norms are based upon students' perceptions of how others will value or view their behaviors on a task or the social pressures to perform the behaviors (Ajzen, 1991; Burak, 2002). For the student, a critical other who obviously affects their subjective norms is the instructor. The relationship between instructor and student can indirectly influence the student's learning behaviors and outcomes (Parr & Valerius, 1999). The instructor may be influenced to assess a student he likes higher than if he dislikes her. So students who engage in the behaviors that college professors like may

influence their assessment by impressing their professors. College professors were found to like for students to engage in behaviors related to active classroom participation, effort on assignments, conscientious behavior in the classroom and respectful behavior toward the professor as an individual (Parr & Valerius, 1999). Behaviors professors did not like were those that were distracting or showed disinterest in the classroom including not participating in the class or engaging in other activities while in the classroom.

Perceived Behavioral Control

Perceived behavioral control relates to how easy or difficult the student perceives the task to be (Burak, 2002). Perceived behavioral control is influenced by control beliefs and perceived power. It was added to the theory of reasoned action, creating the theory of planned behavior, to take into consideration that while a person might be motivated to pursue a task, actually engaging in the intended behavior may not be a choice under the individual's complete control.

Perceived behavioral control should not be confused with locus of control. Locus of control refers to an individual's beliefs about how his or her actions can influence the situation. For instance, students with an internal locus of control believe that they have control of their academic success and failures (Fazey & Fazey, 2001). These students are more likely to believe that they can work hard to positively influence their grades. Students with an external locus of control believe that they are at the mercy of more powerful others. They believe that their academic successes and failures are under the control of others and thus working harder will not ensure better grades. While locus of control tends to be static and stable across different situations, perceived behavioral control can change depending upon the situation (Ajzen, 1991)

Self-perceived competence or self-efficacy refers to how much a student believes that she is competent enough to or able to perform a task and is sensitive to the domain of learning (Zimmerman, 2000). High beliefs in personal competence are necessary to be an autonomous learner. Bandura (as cited in Ponton, 2002) noted that self-efficacy has a "mediating" effect on motivation. Students are more motivated to

pursue a task they expect to succeed at rather than a task where they anticipate failure. Students' self-efficacy beliefs affect both their rate of performance and energy expenditure on a task and influence the stress, anxiety and depression they feel towards a task (Zimmerman, 2000). According to Zimmerman, students with higher self-efficacy were "better at monitoring their working time, more persistent, less likely to reject correct hypotheses prematurely, and better at solving conceptual problems than inefficacious students of equal ability" (p. 87).

Perceived behavioral control is not just reflective of the student's competence but can also be affected by the student's access to necessary resources and opportunities. In the preceding chapter, I defined the role of the instructor in a student-centered classroom as being to provide resources and opportunities for learning. By helping the student recognize that she has access to the necessary resources, the instructor's influence is already evident in helping to develop a student's perceived behavioral control.

TPB in the Classroom

In the previous chapter, I expressed my belief that the only way a teacher could influence students' learning outcomes was by influencing students' learning behaviors. My simple model is shown again in Figure 6.

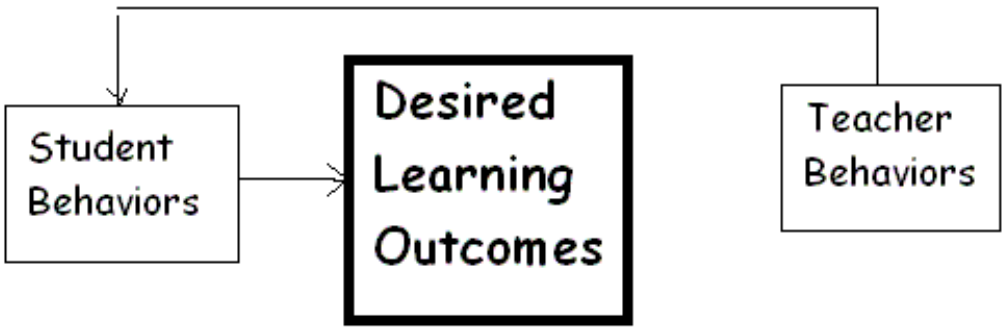


Figure 6. My simple model of the classroom interactions between student and teacher behaviors to achieve the desired student learning outcomes.

The theory of planned behavior can be applied to teacher behaviors as shown in Figure 7. The teacher's behavioral intentions are influenced by the teacher's attitudes, subjective norms and perceived behavioral control.

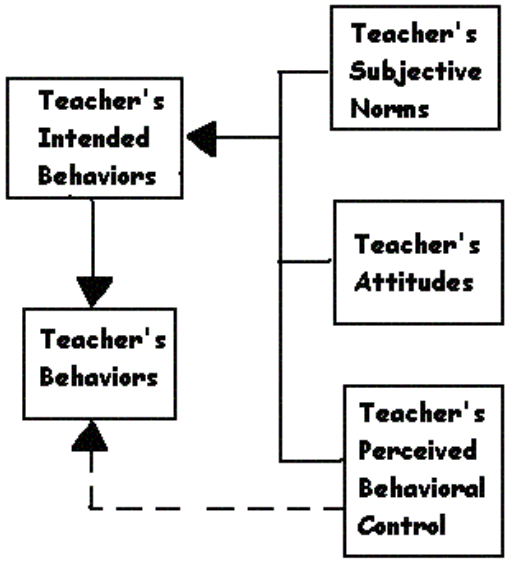


Figure 7. TPB applied to teacher behaviors.

We can apply TPB to student behaviors as shown in Figure 8:

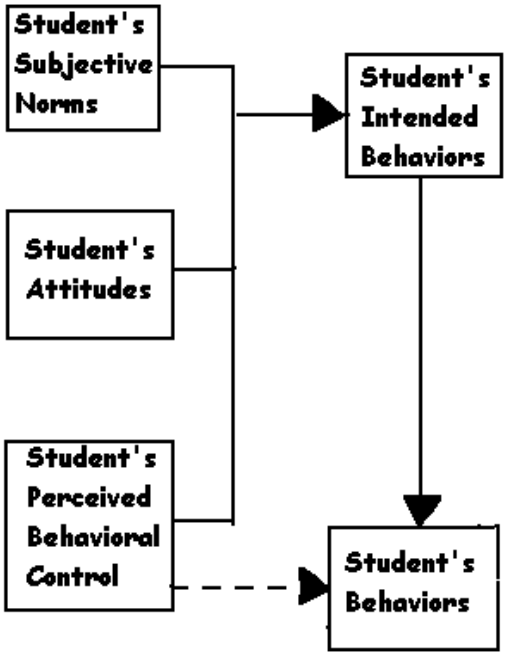


Figure 8. TPB applied to student behaviors.

These two expanded representations of teacher and student behaviors can now be inserted back into my simple model as shown in Figure 9.

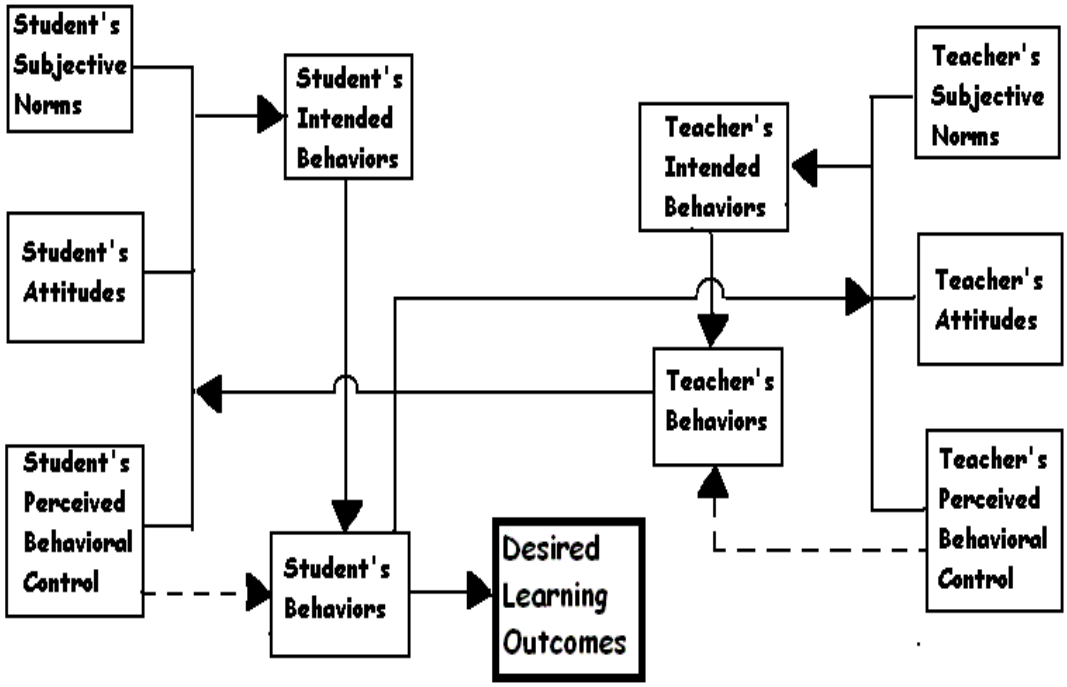


Figure 9. TPB Applied to the Classroom

The simple model has obviously become more complex. Looking at Figure 9, in order to affect the students' behaviors, the teacher's behaviors must influence the student's attitudes, subjective norms and perceived behavioral control. Hopefully the student is then influenced to at least intend to behave in the desired learning behaviors. If these intentions then become actual actions then the desired learning outcomes are met. I also added an arrow in Figure 9 to indicate that the students influence the teacher's behavior by influencing the teacher's attitudes, subjective norms and perceived behavioral control. So the teacher is influencing the students' behaviors and the students are influencing the teacher's behavior, all by influencing attitudes, subjective norms and perceived behavioral control.

Motivation Theory

According to Eccles expectancy-value of motivation theory " (a) student beliefs about a task and (b) student expectancies for success on that task are directly related to their achievement behaviors: performance, task persistence, and task choice" (Warton, 2001, p. 156). Further research into this model indicated that Eccles and associates used it more for explaining the behaviors of children and adolescents. Could it also support the behaviors of young adults? Instead of looking at the relation between adults and children, could I look at the relation between instructor (professor) and college student?

In Eccles' model, shown in Figure 10, children's behavioral outcomes are affected not just by their expectations of success or failure and the subjective value of the task but by social psychological influences defined by adults (teachers and parents) in their lives. Reflecting back to the theory of planned behavior, this sounds similar to attitudes and subjective norms. With respect to children's homework, conflicts may be associated with different perspectives of adults and children of the costs versus the benefits of the homework or "their subjective task values differ" (Warton, 2001, p. 157). Could this difference be due to the teacher not conveying the importance of the homework so that the student does not believe it is worth the cost for the benefits to be reaped? Or looking back to Nunan's observations, if the students and teacher enter the classroom with different agendas then the teacher needs to be sure to communicate the rationale for the learning activity (homework) so that the students, who probably can see the costs, will be able to fully understand the benefits and be potentially be more willing to pay the price.

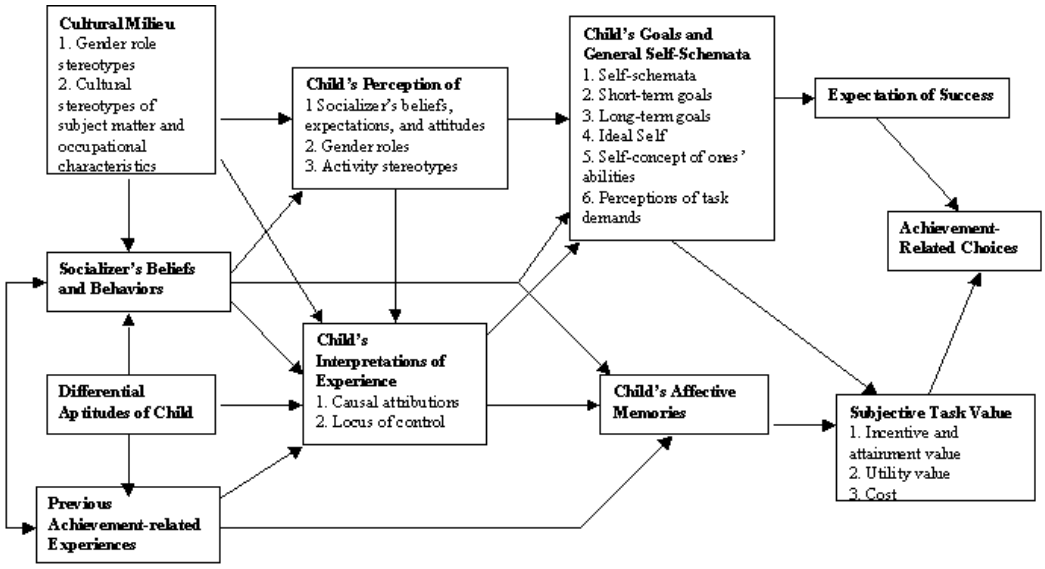


Figure 10. Eccles, Wigfield and colleagues' Expectancy-Value Theory of Achievement Motivation (Wigfield & Eccles, 2000, p. 69)

STUDENT LEARNING BEHAVIORS

Students exhibit both positive and negative learning behaviors in the classroom. Obviously the goal of the instructor is to encourage the positive learning behaviors such as autonomous learning behaviors and not negative behaviors such as avoidance.

Autonomous Learning Behaviors

Autonomous learning behaviors are not just student outcomes desired by academia but also by industrial employers (Fazey & Fazey, 2001). Autonomous learners "are intrinsically-motivated, perceive themselves to be in control of their decision-making, take responsibility for the outcomes of their actions and have confidence in themselves" (Fazey & Fazey, 2001, p. 345-346). Autonomous learners have enough belief in their own competence to take risks in pursuing tasks while those with less belief in their competence may not be willing to take these same risks (Fazey & Fazey, 2001). Three psychological constructs affecting autonomous learners include motivation, perceived control and perceived competence (Fazey & Fazey, 2001).

Motivation

Intrinsic motivation is considered to come from inside, from internal rewards. "People who are intrinsically motivated tend to engage in activities for the interest and enjoyment inherent in engaging in the activity itself" (Tripathi, 1992, p. 709). They learn "for the joy of it" (Johnson, Johnson, & Smith, 1989, p. 78). Mastery goals have been shown to positively predict intrinsic motivation while performance-approach goals were negative predictors (Church, Elliot & Gable, 2001). Providing external rewards has been shown to reduce intrinsic motivation (Deci, 1995; Tripathi, 1992).

Deci (1995) describes intrinsic motivation as occurring when an individual is behaving autonomously and authentically in reaction to his own integrated value system. Extrinsic motivation occurs when an individual is behaving in reaction to pressure or control. Instead of integrating values an individual believes, the individual might introject values that the individual cannot accept and therefore cannot internalize. These introjected values then control the individual's behavior as the individual behaves in response to these values. Individuals behaving in response to introjected values are extrinsically motivated by other's behaviors when these external behaviors involve external rewards such as pay raises, praise or punishment.

Extrinsic motivation can be divided into identified, introjected, and external self-regulatory processes (Fazey & Fazey, 2001). Identified regulation is close to intrinsic motivation except that task or action is externally initiated. With introjected regulation, the student values the task but is not motivated by a personal interest in performing the task but by rewards or fear of failure. External self-regulatory processes are the opposite of intrinsic motivation. The student is motivated only by external sources which may result in student behavior contradictory to the student's own values and sense of self.

While instructors can be argued to have a role in motivating students, their greater influence may be in demotivating students (Gorham & Millette, 1997). In a study (Gorham & Millette, 1997), teachers were more likely than their students to believe that the teachers' actions motivated the students. Teachers also attributed demotivation to non-teacher related factors and to more student-related factors. The students, however, attributed their motivation to factors that the students brought with

themselves into the classroom and that were unrelated to the teachers. They attributed more demotivating behaviors to factors under the teachers' control. Interestingly, there was some agreement between students and teachers that teachers are not responsible for motivating students.

Glasser (as cited in McCluskey & Parrish, 1996) considers motivating students to be a rather simple task. Just focus the classroom material on what the students are interested in learning. The professor should always take the time to explain to the students the usefulness of what they are studying and continually question the usefulness of all material presented. A tip sheet is one way to help students better understand the requirements of their assignment and how it will be evaluated. This understanding will then motivate the student to instill that quality, as defined by the tip sheet, into their work (McCluskey & Parrish, 1996).

Perceived control

The autonomous learner has an internal locus of control, perceiving that academic success or failure is under her control. Students with an external locus of control believe that they have little control over their classroom success or failure. Obviously, the student who does not believe her efforts make a difference in her academic outcomes has little incentive to try.

Perceived competence

Perceived competence refers to the individual's belief that "she can meet the demands of the context" (Fazey & Fazey, 2001, p. 346). Autonomous learners perceive themselves as competent enough to try the task even at the risk of failure. So students' perceptions of personal competence can limit their behavioral choices if they are afraid to take a risk and pursue a challenging task.

Cognitive Strategies

Like a magician with a box of tricks, students may have a stash of cognitive learning strategies they turn to depending upon what they believe is required for the

situation. These cognitive learning strategies can be meaningful or effective or they can be shallow and ineffective. Both perceived ability and student learning goals have been shown to be positively related to meaningful, as opposed to shallow, cognitive learning strategies and self-regulation (Greene & Miller, 1996). Students who believe they can learn and want to learn are more likely to acquire meaningful cognitive strategies. One study found that

> Prior knowledge may also affect the learning strategies that students employ. Students with the most developed prior knowledge and understanding seem to be able to focus on those aspects of their learning environment which evoke deep approaches to study in a coherent way, while those with the least developed prior knowledge and understanding seem to focus in an incoherent way (Prosser, Trigwell, Hazel, & Waterhouse, 2000, p. 72.)

Avoidance Behaviors

Even if students believe they understand the instructor's intentions for student behavior, they may have other reasons to not engage in the proscribed behaviors. Students and teachers may both engage in behaviors that protect their own self-views. However, these behaviors may be misinterpreted. One behavior over which students have control is effort made towards completing a learning task. For students, failure after great effort is much more damaging to their self-image than failure after little or no effort (Tollefson, 2000). But instructors come to the class with a different agenda. Teachers may see students who don't put forth effort as less likely to succeed in producing classroom outcomes. Teachers are less willing to help students who they perceive as performing poorly because they don't put forth the required effort as opposed to those who teachers perceive as performing poorly due to low ability (Tollefson, 2000). So the student who is protecting himself emotionally from failure after hard work by not putting forth effort angers his teacher who now does not want to help him because he is not trying. The student is in a lose-lose situation.

CREATING A LEARNING ENVIRONMENT

One way that the teacher influences the students' attitudes, subjective norms and perceived control is through the learning environment of the classroom. Research has

shown that students' perceptions of their learning environment affect both how they choose to learn as well as their learning outcomes (Lizzio, Wilson, & Simons, 2002). The classroom environment can influence whether students engage in deeper learning for meaning or just surface processing of information (Lizzio, Wilson, & Simons, 2002; Marton & Säliö, 1976). The perceived classroom environment can also influence students' adoption of achievement goals which in turn influence classroom performance and intrinsic motivation (Church, Elliot, & Gable, 2001). The most satisfactory learning environments were "perceived to contain good teaching, clear goals and independence in learning" (Prosser, Trigwell, Hazel, & Waterhouse, 2000, p. 62).

Deep vs. Surface Learning

The classroom environment influences whether students learn deeply for meaning or just memorize facts and other "surface" information. One of the reasons for using projects in the classroom is to stimulate deeper not surface learning. Whether intentional or not, the instructor can influence whether the students pursue surface or deep learning. For instance, perceptions of heavy workloads are associated with greater surface processing of information (Lizzio, Wilson, & Simons, 2002). Classroom assessment practices are another determinant of whether students learn deeply or shallowly (Lizzio, Wilson, & Simons, 2002; Marton & Säliö, 1976). Students' levels of prior knowledge, which are not necessarily within the instructor's control, have also been linked to the learning approaches they choose. Students with more prior knowledge use learning approaches that strive for deeper knowledge while students with less prior knowledge tend to use an approach that results in surface learning (Prosser, Trigwell, Hazel, & Waterhouse, 2000).

Achievement Goals

Whether or not students pursue deep versus surface learning can be related to what achievement goals the students choose. Achievement goals can be either mastery or performance goals (Ames, 1991; Church, Elliot, & Gable, 2001; Tollefson, 2000). Mastery goals, which lead to the development of skills and competency, are associated

with high intrinsic motivation. Performance goals, which have been related to shallow learning (Greene & Miller, 1996), can be divided into performance-approach and performance-avoidance goals (Church, Elliot, & Gable, 2001). Performance-approach goals seek positive approvals of competence relative to the performances of others and have been associated with higher grades. Students with performance-avoidance goals just try to avoid negative evaluations. Performance avoidance goals have been shown to be associated with both lower intrinsic motivation and lower grades.

Achievement goals have been linked to three variables defining the classroom environment: lecture engagement, evaluation focus, and harsh evaluation (Church, Elliot, & Gable, 2001). These are all variables influenced by the instructor but dependent upon student perception. Lecture engagement refers to student perceptions of how interestingly the instructor presents the material. Research has indicated that lecture engagement is positively related to the adoption of mastery goals but was not related to performance goals (Church, Elliot & Gable, 2001). Evaluation focus refers to how much the students perceive the instructor emphasizes grades and other evaluations in the course. Evaluation focus was shown to positively predict both performance goals while negatively predicting mastery goals. Harsh evaluation refers to students' perceptions of the grading structure as so hard that they cannot make a good grade? Harsh evaluation was shown to positively predict performance avoidance goals while negatively predicting mastery goals but did not predict performance-approach goals.

The activities chosen for the classroom influence student choices whether to pursue mastery or achievement goals (Ames, 1992). Mastery goals are more likely to occur when students perceive the learning task to have meaning to them. Tasks that students find interesting and personally challenging also contribute towards mastery goals. Performance goals are related to avoiding challenging tasks.

Grades

The role of grades is a critical factor of the classroom environment and is, consciously or not, defined by the instructor in explicit and subtle ways. For instance, the instructor who values grades in the classroom may focus on the students with the

top grades and use grades to promote competition rather than collaboration in the classroom (Pollio & Beck, 2000). In such an environment, learning for learning's sake is seemingly not valued.

At the college level, grades have been creeping up over the last thirty years, ironically as other indicators of aptitude have been dropping (Darnell, 2001). The distribution of A's has grown from 7% of grades awarded in 1969 to 26% in 1993 while C's awarded went from 25% in 1969 to 9% in 1993 (Darnell, 2001). This grade inflation and high distribution of high grades occurs at all levels of higher education, even at the most prestigious schools (Darnell, 2001). Students may expect good grades just because they attend class and work hard (Landrum, 1999, as cited by Gaultney & Cann, 2001). With this high distribution of A's, the very top students are no longer distinguished. Grade inflation also leads to students performing lower quality work.

Unfortunately, sometimes students care more about a high grade than learning the material (Pollio & Beck, 2000). How much does today's educational culture, with its emphasis on standardized testing, influence student's focus on grades at the expense of learning? Grades mean different things to different students. Students with higher grades have been shown to view grades as more valid than students with lower grades (Woo & Frank, 2000). Students with lower grades may be more likely to attribute their GPAs to lack of effort rather than lack of ability (Woo & Frank, 2000) or possibly more specifically to effort not being accurately included in their grade by the instructor (Gaultney & Cann, 2001). One study suggested that both undergraduate students as well as their instructors prefer more emphasis on learning and less on grades but blame the other for their entrapment in an environment stressing grades over learning (Pollio & Beck, 2000).

Students in a study of university psychology students expressed many conflicting desires for classroom assessment. While 65% wanted "success," 35% wanting "learning" (Gaultney & Cann, 2001). They also wanted to be graded on a normal curve but they didn't believe the normal distribution of grades was fair. They wanted their courses to be fun and easy but to stress mastery of the material. They wanted their professors to include effort in the grading process even though effort

cannot be objectively measured. Since these expectations obviously cannot be met, students may never be satisfied with the grading process.

PROJECTS IN THE ENGINEERING CLASSROOM

Engineering graduates are expected to possess not just technical knowledge but non-technical skills such as the abilities to work in teams and to learn new skills. Engineering students need to know not just the "ics" -- mathematics, physics, electronics -- but the "ings" -- communicating, designing, listening (Matthew & Hughes, 1994). "The 'ics' may be considered as fibres held in place by a matrix of 'ings.' In a composite the beneficial properties are only achieved by the fibres and matrix acting in consort" (Matthew & Hughes, 1994, p. 235). While the 'ics' have traditionally dominated the engineering curriculum, the demand for developing engineering students' personal, interpersonal and cognitive skills is increasing, especially among potential employers. Matthew and Hughes (1994) argue that if we can agree on the basic core material to be taught then it should be "relatively easy to reduce content (ics) and replace it with process (ings)" (p. 236).

Projects allow engineering students to learn the “ics” along with the “ings.” Projects are used in the classroom for many reasons – to encourage mastery learning goals, to encourage autonomous learning, to develop problem-solving skills, to promote transfer of learning, to develop professional skills. The project should be “as close to reality as possible” (Lenschow, 1998, p. 157) and appropriate for the students’ levels of competency. While they did not find evidence that problem-based learning (PBL) improves problem-solving skills, Norman and Schmidt (1992) presented several advantages that seem to be exhibited by PBL students. PBL students may not test as highly immediately after the learning activity but they have been shown to retain information for a longer period of time. PBL may also lead to greater ability to retrieve knowledge.

Projects may also allow students the opportunity to learn through the use of hands-on activities. Hardware, which can be a component of these hands-on activities, has been shown to affect engineering students’ learning and thinking through design

experiences (Brereton, 1998; Brereton &McGarry, 2000). Other benefits from PBL may be students who use resources more effectively for self-directed learning and also students with a greater intrinsic interest in the subject. A study of college students found that students appeared to attribute improvements in problem solving and critical thinking skills to problem based learning (Sluijsmans, Moerkerke, Merriënboer, & Dochy, 2001). Students in PBL classes may become more motivated but this may be after first experiencing frustration from the lack of detailed instructions (Lenschow, 1998). But after students adjust they appreciate the freedom to be creative.

In a study in which complex problems or projects were used with calculus students in a discovery learning environment, results indicated that the projects increased students' confidence in their problem-solving abilities (Conley, Steussy, Cohen, Gaughan, Knoebel, Kurtz, & Pengelley, 1992). Students tended to be more appreciative of the projects as activities beyond their homework as well as the group work. This study also noted that the students who preferred projects were more similar than the students who did not prefer projects.

Situated Learning

One of the basic beliefs of the educational philosophy known as constructivism is that "meaningful learning occurs within authentic learning tasks" (Puntambekar, 1999, p.2). Authentic tasks represent real-world applications or situations. The hope is that students will be able to transfer what they learn working on this task to other situations in real-life. Some popular approaches to learning through authentic tasks include situated learning and problem-based or project-based instruction/learning (PBI/PBL).

Situated learning seems to have first received attention with a frequently cited article by Brown, Collins, and Duguid (1989) where the authors present knowledge as being "situated" in the culture and the context of the activity so that learning activities should reflect the activities of practitioners. They support the use of collaborative learning for collective problem solving, to expose the students to multiple roles, to help uncover student misconceptions, and to provide an opportunity for students to develop

skills in working with others. The authors also propose the practice of "cognitive apprenticeship" where students learn in a "culture of the domain, not of the school" (p. 40). Lave and Wenger (1991) further explore situated learning by exploring legitimate peripheral participation (LPP). LPP refers to the process from newcomer to practitioner that learners go through as they "move toward full participation in the socio-cultural practices of a community" (p. 29).

Problem-based vs. Project-based

As with many areas of education, a lack of agreement in terminology may lead to confusion when discussing the use of projects in the classroom. The terms problem-based learning, project-based learning and project work may be used by various authors to describe the same intended learning experience and by others to distinguish between different features of distinct educational practices. Problem-based learning and project-based learning are both strategies for student-centered learning through real-world applications. The intent is that while addressing the task, students exhibit the same behavior as a real-world practitioner in this field (Savery & Duffy, 1996) thus gaining entry into that community of practice. The problem or project acts as a stimulus, focus, or framework for learning. The focus is on learning, not teaching. The students learn as they work to understand the problem and define possible solutions or to develop the project. The instructor is responsible for introducing the problem or project in a way that excites the students to want to work on it.

Blumenfild, Soloway, Marx, Krajcik, Guzdial and Palinscsar (1991) describe project-based learning as "a comprehensive approach to classroom teaching and learning that is designed to engage students in investigation of authentic problems" (p. 369). They describe "two essential components" of all PBL courses. First, there must be a "question or problem that serves to organize and drive activities; and these activities result in a series of artifacts, or products, that culminate in a final product that addresses the driving question" (p 371). The question must be broad enough to allow students room to "develop their own approaches to answering the question" (p 372) as well as room to create the artifacts that aid students in "constructing their knowledge" (p 372).

They define artifacts as "representations of the students' problem solutions that reflect emergent states of knowledge" (p 372).

With problem-based learning, students are typically presented with a "vignette" that defines a problem to be explored (Nulden & Scheepers, 1999). Project-based learning or project work promotes many of the same experiential learning behaviors as problem-based learning although some might argue that project work is more teacher-centered than problem-based learning (Kolmos, 1996). Project-based learning is very similar to problem-based learning except, as the name implies, the students are not necessarily addressing a problem but developing a project on a topic. Project-based instruction involves a question or problem that drives the investigation and is completed with the production of an artifact or final project in response to the driving question (Blumenfield, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991). Problem-based learning might not necessarily produce an artifact.

Kolmos (1996) presents three types of projects used at Aalborg University. The first she refers to as the “assignment project.” This is controlled educational experience where the methods are defined ahead of time and the teacher is actively involved in guiding the students’ progress with the project. In engineering education, many traditional laboratory experiments could be considered assignment projects. Next is the “subject project” where either students choose a problem within an already defined subject or choose a problem from a listing of predefined problems within the defined subject. With the “problem project,” students start out with a problem that they must analyze and solve. This third type of project is the most challenging for teachers since it is less controlled and more likely to challenge the teacher’s abilities and knowledge. The “problem project” is also most aligned with the traditional definitions of problem- or project-based learning. In engineering education, capstone design projects could be considered an example of problem projects.

PUTTING IT ALL TOGETHER

So how does an instructor influence students’ learning behaviors in a project-based classroom? Referring back to Figure 9, by integrating projects into his classroom

an instructor might influence all three variables affecting student behaviors according to the theory of planned behavior. First, the projects can potentially increase the students' perceptions of behavioral control. With projects, versus doing homework problems and taking a test, students are able to make more decisions and individualize their work. The students' subjective norms may be influenced by the open-endedness of projects. Their innovative ideas may actually be encouraged in this environment. And the students' attitudes may also be affected. Many students prefer the hands-on and real-world nature of projects versus sitting passively in lecture. Projects may help them to be able to see how the learning task relates to their future goals. So, by using projects in the classroom, the instructor could potentially change the students' learning behaviors to achieve the desired learning outcomes.

Chapter 3: Methods

This study used predominantly qualitative research methods for exploring my four research questions.

How does an instructor convey his expectations of student learning behaviors to his students?

How do the students then perceive his expectations for their behaviors?

What learning behaviors do the students then actually choose to employ?

Why do students choose those learning behaviors?

While quantitative methods are useful for implying "what" the situation is, they do not tend to provide answers for "why" the situation exists. With qualitative methods, we can dig deeper and gather "thick and rich" data to better understand the situation and answer the "why" and "how" questions. Choosing to use qualitative methods to study engineers was a bit daring since engineers are commonly considered to prefer quantitative to qualitative data. However, even engineers have seen the benefits of qualitative data to expose information not apparent through quantitative methods (Thompson, Flick, & Gummer, 2003).

The bulk of my study used narrative inquiry or narrative analysis, a qualitative research method of increasing popularity with educational researchers. Narratives are a part of human life. Stories have been used to pass on culture long before writing. Narratives are frequently referred to as life stories. I did not seek life stories from birth but stories for the life of the project. Since every narrative requires a definitive beginning and ending (Riessman, 1993), the beginning and ending of the project established the beginning and ending of the narratives, although reflective interviews continued after the project was completed.

Why I Chose To Use Narrative Inquiry

I anticipated that the professor's expectations and the students' perceptions of those expectations would be formed and changed over time, and in parallel, in reaction

to events in the classroom. I needed a research method that allowed me to construct how events might affect behaviors. Polkinghorne (1988) describes narrative as both "a scheme by means of which human beings give meaning to their experience of temporality and personal actions" (p. 11) and as displaying "the significance that events have for one another" (p. 13). I felt that narrative would allow me to do exactly what I wanted to do.

Researcher's Influence

Unlike quantitative research, the researcher's influence is accepted in most qualitative analysis. The researcher is just another instrument in the study. The researcher is "seen not only in defining the focus and field of the inquiry, but also in navigating the relationships with the subjects, in witnessing and interpreting the action, in tracing the emergent themes, and in creating the narrative" (Lawrence-Lightfoot & Davis, 1997, p. 13). I was an influence in my study. I was not strictly a fly on the wall in the classroom I observed. The students knew me and spoke to me in the hallways outside of class. While most of the time I sat quietly, there were occasions where I spoke up in class or was occasionally asked to comment by the instructor.

DESCRIPTION OF RESEARCH METHODS

I used what I considered to be a three-dimensional data collection strategy by considering the breadth (two dimensional) as well as the depth (a third dimension) of my data gathering techniques. I describe this strategy through the analogy of exploring the composition of a field. I can walk around the field and look at the surface of the field, maybe poke around in the dirt with a shovel and see what is near the top. I could use this strategy to explore the top surface of a large area fairly quickly and easily, noting the vegetation, rocks, and insects. The two dimensions composing breadth are large but the depth is shallow. I may learn a lot about the surface but exploring the surface does not provide me with information about what is below the surface. How deep is the topsoil? Are there rocks underneath? How far is the water table? To see what is below the surface of the field, I could drill core samples or dig deep holes in strategic

places that I believed, or hoped, would provide some useful information. Now the breadth of my sample is small but the depth is large. While these core samples will not provide data for positively describing everything that's under the entire field, they will give us some insight about what is under part of it. We are then left to make our own individual interpretations of what might be under the rest of the field. For instance, if all my core samples are solid rock, do I assume there is solid rock under the entire field? For my study I gathered broad but shallow surface data through surveys and then used individual interviews to "drill" narrow but deep core samples to gain some insight into what lies beneath the surface.

BROAD BUT SHALLOW

For the broad but shallow part of my research -- analogous to walking around looking at the surface of a field -- I used traditional survey methods to gather information from all the students in the course, or at least those willing to respond. These surveys were intended to provide answers to the second research question, "How do the students then perceive his expectations for their behaviors?"

Surveys

I gave three surveys during the course. These surveys were intended to provide insight into the views and experiences of the entire class. All surveys were accompanied by an approved cover letter (see Appendix G). The purpose of the first survey, which I refer to as the screening survey, was to 1) help me determine which students I wanted to invite to participate in the narrow but deep portion of the study and 2) provide a larger picture of the attitudes and characteristics of the students in the course. This survey was given the first week of class. A copy of this survey is provided in Appendix D.

The second and third surveys I refer to as the pretest and posttest. The pre-test was given mid-semester shortly after the course project was assigned. A copy of the pretest is provided in Appendix E. The main focus of the pretest was to gather the students' early perceptions of what the instructor was expecting them to do for the project. The posttest was given the last day of class, the day before the final project was

due. The purpose of the posttest was to gather the students' perceptions of the instructor's expectations at the end of the project. A copy of the posttest is provided in Appendix F.

All three surveys contained some Likert scale items. These items were included to provide broader insight into possible changes in student attitudes during the course. The Likert scale items were compared using paired t-tests. The results are presented in Chapter 4. To compare the Likert scale items, I used SPSS, Version 8, to run paired t-tests. The data were first entered into Excel then imported into SPSS.

The pretest and posttest (see Appendix E and Appendix F) both contained an open-ended request for the students to define their understanding of the instructor's expectations for them on the final project. I analyzed this data in two ways. First, I had the instructor also respond to this item. He did this in bullets which worked out conveniently for me. I went through each student response and looked for items in their responses that matched the instructor's response. I recorded these numbers on an adhesive note stuck to each student paper.

I also analyzed these student responses looking for common themes. I went through the papers and extracted phrases or summaries for each thought expressed. I typed these in a word document. I then sorted all these responses into common categories. I determined thirteen common categories for all these responses from both the pre-test and post-test. I then went back and determined how many "hits" there were for each response on both surveys (see Appendix J). The results are presented in Chapter 4.

NARROW BUT DEEP

For taking core samples, gathering the narrow but deep data, I used methods of narrative inquiry for collecting and analyzing interview data from four purposively selected students as well as the instructor of the course. This strategy was intended to collect data for addressing all four of my research questions. The interviews with the instructor were anticipated to provide answers to the first question. The interviews with the students were expected to answer the second, third and fourth questions.

Choosing the Student Participants

The participants were chosen based upon their responses to the first screening survey and from classroom observations. I tried to pick students with some diversity in how they responded to the screening survey, analogous to trying to drill core samples where I might hope to find something different. I also watched students in class for a few weeks. I wanted to choose students who I thought would talk openly with me and provide insightful information. Consequently, I did not choose any of the very quiet students who never spoke up in class. I continually vascillated over which students to choose. In retrospect, I truly believe that any of the 36 students in the class would have proven to be an insightful participant with their own fascinating story to tell. I do not think I could have chosen any better or worse had I pulled names from a hat.

The students I chose were two females and two males, including one older than average student who was married and a parent, one student with no work experience, one student with substantial work experience, and two students born outside the United States. The four students also had varying responses to the Likert scale items. Two of the students sat on the windows side of the room and two sat on the door side of the room. One sat towards the front of the room, two in the middle, and one on the back row. In the end, there was no algorithm for which students I chose. If I had picked the day before or the day after I might have picked a different group.

The students were initially contacted about being participants through email. I used email for much of my contact with the students. I began to use the phone a little more towards the end of the semester and regretted that I did not use it more in the beginning. While I tend to depend upon email, I think some of the students were more dependent upon their cell phones. I guess it was a generational difference. I allowed the students to pick their own pseudonyms and did request they not choose a real long name since I would be typing it frequently. They chose Barbie, Bill, Mary, and Sami.

Interviews

According to Stuhlmiller (2001), interviewing for narrative inquiry has three distinct phases: the warm-up, the story, and the wrap-up. During the warm-up phase, the

interviewer and the participant get to know each other and the interviewer explains the "goals, purposes and rules" of the interview. This is a critical time for the entire research process. The researcher and participant are making those first impressions that will affect their relationship for the entire interview process. If the participant is comfortable with the researcher then the participant will be more comfortable sharing information and both the quality and quantity of the data will be improved. I did not know my four student participants prior to this class. My first interview with each participant was the warm-up interview where we became acquainted, made early impressions, and hopefully developed a trusting and open rapport.

During the second or story phase, the researcher begins asking open-ended interview questions. The interviewer must be perceptive to pick up the level of personal disclosure the participant is comfortable engaging in and maintain the interview at that level. The interviewer must also convey genuine interest in hearing the participant's story. The second through fifth student interviews were the story phase of my research. Finally, during the wrap-up, the interviewer addresses any closing concerns with the participants. The last interview, or interviews, after the course was over was my wrap-up phase.

In the first interview I told each student about the study, allowed them to ask me any questions about the survey, had them sign the consent forms, and found out more about them. While my target was to survey the students six times each, timing conflicts and communication glitches limited the number of interviews, particularly later in the semester. I interviewed Barbie and Mary five times each during the semester, once immediately after the course was over in December, and then a seventh time in January. I interviewed Sami four times during the semester, once in December after the course was over, and a sixth time in January. I interviewed Bill four times during the semester and then once in December after the course was over. Bill graduated in December and moved on so I was not able to interview him in January.

The main focus of my interviews was to inquire about what the students considered to be the instructor's expectations of them. However, many other topics came up. Sometimes these other topics led back to the instructor's expectations.

Frequently the other topics gave insight into the course or curricula as well as problems with faculty. Sometimes I felt more like a therapist. I seldom entered the interviews with an explicit list of questions in front of me. If I did have specific questions they were usually jotted down shortly before the interview. Or sometimes I thought of a question to ask after I had transcribed and summarized the latest interview. For instance, something the participant mentioned that I wanted to hear more about. But typically I began with an open-ended "How's it going?" then tried to keep the interview focused back on instructor expectations. I found that letting the participants talk seemed to loosen them up and might eventually even lead to something valuable. In interviewing the instructor, I might refer back to my notes from the classroom observation to discuss a topic that occurred in class. But frequently he already had a topic he wanted to discuss.

The intent was that the identity of the student participants would be kept confidential with only myself and my faculty advisor knowing the actual identities. I tried to be faithful to this plan. However, early in the semester, Sami did not remember where we were meeting and was running late and ran to the instructor's office to see if he knew where I was, thus blowing his cover. However, I tried to hide the identity of other participants when talking to the professor, for example, using male pronouns when discussing a female participant. At other times, when the student participants did not respond to email requests, I might make personal contact with them in the hallway after class. I tried to do this away from the instructor. I also tried to speak with other students outside of class to cover my tracks. To my knowledge, the student participants did not know who the other student participants were which was especially interesting since two were assigned to the same team for the course. The students were less concerned about preserving their confidentiality than I was.

One interview took place in my office and one interview at the participant's home. All other student interviews took place in a small conference room on a different floor than where the instructor's office was located. All interviews were tape-recorded (audio), transcribed, and summarized. The summaries were sent to the participants via

email for review. The summaries were not discussed unless the students had comments, which they seldom did.

Instructor as a Participant

Data for creating the instructor's narrative were gathered similarly to the methods for the student participants except that the first interview with the instructor was before the semester began. It was not a warm-up interview in the sense of getting to know each other since we knew each other well but it was an opportunity to discuss the structure of the research. I met with the instructor prior to the beginning of course to discuss the instructor's intentions for the course. Emphasis was placed on creating a clear definition of the instructor's intentions or expectations of student behaviors and student learning outcomes prior to the first project. With the exception of one week in November, I then interviewed the instructor weekly in his office on Thursday after the discussion lab for the course. Sometimes these were short interviews because we were both tired. Other times he was fired up about something that had just happened in class. Overall, the benefits of talking immediately after class seemed to outweigh the negatives. We began making therapy jokes about our interviews. We had a wrap-up interview in December and another in January, in addition to some casual conversations throughout the spring semester.

Other Qualitative Data

Except for one week in November, I observed all meetings of this class. I tried to focus upon recording incidents in the class related to the instructor expectations, whether it was the instructor explicitly expressing what he wanted or students expressing their perceptions of what he wanted. Some days there was little said. Others there was so much said that I could not write it all down. The classroom observations collected data to address my first three research questions.

I also attempted to conduct some focus groups with limited success. The first focus group was with the members of one instructor-assigned team from the course. Three of the five team members were there for the whole time, one came in late and the

de facto leader, with whom I was especially interested in talking, didn't show. I wanted to do another focus group with students from different teams. I contacted them through email and asked them to RSVP. Three did, two saying they would be there and one saying he would probably be there. Only one, "Heavy D," showed up for the focus group so it ended up being an interview.

Artifacts such as the course syllabus and other course postings – paper or online -- were collected from the instructor and student participants. Some of these items are included in the appendices. While I had hoped to have the instructor and even participants keep journals, in the end I was the only one who did. I used my electronic journal to record my personal thoughts, experiences, informal communications, and data analysis process. A sample from my journal is included in Appendix O.

Data Analysis

The interview data for each participant were collected and analyzed through narrative analysis. Narrative analysis doesn't just create stories but seeks to make sense and meaning and provide significance for these stories through the use of plot. Polkinghorne (1988) compares plot to hypothesis: "Both are interactive activities that take place between a conception that might explain or show a connection among the events and the resistance of the events to fit the construction" (p. 19). The role of the researcher is to find the connections and support them with the data through narrative.

While more traditional qualitative research analysis methods use coding and chunking processes to break down data, narrative analysis can be viewed as going in the opposite direction by building the data up into a greater context. So instead of dismembering the data and potentially losing meaning through disassociation from the original context, my goal was to take the data and put it together to create the stories of my participants as they went through this class.

Stuhlmiller (2001) describes four stages for analyzing narrative data. The first stage reviews the narratives to describe experiences. Themes are sought from the transcripts in the second stage. In the third stage, exemplars or specific examples supporting the themes are picked out from the interview data. Finally, in the fourth

stage, the data are examined to identify common themes or patterns across participants. This is the analysis process I essentially followed except that I limited the themes I explored in stage four through a focus on answering my research questions.

Each interview was audio tape-recorded. I then transcribed each interview and created a summary from the transcription. This transition mainly consisted of converting the dialogue into logical paragraphs preserving quotes from the participant and minimizing the researcher's role. I also purged any irrelevant conversation. The summaries were then emailed to the participant for member checking and discussed, if necessary, at the next interview. An example of the evolutionary process from transcription to summary to narrative is available in Appendix M.

During our interviews, the students shared many intriguing experiences and insights with me about the curriculum, the faculty, their beliefs about grading, and their prior academic experiences, as well as snippets of their personal lives. I had so much data that I had to focus upon my original research questions and exclude many fascinating themes that arose. In the student narratives, I focused upon three subplots. First, I wanted the reader to get to know the participant. I felt the stories had little meaning unless connected to the individuals. This subplot was often composed from information volunteered by the participant to a more general question such as "tell me about yourself." So the first part of the narrative gives the reader an opportunity to meet the participant. The second part of the narrative shares the students' experiences through the course using an underlying structure of the common pivotal events. Finally, the third part of the narrative tells how the students' perceptions of the instructor's expectations of them changed through the course.

A narrative seeks to relate events that happen through time. The first step of my analysis was to identify those key events, or experiences to use Stuhulmiller's model, as evidenced by my observations and the interviews with the participants. For the instructor, his plot was anticipated to follow how he defined, and redefined, his student expectations through the course as he worked with the students. For the student participants, their plots were anticipated to follow how they perceived the instructor's expectations, modified their perceptions, and how they were guided by these

expectations in completing the project. Each story occurred in parallel so common events were anticipated to influence all participants, but perhaps in different ways. While I initially intended to use a timeline for all the narratives, the flexibility of the deadlines in this course made a timeline impractical because students were not on the same timeline. However, certain pivotal events did occur in the same sequence for all participants. I used this sequence of pivotal events for my structure.

Much of my creation of the narratives was done through cut and paste on a word processor and through information I literally held in my head. I consider the process I used as comparable to editing video. I had to hold all the information in my head until I could put it together where it belonged. It was not a linear process that goes down neatly on paper. It was mental synthesis. Sometimes I used temporary subheadings to group by theme or topic, such as P2 or grades, until I could arrange the text, quotes and thoughts in what I believed was an effective presentation. And it was an iterative process of reviewing the summaries and observation notes to find a quote or make sure that I had not omitted anything pertinent.

Eventually the process became one of trimming and purging to edit the narratives down to a manageable size. This was the most frustrating part of creating the narratives – all the litter on the cutting room floor. With five narratives to present, length became an issue. Even at just 20 pages each, that is 100 pages of narrative. My goal was to get the narratives down to 15 pages each while retaining the essence of the individual as well as the pertinent data. In a personal compromise, I promised myself that I could still quote in the discussion of results data not included in the narratives.

INSTILLING RIGOR

Qualitative research methods do not answer to the same criteria for quality that are used for quantitative research. The procedures used for instilling rigor in this study are described below.

Validity

As with all qualitative research methods, one of the great challenges of narrative inquiry is providing support for the validity of the results. Reliability is not essential for validity with qualitative research within a naturalistic or interpretive paradigm where reality is "assumed to be multiple and constructed rather than singular and tangible "(Sandelowski, 1993, p. 3). Sandelowski (1993) describes qualitative research as an art where the researcher seeks to present the "essence" of the situation without flooding the readers with details. Just as no two artists will present a subject in the same way, every researcher will present the "essence" of her research differently, dependent upon her beliefs and backgrounds. In other words, my interpretation of the data is not necessarily right or wrong but they may differ from someone else's interpretations. Another reason reliability is not a factor in assuring the validity of narrative inquiry is "the inherently revisionist nature" of the participants' stories (Sandelowski, 1993, p. 4). With my research topic, I fully expected my participants' stories to change with time. In fact, this expectation of change was a basic assumption that provided part of the rationale for my study. I wanted to observe these changes and seek to understand why they occurred.

Polkinghorne (1988) describes the validity in narrative research as referring to well-grounded conclusions, frequently supported by informal reasoning that produces likelihoods, not certainties. Validity is established when the argument can withstand challenge. According to Polkinghorne, narrative research "aims rather for verisimilitude, or results that have the appearance of truth or reality" (1988, p. 176).

Riessman (1993) cited four ways to approach validity in narrative analysis: persuasiveness, correspondence, coherence and pragmatic use. Persuasiveness refers to whether the narrative analysis is reasonable and convincing. Correspondence includes having the participants review the interpretations. Coherence shows that the "interpretation is more than ad hoc" (p. 67). The fourth, pragmatic use, refers to the value the interpretation has for future studies.

Member Validation

Member validation or member checking plays a delicate role in narrative inquiry. Did having the member, or participant, review my interpretation of her story improve the validity of my interpretation? According to Reissman (1993), it did by addressing correspondence. However, Sandelowski (1993) argues that member checking can actually threaten the trustworthiness of the project. The participants and the authors may have "different stories to tell and different agendas to promote" (Sandelowski, 1993, p. 5). The participants will be looking for their own concrete reality in their stories while the researcher is likely to be trying to abstract their stories to connect the multiple realities of all the participants. Sandelowski (1993) suggests that "members may also simply not be in the best position to check the accuracy of the account" (p. 6). Members (participants) may simply forget what they said or how they said it, creating a dilemma for the researcher if other evidence contradicts the member's memory.

The researcher must decide what and when to member check and recognize that member checking may instigate change to the data (Sandelowski, 1993). Does the researcher show the participants the transcripts and notes creating their data, or wait until she has created their narrative, or even until after she has analyzed their narrative with respect to the stories of the other participants? Even then, do the participants care? Will they be comfortable disputing the researcher's interpretations? These are questions the researcher must consider.

Member checking also brings up the issue of who owns the data. Clandinin and Connelly (2000) suggest "reframing concerns of ownership in narrative inquiry into concerns of relational responsibility is a more useful way of thinking about this matter" (p. 177). Instead of worrying about who owns the data, researchers should be conscious of their responsibilities to protect not just the participant but others who might be affected by the participants' stories (Clandinin & Connelly, 2000).

My Quality Plan

Perhaps Bailey (1996) best summarized the quality process for narrative inquiry as "to simply make the research process visible, allowing systematic scrutiny" (p. 191) so that the researcher is not necessarily the "sole interpreter." That was my quality plan – to create an auditable and understandable trail from my raw data to my final interpretation. The reader is then a judge of whether my research is valid and trustworthy. To create and maintain this trail meant that I must document my process and save all my data to provide the reader with access to a continuous path from data to final interpretation. Ideally, this meant every scrap of data should be available to the reader. Recognizing that there was going to be a large quantity of data and that most readers were not going to want to look at every scrap of this data, I have included just representative examples of my data gathering and analysis process in the appendix. Any reader wanting to see more data can contact me personally through my permanent address.

As discussed, member checking is a sensitive issue in narrative analysis. I did believe that some amount of member checking was necessary. The question was "how much and at what stage of the analysis?" I did not have my participants member check their raw transcriptions. My rationale was that first, they will not remember what they said and want to change the content. Second, transcriptions can be upsetting when you are not used to seeing your spoken word in type since it is typically not as grammatically correct as if you had written those thoughts. I provided my participants with a copy of the summaries of their interviews for them to member check and discuss with me at the next interview.

I met with each participant, except for Bill who had moved out of state, to discuss the final narrative and hear their reactions as a final grand member check. I did not seek their approval of my final narrative analysis. I made this decision due to my concerns about the differing agendas for participant and researcher. Even though I did not review my analysis directly with the participants, I was always aware that they might read it. I recognized that my dissertation will be a publicly available document

and the participants will be free to read it once it is published. I also tried to focus upon interpreting their data, not passing judgment upon their behaviors. This was not easy.

SUMMARY

I used predominantly qualitative research methods for this study. I divided the study into two levels: broad but shallow and narrow but deep. The broad but shallow component of the study involved surveys of all the students in the class. The narrow but deep used narrative inquiry to develop the stories of four students and the instructor as they experienced this course. The broad but shallow data were intended to answer my second research question. The narrow but deep data were intended to answer all four research questions. Classroom observations were anticipated to help answer my first research question.

Chapter 4: Results from the Surveys

This chapter presents the results of the quantitative data gathering processes used in this study. Three surveys were given throughout the semester. About 90% of the students responded on these three surveys although response rates did vary. I believe the high response was due in part to my daily presence in the classroom. I was not strictly a fly on the wall, with a notebook. The professor included me in the class, sometimes asking me to share my experiences as a practicing engineer. I also did a workshop on team development one day when the professor was out. One problem I did encounter was some students not putting their student ID on their surveys even though I asked for only the last five digits. Without this information I was not able to compare their data.

SURVEY 1 – SCREENING SURVEY

Survey 1, the screening survey (see Appendix D), served two purposes. The first was to gather information in order to profile the students in the course to choose the four interview participants who exemplified different attitudes and characteristics. The responses to the survey also served to measure student attitudes at the beginning of the course. Most of the items on the first survey used a Likert scale from 1 to 5.

SURVEYS 2 AND 3 – PRETEST AND POSTTEST

Surveys 2 and 3 (see Appendix E and Appendix F) each began with an open-ended request asking the students to "Please write your understanding of what your professor expects/expected from you for this project." Both surveys also included some items on a Likert scale which were intended to be compared with responses on the first survey.

To analyze the data from the open-ended request on the second and third surveys, I sorted the content of the responses into thirteen descriptive categories as described below: (see Appendix J)

1. Make engineering decisions: Trusting your own judgment to make decisions when a turning point is reached.

2. Design/analyze engine: Doing the actual design and analysis of the engine.

3..Effort and initiative: Labor, exhibiting actions prerequisite to accomplishing other course goals.

4. Skill, understanding and knowledge gains: Skills, understanding, and knowledge gains for areas other than thermal-fluids content such as group work, project management and other professional skills.

5. Not about right answer: The professor stressed this often. It's not about the right answer but about the process.

6. Solving open-ended problems: Many students added "open-ended problem" to their vocabulary, closely related to (5).

7. Importance of process: Closely related to (5) and (6). I am seeking where students explicitly mention the role of process.

8. Real world applications: Looking for the term "real world"

9. Seek and use external resources: Students going to library and Internet.

10. Work with others: Seeking explicit mention of teams and group work.

11. Increase understanding of Thermal – Fluids: Seeking explicit mention of the prerequisite courses – thermodynamics, fluids and heat transfer.

12. Make connections: Making connections between concept and analysis questions or concepts taught. I looked for the word "connections" or strong implications of making connections, including connecting knowledge from prior courses

13. Dazed and confused: Students who mention lack of understanding what is wanted or otherwise indicate that they do/did not understand why they were being asked to do what they did.

I then reviewed the mid- and end-of-semester surveys, coding each one for the number of "hits" in each category. Since 35 students took the mid-semester survey and only 31 took the end-semester survey, I reduced the data to percentages of respondents. The results are presented in Table 1 below. The first two columns of data represent the percent of students who responded with a "hit" in that category. The final column

represents the change from the middle to the end of the semester in the percentage of students responding in that category. Negative values in the last column indicate a decrease while positive values indicate an increase in the percentage of students responding in that category.

Category	Mid-semester (% of respondents)	End-semester (% of respondents)	End-semester – Mid-semester (% of respondents)
1. Make engineering decisions	46	29	(-17)
2. Design/analyze engine	60	26	(-34)
3. Effort and initiative	20	29	9
4. Skill, understanding and knowledge gains	6	45	39
5. Not about right answer	14	32	18
6. Solving (open-ended) problems	40	45	5
7. Importance of process	14	26	12
8. Real world applications	29	32	3
9. Seek and use external resources	26	29	3
10. Work with others	20	23	3
11. Increase understanding of Thermal – Fluids	63	29	(-34)
12. Make connections	29	19	(-10)
13. Dazed and confused	34	13	(-21)

Table 1. Categorical results from open-ended question on Pretest and Posttest.

These data appear to indicate some changes in how students viewed the professor expectations. Looking at the last category, the percentage of students who did not know what was expected of them was down from mid-semester. Looking at categories 2 and 11 in Table 1, students at the end of the semester seemed to give less focus to learning the science content and more to focusing on improving their skills and recognizing that the course was not about the right answer but about the process, a message the professor continually stressed to them. Category 4 included references to

reports and demonstrating or communicating their understanding of the material. Since their final project was due the day after they completed this survey, they were probably very attuned to those expectations.

Professor vs. Student Responses About Expectations

For the pretest, the professor responded to the request "Please write your understanding of what your professor expects from you for this project:" with five expectations. In Table 2 below, the professor's five expectations are listed in the first column. The second and third columns present the percentage of students whose responses corresponded with each of these instructor expectations for the Pretest and Posttest, respectively.

Instructor's Expectations Pretest	Percent of students with corresponding response	
	Pretest (n = 35)	Posttest (n=34)
1. Think through the problem to the point of understanding what the problem "is."	51	47
2. Plan a logical approach to the problem (using background from prior courses plus assigned reading and class discussion).	66	76
3. Execute the plan (asking questions and gaining further background by reading, Internet, etc).	43	59
4. Present results of analysis and reflect on the meaning of the results.	23	0
5. Discuss what was learned.	3	0

Table 2: Comparison of student responses to professor's expectations on Pretest

For the posttest, given on the last day of class, the instructor recorded four expectations in response to the request "Please write your understanding of what your professor expected from you for this project". He was tired and told me he could add more if I wanted him to. I later asked him to add more. He added two more for a total of

six. These six expectations along with a comparison of the percentage of students with corresponding responses on the Posttest is given below in Table 3. Note that expectations 1 and 5 appear to be very similar.

Professor's Expectations Posttest	Percentage of students with corresponding response Posttest (n=34)
1.To borrow a thought from Kolari and Ranne, "encourage students to ask questions take an active role in finding answers…. to trust their capabilities to use their former knowledge and process it further."	24
2. To construct an understanding of the concepts discussed through application in a new (but related to past course work) area.	59
3. To find the library, identify resources, and find relevant information.	32
4. To better understand the process of modeling and parametric analysis. Learn to apply the procedure to the design of a thermal fluid system.	59
5. To build confidence in their ability to work through new problems… to work independently, identify creative (new) approaches to the problems they encounter (at the risk of using a "catch phrase," to empower them…)	21
6. To recognize and nourish their most important resource – their own mind.	3

Table 3. Comparison of student responses to professor's expectations on Posttest

In interpreting the data presented in these tables, the reader must recognize that the students were asked for open-ended responses. The students wrote what came to their minds at that moment in class, knowing that the sooner they finished their response, the sooner they could leave. While I am assuming their responses to be accurate and reflective of what they believed the professor wanted, their responses should not be interpreted as all inclusive. If I had been interviewing the students and perhaps prompting them with questions, or if they had composed these in groups with discussion, they might have produced more inclusive statements. I am, however, making the assumption that students wrote down those expectations that first came to

their minds and that those expectations that first came to their minds were those they considered most important. Based upon this interpretation, then the changes in number of hits indicate a change in those expectations the students consider most important.

When reviewing the student responses, I was frustrated reading responses that seemed dead-on to what the professor was saying in class but that had few "hits" with what the professor actually wrote for his responses. The opposite was also true. Students who I thought, based upon their written responses as well as classroom behaviors, demonstrated just a marginal understanding of the professor's expectations had multiple hits with the professor's written expectations.

The thirteen categories which emerged from sorting the open-ended responses from the survey, with the exception of "Dazed and Confused" better reflected the expectations the professor had expressed and stressed in class than his expectations listed in Table 3. Looking at his expectations in Table 3, the first expectation was based upon a quote from an article that he never mentioned in class. While he stressed "it's not about the right answer" in class, he did not mention the right answer here. He told me later that had he better understood what I was doing with the data that he would have written his expectations differently.

STATISTICAL COMPARISON

All three surveys had data that was recorded on a scale of 1 to 5 on a Likert scale. The intent was to statistically compare the results at different times in the semester to look for indicators of changes. The students were asked to put their student identification number, or at least last five digits, on each survey to allow for paired t-tests. Some students did not record their serial numbers for every survey which eliminated their responses from paired t-test analysis.

Some identical items, or similar items, were used on more than one survey. The corresponding variables produced by each survey (see Appendix I for a more detailed description of each variable) were compared through a paired t-test as shown in Table 4 below. Descriptive statistics for all variables gathered are available in Appendix K.

Variables compared	Description of Variables	Significance (2-tailed) ($p<0.05$)
pre2 & post2	Comfort with understanding of this assignment	0.001*
pre3 & post3	Attitude towards project	0.661
env1 – env2	Preference for creative vs. structured classroom environment.	0.004*
team1 & team2	Enjoyment of working on teams.	0.603
plans1 & plans2	Plans after graduation – technical or management	1.000
pref1 & tc2	Preference for project vs. lectures in classroom.	0.592

Table 4: Results of comparison of means via paired t-tests.

Two statistically significant differences were found. The first was between the responses on the first and third survey for the item:

I like a classroom environment that :

1 2 3 4 5

let's me be creative and do things my way

has lots of structure where I know what is expected of me

The class mean response for this item was 3.58 on the first survey and 3.28 on the last survey indicating a shift in preference towards a more creative and less structured classroom, although still weighted towards the more structured classroom. Lenschow (1998) described how some students come to prefer the freedom and creativity in project-based classrooms.

The second statistically significant difference was found between the variables pre2 and post2. Pre2 was on the second survey and post2 on the last survey. The wording was different to accommodate the timing of the survey relative to the project. Pre2 was in response to the item:

I feel:

1	**2**	**3**	**4**	**5**
very comfortable with my understanding of this assignment				very uncomfortable with my understanding of this assignment

Post2 was in response to the item:

Now that I have completed the project, I feel

1	**2**	**3**	**4**	**5**
very comfortable with my understanding of this assignment				very uncomfortable with my understanding of this assignment

The mean dropped from 3.05 at the middle of the semester to 2.70 at the end, indicating the students felt more comfort with their understanding of the project assignment by the end of the semester. Certainly these results would be expected. At the beginning of the project students were facing many unknowns. By the end of the project they had hopefully figured out these unknowns.

SUMMARY

The second and third surveys included an open-ended request for the student to define his or her understanding of the professor's expectations. These responses were categorized and compared to the professor's responses. Statistical analyses were conducted on the results from three surveys. Identical or very similar items were used on the surveys to allow for comparison. Only two statistically significant differences were found. First, the results indicated a shift in preference away from a structured classroom environment towards a more creative classroom environment, although the mean was still weighted towards the structured environment. The second significant difference indicated that students were more comfortable with their understanding of the assignment at the end of the semester than at the beginning.

Chapter 5: Presentation of Narratives

This chapter presents the qualitative results of this study, predominantly consisting of the student and instructor narratives. The bulk of this study consisted of interviews with five individuals – the instructor and four students. The instructor was interviewed weekly after the Thursday class. The four students were interviewed every two to four weeks. These interviews were summarized and member checked. The summaries were then used to create narratives for each participant. This chapter presents those narratives.

These narratives are just a brief glimpse into the five distinct personalities I interviewed for a semester. In creating the narratives I have tried to focus upon the immediate interests of the study, while still conveying the personality of the participant.

SETTING THE STAGE

Following the narrative results of this study, particularly the student and instructor narratives, requires an understanding of the structure and vocabulary of the course that was studied so I will begin with an overview. The course was composed of 36 junior and senior level mechanical engineering students. The classroom itself was not a sloped lecture hall but a traditional, level classroom with long tables. Students sat eight to a row with an aisle up the middle, four on each side. The classroom layout allowed the students to work together easily since they could turn around and talk with those students behind them. The room was crowded but this may have contributed to a more intimate classroom. A low level of competition seemed to have evolved between the students on the windows side of the classroom versus those on the door side of the classroom. The windows side was much louder. Evidence of this division was provided one day when a student on the windows side commented about the low attendance that day, “Look what side it is.” to which a student on the door side responded “It’s quality over quantity.” One student participant later explained that this division was because

many of the students who sat on the windows side worked together before class in the computer lab.

The class met twice a week on Tuesday and Thursday afternoons for an hour and fifteen minutes. On Thursdays they took a fifteen-minute break then returned for a forty five minute "lab." The intent of the lab was to allow them time to work with their groups. Attendance for the class was actually quite high. Some students had to miss a class or two for employment interviews, a few had chronic absenteeism problems, but overall most students had very few, if any, absences.

The instructor for the course section of this study, who will be referred to as Dr. Austin, used only one project for the course. The course was structured so that all assignments built up to this final project. The assignments were composed of concept questions, analysis questions, project problems and then the final project. The concept questions could be considered as deep discussion questions. The instructor told the students the second day of class, "seldom will you look up and be able to copy a three sentence answer out of a book." The concept questions frequently required the students to do research in the library, on the Internet, or in their textbooks from previous courses. The concept questions prepared the students for the analysis questions which often required calculations and even computer modeling. The students were free to use the computer modeling tool of their choice. The instructor used Excel as did some of the students. However, MATLAB was probably the most popular tool used.

Four project problems were assigned during the semester (See Appendix C). Each of these project problems was dependent upon the analysis questions. For instance, project problem two, or P2, depended upon a correctly functioning model for analysis question 8, or A8. Project problem three, or P3, depended upon a correctly functioning model for A13. Project problem four required both A8 and A13. Only the first project problem, P1, was turned in individually. The remainder of the project problems as well as the final project were turned in by the class-assigned teams.

For some students this was the first project-based course they had encountered. However, while this course was intended to be a junior level course, over half the class were seniors who were also taking one of the two capstone design courses, also strongly

project-based. The students frequently referred to these courses as J and K. Coincidently, Dr. Austin was also teaching all sections of J that same semester.

The pedagogy for the course was student-centered, not teacher-centered. The instructor included a lengthy passage in his first-day syllabus (see Appendix A) describing student–centered learning. While the terminology was new to many students, they did seem to adopt it into their vocabulary. Some embraced the approach of students defining the course content of the day by their questions. The instructor even expressed frustration to me one day when the students had so many questions, he couldn't cover what he wanted to cover.

INSTRUCTOR'S NARRATIVE

The instructor's narrative tells his story through the course, including his expectations of the students and how he tried to convey these expectations. His narrative begins by describing his pedagogical beliefs because these are the foundation for his expectations. The narrative then discusses his expectations of the students, how he tried to convey his expectations through pivotal events in the course, and finally how his expectations of the students changed through the semester.

Underlying pedagogical beliefs

The instructor has been involved in this course since the idea of such a course was first proposed. He has been interested in finding and trying new practices in his classroom and was open to suggestions. The instructor taught the course using an open-ended, student-centered, project-based pedagogy rather than the more traditional teacher-based lecture format. He believed that this format resulted in his expectations of the students being closer to those the students would encounter in the real world.

> The reason I keep trying to do it that way is because I think it's realistic. The other part of it is that I really came alive as far as engineering was concerned when I started having to really deal with things, when it wasn't just book learning.

He described his experiences as an intern while in college where he was told

> ‘We need to work this out. Do it.’ And I thought ‘Gee, what am I going to do?’ and got into the habit of looking for things and trying to figure things out and work through it and so forth and I thought ‘Hey, I really like this.

The instructor felt a shared responsibility for what the students did in the course.

> If they’re not doing what I expect them to do then it’s not all their fault, nor is it all mine. I just don’t think the blame game serves any purpose. All I want to do is make it better. I want to encourage them to work harder or do better or plan better, whatever it takes. I don’t know.

The instructor looked at his role as more to prepare the students to go out into the world than just teaching content.

> Students expect that they will be able to go out of here and lean on somebody else, learn from somebody else and it isn’t that way….I really find that very frustrating. The whole point of their education is that they go out of here capable of doing some things on their own without having to be told what to do, how to do it, when to do it. And then expect to be paid for it. Besides it’s no fun. I’m serious. Can you imagine working a job that was brainless?

The instructor wanted the students to build confidence and trust in themselves and their abilities. The instructor reflected on an incident in class when one student said that he understood the need to go somewhere and look but didn’t know where?

> Yeah, he really sort of set me back on my heels. That’s a question that deserves an answer. That’s when I did respond and say that you’ve got to draw from within yourself. That’s really the point that you need to find a way to make students realize that this isn’t fun and games, this isn’t spending time, this is serious preparation….The notion that everything has got to be worked out, that there can’t be any surprises, that I always have to, as a faculty member in the classroom, have the answer, to me that’s just all nonsense. It isn’t accomplishing anything. It isn’t a game of ‘I know something that you don’t know.’ Really, what I meant by that is the point of education is to prepare you to do useful things with your life. And when you get out of here and you cannot draw on that education to do something useful with your life, you have just proceeded to waste a tremendous amount of time and a tremendous amount of money and no it isn’t all your money or your parents’ money.

He believed students were used to not being allowed outside of the box in their previous academic experiences but he was trying to get them out of the box.

> I think that that is probably the single largest barrier for doing what I want to do. It is just their conditioning, or the extent of their conditioning, to have to get the right answer and have to do it in a particular way. Isn't that just absolutely the opposite of what you want in the real world?

The students' previous experiences were affecting how they thought or what they expected now.

> What goes on in their minds is what we've trained to go on in their minds. That's the problem. And we have found, starting with grade school, the kids get in trouble on long projects so what is our solution to that? Instead of teaching them how to handle long projects, we give them little bitty separate things so that if they get behind, they can always start over again on the next topic or the next subject. There's no penalty for not doing their work. Not learning it….they think everything is neat and that I'm going to give them precisely everything they need in the problem statement to do the problem. I just don't buy that. I just can't bring myself to think spoon feeding has anything to do with education.

But if students left his class prepared for the future then he felt it was worth his effort.

> If they really will get out of the class what I want them to get out of the class in terms of increased confidence and capability, in terms of gathering information and putting it together and learning to make some judgments, build a real sense of how you go about understanding something, if they're getting that out of the class then it's worth all the effort. If they're not then, I just get sort of second thoughts in a sense because it is a lot of work and if some of them are just getting through being bored and living off somebody else then I'm not too happy about that…. I'd like to have them prepared. In the end that's what you really want, is for them to be prepared.

The instructor frequently did not have problems fully worked out ahead of the due date. He felt that this kept him from telling the students the final answers because he really didn't know the answers to tell.

> I became aware several years ago that if I had every one of these problems down so that I'd just bang, bang, bang, bang, students would come in and ask me and I'd end up essentially laying the whole problem out for them. I never would do it in class but if they'd come in the office I'd sit down, mostly just to get the point across to them and get them on their way. I'd do that. I don't think that's right….I just decided sometimes it's good not to have the answer… I really think there's more to be learned from struggling through some of these things, with some false starts instead of all of this slick packaged stuff.

Part of his avoidance of working out problems ahead of time was due to his emphasis on process.

> Some of my students accuse me of being rather lax about finishing things. Getting it down and particularly about coming to a number at the end. I don't know how to deal with that because I'm not interested in a number at the end. I'm interested in the process of setting the problem up. When it gets to the point of getting the answer, I've completely lost interest.

He enjoyed an active classroom. Part of his pedagogical beliefs for the classroom were that the students would define the content to be covered through their questions.

> Heavens, we're going to have them all talking and then what will we do (laughs)….I get excited when they're tuning in. …But the real point of all of this is to get them involved in thinking about a problem and asking questions about it as opposed to focusing on this fact and that fact and the other fact.

He was happy with his rapport with this class.

> I have never had a class this large that I've had this kind of rapport with. I have had in smaller classes. The class I had two or three summers ago, may have been three summers ago, had a group of students in that I really got to know well. And it was so much fun.

But he also expressed concerns about the students who did not seem to be involved with the class. "I'm definitely more encouraged as time goes by. I don't want to see any of the students drop out." By drop out he meant mentally, not physically. He expressed concern about those students who seemed to be dropping out or not engaged

and seemed to feel responsibility for keeping them engaged. “There’s one or two people in there I’ve got to find some way to talk to. Try to get them moving a little more.”

The instructor felt it was important to learn and use his students’ names to help facilitate an open and respectful classroom environment. However, while he worked hard with the assistance of a seating chart with pictures to learn all his students’ names early in the semester, he did not use their names in grading. “I wouldn’t do it any other way than get to know them. But there’s a cost associated with it. There’s a price you pay for it.” He had the students put their student ID’s, not names, on their assignments and used these while grading.

> I didn’t really believe that was necessary until I started doing it and discovered I should have been doing that for a long time. … I very seriously was trying to be evenhanded about things but one reason, when the subject about using their student ID’s came up, that I switched so quickly, was that I began to worry about it. I’d sit there and say ‘Look at this student’s results. They know better than that. They really understand this stuff’ and it would sort of creep into the grade. Having said that, maybe I was right. Maybe my tempering my response in a particular situation like an exam was the smart thing to do. But then again, maybe it was biased…It’s funny, all of my life in teaching, when they had student names on the papers, I didn’t go back and intentionally look at the names but when I don’t know whose paper I’m grading, it really does make a difference. Maybe not a big difference but when I go back through and I see the grade for a particular person and I see who it is then I’m really surprised. It isn’t always that this person didn’t do as well as I expected but sometimes this person did a whole lot better than I expected.

The instructor had many conflicts relative to grades, particularly when grades stood in the way of learning. He saw grades as incidental.

> Of course, since we’ve used that as the whip to drive them for so long, we’d have a hard time convincing them that it was incidental. But that has absolutely nothing to do with the objectives of education, the grade. It’s just the particular method we’ve used to try to motivate them to do something and I think it has been stretched and distorted to the point that it’s essentially useless. The grade and grading drives everything.

He hated giving grades but included components in his course to support grading such as the quizzes. One thing that really concerned him as the course progressed was his students' preoccupation with grades.

> One of the students who was in here a few minutes ago was complaining about his grade relative to other peoples' grades which worries me a little bit in and of itself. If he was concerned about his grade that was fine but in relationship to somebody else's, that kind of bothers me. (sigh) I don't like the comparison but they have some responsibility I think in not making it easy for other students simply to copy their work and turn it in. If they are concerned about that happening, about somebody essentially living off them or feeding off them, they need to exercise a little discipline and say 'Hey look, I'm happy to work together but no, I'm not going to give you this.'…I think that some people are pretty good at intimidating or playing on the emotional concerns of other people to get information out of them… I'm very much committed to having students work on a team basis. I think it's absolutely essential but the combination of the societal or institutional emphasis on GPA and teams creates a real problem. The idea that someone who is working on a team, who actually is making a real effort to bring their teammates along, in their efforts to do that, might be jeopardizing their own position so to speak. I mean that's just terrible…. How are we going to promote project-based teamwork that really has the potential for meaningfully improving education and learning and retention and all the rest of these things, humanity amongst them?
>
> One of his concerns was how to provide students with access to his solutions.
>
> I want them to read, and I've said this in class too, my answers to the concept questions, to look at the solutions I've come up with for the analysis questions but then I worry about them not doing anything but that, instead of answering questions that they've generated, 'I'll wait until he hands this stuff out.'

While he has a locked glass case outside his office for displaying solutions, he is hesitant to post solutions there because students would come and "slavishly" copy every word and term. He did, however, post some of his solutions online in Prometheus where students could download and print them.

The instructor was not strict about deadlines for assignments. He acknowledged that some students felt he should be more forceful about the due dates but he did not see his role as one of parent. His flexibility with deadlines was based upon a desire to allow the students a chance to learn but not a chance to procrastinate.

> If I initially gave them, now here I'm being judgmental, if I initially gave them as much time as I'm willing to give them on these things, they would spend all their time on something else and still not get it done. So some of the time I set up deadlines and if I find that people really are making an effort and are not getting where they need to go with it then I'll give them additional time. If on the other hand, it becomes very clear that they're just not trying then I'm going to enforce the deadlines. … I want to see them learn the material and if I've got to give them a little more time to do that, that's fine, but I'm not going to give them more time for procrastinating, so that they can spend a few more hours at the bar or football or someplace else.

The instructor described the vision he had for his classroom

> I have a very clear, in my own mind at least, vision of what I would like to see happen in the classroom… to have the students come in and be inquisitive and be willing to take some risks and to really pursue the knowledge rather than being little cups sitting there waiting to be filled so that they can pour it out on the test, so that they can walk away empty and ready for the next class. But I really want them to demonstrate some initiative, some curiosity, some involvement, some desire to learn and understand things, not just answer questions. Are some of the questions not good questions? I'd love to have students – and they do occasionally and I appreciate it – they come back and say 'gee this isn't clear.' 'I don't think this is a good question' even would be fine. If students aren't willing to challenge things, they're never going to learn. So I really want the students to be in charge. I want them to be involved. I want them to be seeking knowledge.

Recognizing that students may have it ingrained in them not to challenge faculty, he keeps trying to invite the challenge.

> The way I respond to someone who does challenge me is, I hope, always positive. I try very hard not to put them down, not to be belligerent or argumentative about it. I try to discuss the issue as I did the other day. I'm quite willing to say 'fine, you have a different point of view. You're welcome.'

Instructor expectations

At the very beginning of the semester, the instructor defined five expectations he had of the students:

- Pay attention in class

- Be willing to participate
- Be willing to try new things, even if you don't think you need to
- Be willing to argue with the instructor about content or procedure, but not simply from the point of view of what is fair or what the instructor can or cannot do
- Don't try to agree with or flatter the instructor to manipulate or influence him.

He also asked them to keep notes, questions, and ideas in a non-spiral bound journal and organize and maintain a 3-ring homework binder. Both of these could be used during quizzes and would be turned in at the end of the semester.

He was concerned about the students' overall attitude. Prior to the first day of class he wondered what would happen if he walked into the classroom and told them that half their grade was

> going to be based on your attitude, on your willingness to do things, on your willingness to accept the challenge and do something creative. It's not going to be on how you perform on a given day on an objective examination. I can imagine what some of the response is going to be. 'Well that's not fair' Wait a minute. What's not fair about it?…Well, to me, attitude is extremely apparent. I mean you have to be deaf, dumb and blind not to see this. I cannot imagine why we have gone so long in education without putting in it, any emphasis on attitude. I've been sold on the idea all these years that it isn't fair to judge on the basis of attitude. What's not fair?

While he stressed what was a good attitude and a bad attitude the first day of class, he did not state it would be half the grade.

The instructor felt that effort was more important than the right answer but

> my presumption is sensible effort will at least get you in the ballpark on the right answer. I think if someone is really putting in an honest effort into it, on the fine scale, they can miss the answer, but on a grosser scale, they'll have it.

He described the importance of the right answer in most engineering classes as being a ten but he would put the right answer without demonstration of understanding "in the range of a six." While he described effort as about a seven in most classes, he would put

effort as a ten, "the right answer and no effort is not passing as far as I'm concerned." But not all effort was equal.

> If people put a tremendous amount of effort into something and if you sit down and look at it and say 'that can't be right, I mean it just doesn't make any sense at all' then I don't value that kind of effort very highly. If they say 'I worked really hard. This makes no sense.' I am particularly concerned in these areas. The 'I worked really hard' doesn't get them a full reward by any means.

However, he agreed that if they had provided supporting discussion that demonstrated they worked hard,

> That definitely will get them a passing grade. If they then add some insight into where the problem is or very specifically why they don't feel like it makes sense, then that'll get them a whole lot better than a passing grade.

In early October the instructor was reflecting about what trade-offs he was willing to make between learning and covering material.

> In the end I have accepted fairly mediocre results sometimes in the process of trying to get through everything. I personally feel that the majority of the students learn from the effort even though they didn't exactly get it right in the end. They learned something from the process. But, I'm wondering if I shouldn't reevaluate that in the sense of saying that I do in the end want a finished product so that they have some sense of closure with it. I really don't know what to think about that. Whether it's necessary. Whether it's not.

He was concerned early on with students making the connection between the concept questions, the analysis questions, the project analysis problems and the project. His intent was that

> the first project problem is essentially chapter one of the project. The second is chapter two. So that's the intent there. And what's left at the end, in terms of getting the project report, is not writing some big, long difficult report. It's writing the transitions and doing the revisions that are necessary. …By the time they get through that last one, there's going to be some stuff to look back on, one in particular, and say 'Noooo. We've got to change that, we've got to fix that.' But that's part of what I'm trying to get them to do is to get them to go back and correct on the basis of their more mature understanding of a process,

> go back and correct what they did initially…. It's prodding them to get into new knowledge areas but trying to get them to do that from looking at what they know already and then move forward.

While he acknowledged that some students who were lost at the beginning of the semester but figured expectations out somewhere during the semester and then enjoyed the course, his concerns are for those "that never make that connection."

He described his expectations of the students as always challenged by

> trying to be sensitive to the student needs as well as my objectives. Trying to balance them. That's what it really comes down to. I cannot do exactly what the students want me to do because what they want me to do is tell them precisely how to do what I have asked them to and that doesn't teach them anything. I mean, it may demonstrate that I know how to do it but it doesn't help them learn how to do it themselves and I'm not interested in what I know in the context of the classroom. I'm very interested and committed to learning and involvement and so forth as you know anyway for myself but in the classroom I'm interested in how can I help them learn. How can I help them understand the process of solving open-ended problems? How can I help them gain the confidence that they can *do* that so they know they *don't* have to be told? That they can be independent and be successful…. I realize that's very idealistic but I don't care. That is what I would like to see done. And if it's idealistic, too bad. If you don't have goals and things to work for, you're never going to get there, right?

Conveying expectations

The instructor conveyed his expectations to the students through text, through what he said in class, and through modeling behaviors in class, something he did very consciously. For instance, he would look up information in a book, starting with the index, to try to show the students how they too could find things in a book.

> Students frequently do not understand that even experts have lots of false starts… If you're traveling a new road, you're not going to know precisely what to do but to be able to catch yourself, and back up, and change it. That's what it's all about.

At the beginning of the course, the instructor posted his problem-solving methodology for the students to download. He also reviewed part of his methodology at the end of the second class. He explained why he promotes his methodology.

> If you have a very open, general process, or procedure, for looking at these things and if you're stuck then you can at least ask yourself those four or five questions and in the process of getting that down, you can say 'Okay, what can I remember about this one in particular? What are my choices on systems – open cycle or closed cycle? … And in what way does any one of these things fit the type of problem that I'm dealing with or if I can't answer that question, what information do I need about the system or what kinds of assumptions or estimates can I make?' That at least gives me a start working through it.

He recognized that his methodology did not match the work habits of those students who just want to get their homework done and move on. "They want to walk up to a piece of paper, throw down a bunch of equations and have an answer." In previous semesters, he had emphasized his methodology early in the course but didn't this semester. This semester he jumped into the questions supporting the project. He later had concerns that not spending more time on the methodology was a mistake on his part.

He had concerns during the semester about posting solutions to problems A8 and P1.

> Handing out the P1 and A8, I considered doing that earlier but I thought I don't want to get into a situation where the procrastinators can wait until I hand something out then sort of reproduce it and put it in so, I worried a little bit about whether I left it open enough that they would expect now that I've handed out my solution to come back with a great and glorious revision and have me count it as if it were the on-time version. I can't do that. I think what I may have to do is anything that I get out of that set of things is to put a time stamp on it. I wouldn't really mind so much if someone had turned something in and it was incomplete or not correct and then have them go back and correct their work on the basis of mine. Somehow that seems fine. If they put some initial effort into it. On the other hand, if their first pass through the thing is copying my stuff, I don't like that.

The instructor used the first quiz to stress his expectations for this course. The quiz consisted of two questions, both related to the intent of the course:

a) What are the two primary objectives of this course?

b) Why have we adopted a different pedagogical style in this course?

Both of these questions had been addressed on the course syllabus and orally in class. The instructor planned to give high marks on the quiz.

> I think on this quiz, I'm going to give high marks to everybody…This is the point at which a good attitude, going along with me, is going to get you a good grade, and so I'm not going to ding anybody in particular.

He hoped they were getting the message about the purpose of the class – to teach a process not just content.

> Well, I think they all figure I'm crazy anyway so what else is new?….Well, I'm really very anxious to, as best I can, to find out if this works. You know what surprises me is that I have, since I started doing some of these things and looking for the different ways of doing a different focus on things, particularly more from the design or the engineering practice point of view than just the high content, I keep seeing other people other places -- that I had absolutely zero prior knowledge of -- are doing the same thing. So I'm wondering is it something that's contagious, is it in the air, how is it getting around because there seems to be a lot of movement in that direction.

Project Problem One, or P1, was the first assignment that the instructor himself graded since the TA graded the concept and analysis questions. He had moved the due date out from a Tuesday to a Thursday but two students had turned in their assignments on the original Tuesday. He was disappointed with what they submitted and felt that perhaps these students were too, noting that one of these students does not usually respond in such a "meager" way. He was thinking of suggesting to these students that they spend some more time on P1.

> If they want to go back and fix that, that's fine. I'm much more interested in having them have the experience of doing the job than I am in assigning grades in that sense. What I'll happily grade people down for is not doing the work, not putting the effort in. On the other hand, if it's a matter of the timing and they aren't consistently and always late, I'll try to find some way out of it. I'll give them a break.

The instructor waited several weeks to grade Project Problem One (P1). "I glanced through some of them and I was not very excited about what I saw so that's one

of the things I posted (on Prometheus) for them." He had concerns about how they would react to the solution he posted because

> It's a lot more than they did. It's a lot more than they're going to think needs to be done. I don't know, maybe I need to give them examples like this day one but we've got, again, to go through the litany, we've got concept questions, we've got analysis problems and we've got project problems. What I expect to see in the project problems is something that is essentially transportable into the project report. You do remember me telling them that don't you? I'm not just imagining that I've told them that. I know I've mentioned it several times.

For his solution to Project Problem One, he took "stuff out of some of my answers for the concept questions and used that as the introduction for the project problem" and then combined responses for both concept and analysis questions. He described P1 as having more background than analysis. "What I was looking for them to do was to make the connections between the concept questions and the project problem." He noted that "Project two is going to be different. There's a lot of analysis." He was concerned that the students were not making the transitions between the concept questions, analysis questions and project problems. "I had a student in here complaining the other day because he says 'everything is hooked together. If you don't do it or you get behind, you're really in trouble.' And I said 'duh.'"

He was disappointed with the results of P1. The class average was six out of ten due to a lack of comments. The instructor felt

> they just gave me stuff and no explanation, no insight, no understanding. I really felt like I had made that point beforehand. The problem is they don't believe it. I think we've gone through this before.

He described how one student had

> reacted without thought using some very bad language when I talked about the Project Problem One being the first section of their report. It was enough to upset him so he must have heard … If it elicited that kind of knee jerk response and horror, it must have meant something to them.

As Project Problem 2 began to trickle in, he was pleased with one team's results that were "right on the money." The first grades ranged from a four to a ten. Again, for

P2, many teams submitted lots of numbers without organization or comment." He expected more comment on P3 and "a bunch" for the final project. He admitted he had not stressed comments as hard in previous sections of the course.

> I haven't pushed as hard as I should have in previous classes to get the comments. I've had the same objective but sort of, to some extent, taken the attitude that I'm not going to get it so live with it. I don't want to do that anymore. I really think this is important and I'm going to have to push it.

One day in early October he spent two hours, the entire Thursday class, having students come to the board working through parts of Analysis Problem 8, A8. Regarding the frustrations and questions about A8 that the students had brought to the classroom, he was "very pleased that the students were open and honest about what their concerns were" but "very disappointed that they didn't feel they had anything to draw on to answer their own questions. I felt that their level of confusion was a lot higher than it should have been." The instructor described A8 as.

> not a hard problem unless you just sit there and look at it and don't try. I think they felt overpowered by it. They shouldn't. You know, I keep coming up with these old aphorisms for how to eat an elephant. One bite at a time. You've just got to start. … the problem many people have is they just won't try. They feel like if they don't know the answer, they don't do anything. And that's such a shame because all of them are capable. There's nobody in that class that couldn't do that problem. And I feel that way with anything I assign to them. I am sure that they can handle it. The real problem is they're not sure.

After that class, some students hung around to talk to him. He reflected back on their conversation.

> I said that I really appreciated the students getting up to make a presentation because the questions were more of a challenge 'Well, why'd you do this' or 'What was that?' I said 'Why won't you do that with me?' And they said, 'well, because you give us grades' was the immediate response.

But he believed "You have to have a challenging problem. If it's too simple, all you have to do is pick the equation and put in the numbers and turn the crank." Repetition requiring students to work multiple problems is not necessarily a good way

to learn. Students need challenges and time to think about and evaluate what they're doing. "It seems so totally backwards to have them just redo the same problem over and over."

Changing expectations

He had very high hopes for this class early on based upon their enthusiasm and participation. He had originally planned to manage the course more tightly and leave less to student initiative but his early impressions of the class made him optimistic that this might not be necessary.

> Well, if my impression of the class today works out to be somewhat correct, I may be able to back off a little bit … about having to manage them more tightly. I really did feel like there were some pretty good vibes coming back from the class…I think there are enough self-starters in there that we'll be able to get the group going.

The researcher noticed that the students on the windows side of the room were much more vocal than the students on the door side. Overall, the instructor was pleased and comfortable with the classroom environment.

> I want them to be relaxed. I really do. … I've said this number of times. If a student fails at something but it's a safe enough environment for them and they just come back and pick up the pieces and put it together and get it straight, I think that's a marvelous learning experience…. You're much more likely to retain what didn't work than what did.

Early in the semester, the instructor's expectations for the students increased because he was

> having fun with them and they seem to be responding to that and they really are asking some good questions. And they seem to be quite willing to go back and pick up on things from a previous discussion that haven't been completely worked out which I think is a very positive thing.

It's when they didn't respond that he was "miserable." But some days the students responded so well in class that he worried about covering the necessary content

because the students had so many questions for him in class he could not always cover what he intended to cover. Unfortunately both his and their enthusiasm seemed to fade with the semester. By the middle of October, he described his earlier high expectations as "eroded." He didn't want to give up on them. "Every once in awhile it (hope) sort of surfaces."

As his expectations "eroded," he still refused to give up on the students. Towards the end of the semester, as the workload increased, he told them they did not have to do the last analysis questions.

> I don't know if that's a matter of really changing the expectation. From their point of view it definitely is because if I hadn't kept some pressure to try to get through more of this stuff then we wouldn't get as far as we've gotten. And I found myself doing this a number of times. When it really gets down to a real crunch and we're not making it then I'll back up but I feel like I want to keep them moving, kind of apply as much pressure as they will bear, without having them give up altogether. Is that inappropriate or is it reasonable? … I think the thing that is most important is my being forced to stop and think about 'okay, it's not really that hard for you to make your point. … Actually, the process I've been trying to get them to go through this semester is 'what you do about it?' but they, at least some of them, have not recognized it.

After the semester was over, he felt that at least fifty percent of his original expectations had been met.

> Maybe in retrospect I'll get it somewhere between seventy and seventy five but it's not going to get over that. I'm feeling rather glum about that. …it really seemed like we built up a good head of steam and then when it actually got down to them doing something, we just collectively seemed to flounder. And I don't like that. And yet, on the other hand, the one way that I'm sure I could have prevented that happening was to have been willing to and prepared to, to be honest about it, prepared to give them very specific answers to very specific questions and guidance. That doesn't meet my original criteria … that's important to me. To get them to trust their capabilities from their experiences in other courses or wherever that they can build solutions…. it's a matter of saying 'Okay, I have a unique problem or a unique situation, something I'm unfamiliar with. How can I apply these tools, if you will, to sort out the pieces so I can understand what's going on well enough to model it or to design using that information or make happen what I want to happen out of this thing. And I think that's a pretty ambitious goal but it's still the one I'd like to be able to get

> students to respond to. That's the bar I'd like them to get over so they'd just simply sit down and say 'Okay. I don't know what the answer is, but I have confidence and I have the basic understanding that will get me from not knowing what the answer is to the point I can have at least a pretty darn good idea if the answer I've got is any good or not.' Is that ridiculous?

The instructor made several changes to the course in the following semester. First, he had a book. He worked with the publisher to extract and bind pertinent chapters from two textbooks he had used, mainly as references in the library, into one volume. While the cost of this special volume was higher than he initially understood it would be, it was still less than buying even one of the complete books. He was also trying to reduce the time commitment students needed to make to the course. The instructor described how the students had rated the workload high on the departmental course-instructor evaluation at the end of the course of this study. "Student rating of course workload, zero for insufficient, zero for light, two for average, I thought that was interesting, twelve for high and sixteen for excessive." While this did not surprise him, what did concern him was seeing some of his best students burn out.

> Well another thing that I was dissatisfied with about the course and why I'm focusing on the workload is that some of the really good students at the end of the semester, they just worked themselves out. They said 'We spent all the time on this we can. This has to go.' So it didn't come to a conclusion…. And I don't want to do that. Again, I have no hesitance whatsoever to put them into a situation where they don't get perfection out of it. That it doesn't come to a clear, concise 'ah, that is the right answer, you get a gold star.' because the world isn't like that so I don't mind that. But it's all a matter of balance. … I'm trying to push it as far as I can towards the really good outcome without expecting too much and having it flop back over on the thing if you see what I mean. I really do want to push them. I want to challenge them. I want them to have to depend on themselves to make decisions and come to conclusions." He also tightened up the deadlines, particularly for the concept questions, because of grading confusion suffered by the TA. "I've said the rule is that the concept questions have to come in every day and I may give them a little bit of slack on some of the others.

This is the instructor's last year of teaching before he retires. He has mixed feelings about retirement. He enjoys teaching.

> I'm very much of two minds. I'm anxious to retire but I'm not at all anxious to retire…the opportunity to teach students and maybe influence their lives in some way for the better is something I just can't bear the thought of walking away from." He has not decided what he will do after retirement except for moving to another state closer to family. "I expect to be teaching still and I really, really want to find a way to make a difference for engineering faculty, with engineering faculty and how they approach teaching our students because this preoccupation with research and content I think is selling us way, way short. And I see a lot of older faculty go through this same transition.

STUDENT NARRATIVES

The four students were interviewed throughout the course. They are identified by pseudonyms chosen by each student - Barbie, Bill, Mary and Sami. Each narrative begins with an opportunity to get to know the student followed by an accounting of their experiences, including pivotal events, during the course. The last part of each narrative describes the students' perceptions of the instructor's expectations of them and how they changed during the semester. The students' own words are used as much as possible in an attempt to give them their voice.

Barbie's Narrative

Barbie was a very fun person to interview. We laughed and ventured off into many other topics. We could spend hours talking, and did. I think we had two interviews lasting over two hours although much was off the topic. Whether it was from maturity, work experience, time spent talking in the instructor's office, or personality, Barbie did seem to grasp the instructor's expectations very well and seemed to embrace them.

Getting to know Barbie

Barbie was a 28 year old wife, mother, and full-time mechanical engineering student with a ready giggle. Born in Colombia, she came to the United States and lived with her grandparents when she was in high school. She married at seventeen. After high school she worked as a receptionist and then began college at twenty-four. She

originally wanted to go to medical school so her first major was biochemistry. After her GPA dropped below 3.5 she changed to mechanical engineering.

Barbie entered this class with substantial work experience through five engineering internships. She had worked as a research assistant for a professor, worked three semesters as an intern for one company, and one semester at another company. The one semester she worked at the latter company led to a very enticing job offer which she accepted towards the end of the semester.

Barbie's story was one of continual juggling, of trying to balance her personal and academic lives. Fortunately her husband was a recent engineering graduate and was supportive of the time demands of her academic schedule. But her two year old daughter was not as flexible and Barbie obviously wanted to spend time with her too. Time was of special importance to her because she had so little. She expressed continual frustration that her classmates, most of whom were single and full-time students, had so much time for their coursework that they did not always practice effective time management. She also felt that she needed more time than most people to learn, that her learning style was slower, that she had to read things a second time while many students jumped in without reading the material a first time.

Barbie was not confident in her academic abilities. She admitted to anxieties about tests and grades. She attributed part of this to her early academic experiences as a premed student when she needed a 3.5 or better to be accepted into med school.

> I was so into it, into school, that every time I would get a B I would cry because I'm getting a B, I'm not going to go to medical school…. I'd work so hard. I'd study it and study it and I still couldn't get A's. That really frustrated me I guess. That's why I dropped premed because my GPA wasn't a 3.5 anymore. It just kept going down every semester. Sometimes I'd go into a test and I know this stuff but I just don't do well. After I'd see the test graded I'm like 'I know this stuff.' I just get nervous … my GPA right now is 3.1 and I'm trying so hard to keep it from not going below 3.0 because it's going to be shameful to me.

While pressure on tests negatively affected her performance, she felt she was actually more productive when under pressure at work. She found work to be easy. Projects were also easy to her because you didn't spend a lot of time "stuck." With

projects she just did what she thought needed to be done. She found that the tasks she performed as part of working on engineering projects came more naturally than reading books and solving problems.

At the beginning of the class, Barbie did not work much with others except on the occasions when she ran into other classmates working on campus. She gave several reasons she didn't typically work with others. The first was that she didn't know many students in her class. She had spent a year away at another campus when her husband was transferred. She was just a part-time student then, taking care of her baby daughter. When she returned to UT, her former classmates had moved on and she had fallen back with a different group of students who started the program after she did. Juggling her personal life, especially since she did not live near campus at the beginning of the semester, was also an inhibitor to working with others. She did not have the same flexibility with her time. Another reason she liked to work alone was due to her work habits. She described herself as working at a slower pace. She liked to read the book while she found that most people didn't like to read the book.

> I like to read the book, first find out what's going on, then try to do it, go to the professor and then try to do it on my own. That's the way I usually work my problems. Other students, they prefer to just hit on it, get right on it and start working and then kind of reference the book a little bit.

She also found it stressful to work with someone else who knew the subject matter really well.

Course experiences

Barbie did Project Problem One (P1) by herself using Excel. Many of her classmates used MATLAB but she did not know MATLAB. The instructor also used Excel for all his work. She turned P1 in the first day it was due "because I really wanted to turn it in." She said the instructor told her that her grade of seven out of ten was due to not having it in the report format he wanted. She didn't know at the time that he wanted it like his problem-solving methodology. "When he started talking about it, it was the same day I was going to turn it in and I just wrote things to say." Later in the

course she felt she now knew what he wanted and was planning to resubmit it. “I want to polish it, make it look nicer and resubmit it and I’m sure he’ll take it.”

Barbie worked on A8 alone in Excel as well. She got her curves “okay.” But at that point she was starting to fall behind. She explained that she had her graph right working in Excel the first time working alone while some of her teammates had trouble getting their graph (A8) while working with others using MATLAB. But while she described herself as working alone, she had help from both the TA and the instructor.

> I was lucky because (the TA) was in the computer lab that morning when I was working on the A8 problem and I saw him and I went ‘okay, I’m going to attack him’ and I said ‘(the TA), help me. What am I doing wrong? Why is this graph not looking right?’ …So (the TA) looked at it and he said ‘Oh, you got this wrong’ so I fixed it. And he said, ‘You got this wrong’ so I went and fixed it right away so I got the right graph after that but thanks that he was there.

Project Problem Two (P2) was a team project but Barbie said she was not able to contact her teammates about it because many people were out of town for a big football game. About that time her daughter became ill and Barbie missed four days of class. Barbie felt pressure to catch up in order to be able to contribute to her team. She did not feel that she contributed as much as she should have for P2 which they handed in as a group. While she had heard from a teammate that the instructor really liked their P2, she felt

> I can’t take any credit for any of that. I was just lucky to be in a good group. I felt that my contributions were minimal, mainly because I wasn’t prepared….They only meet when everything’s done and they bring everything together. Last time I wasn’t prepared. I’m going to change the way I handle this for the next project. I’m going to get prepared for that meeting. I just went thinking that we were going to solve it together. That’s what I thought. I had not even read books or nothing. I just went and said ‘okay, we’re going to try to solve this together.’ Most of it was done already.

But the peer pressure being on the team was beneficial, driving her to work harder.

> I told Dr. Austin I like it because it makes me feel bad with myself it I'm not prepared and it makes me 'gosh, I have to think, learn, learn, learn.' I have to know this and makes me want to consult more with him and it's good in that sense.

Still, she was not confident about her understanding of the material. She didn't feel that she understood the material to the same depth as some of her teammates who

> went very deep into it and they drew graphs of this versus that to get to there…I'm very glad in the way that I learned but there's a big difference as far as how we think. I feel like I'm at a lower standard than them because I don't have much time to study.

The team she was assigned to for this course both added to her frustrations yet helped her learn. Her team of five included three very academically strong students. Two of these students put a significant amount of time into this course, especially at the beginning of the course. Adding to her frustrations, one of these students was married and a father but still spent much more time on campus than she felt she was able to do. She wanted to contribute her share to the team but often indicated she felt she wasn't contributing her share due to a lack of knowledge, lack of time, or just not being able to determine where to contribute because her teammates had already done everything that needed to be done. Still, she would try to find things to do to contribute.

Working on Project Problem Three, P3, with her group forced Barbie to understand P1 because P3 was a combination of P1 and P2. She had to have P1 and P2 correct to do P3. For her original P1, she had graphed the wrong variables.

> I graphed coefficient of drag vs Mach number and it was supposed to be drag vs Mach number. But back then I didn't know the difference between drag and coefficient of drag. Now I know and I got my numbers right and my numbers match exactly Dr. Austin's.

The instructor had commented on her P1 paper, "needs more discussion" so that was what she planned to do to resubmit it. .

She described P3 as a "very hard problem." Her group had been meeting "a lot" which was not as inconvenient to her since she had recently moved closer to campus.

But still, her group had not been able to generate what they thought to be the correct graph. Curves that they believed should intersect were not intersecting. After Barbie had turned in A13, which was critical for P3, she still felt she was falling behind, especially on her concept questions "because we're on constant schedule on this. A14 and P3, fixing P2 and P1." However, she didn't think she was any further behind than her classmates. "I think compared to the rest of the people, we're pretty ahead of everyone else"

Barbie's team became stuck on P3 and Barbie was very frustrated, both with the project and her team. Barbie felt they had spent too much time already on P3. She wanted to go talk with another professor for advice but her teammates were opposed to that idea, one reason being they didn't know what to ask him.

> I feel that why do you burden yourself trying to solve something you can't do? Why not use your resources? It's been three weeks since we started this project, P3, and we can't get a breakthrough. Why not use another resource? I understand if we work for an hour and turn it in. But we've worked for longer than ten hours at least on this project. So I think it's time to let somebody else look at it and give us some insight…. Something that we're doing is wrong. I don't know what it is. We need somebody to help us open our eyes."

Barbie compared their situation to the real world where you would turn in a report to your boss first for review before showing it to the client. She was ready to turn it in to the instructor like a boss, or even to the TA.

> So I think that if we're going to submit a report to management, I think that we are ready to turn it in, let him look at it, give it back to us… But no, my group doesn't believe in that….They are kind of perfectionists.

Her team turned in their final project on the last day at "like at 6:05 or 6:10" when the projects were due to 6:00 PM. Still, her team was not the last to turn in their project. The computer lab was full of other students in the course racing to finish. Her team never did get P3 working to their satisfaction. She did not know what their grade was on the final project.

As discussed, Barbie had a difficult time finding a role on her team. She wanted to contribute but had trouble finding something to work on. Two of her teammates

> did a lot of stuff at the beginning by themselves so I felt like I didn't have any contribution. So I felt kind of disadvantaged because I could have contributed with something but they already did that something plus a little bit more. So I didn't have anything to contribute, at least for P2. For P3, they did most of it. Like the core analysis, they did it. I started doing research on how could we make this thing fly because their graphs were not intersecting. So that was my contribution, figuring out maybe what are we missing….I went to the library and found some books to read about engines, about turbo fan engines. So that helped me to understand okay 'that's what you have to do?'

She described communication problems on her team, particularly with two teammates.

> They were not communicating with us. They were doing it by themselves…. And even though they were nice, they were very nice, it's just that they would do it, and I was afraid that I would be doing something that they had already done. So I kept asking them 'Have you done this?' 'Yeah, yeah, we did this.' 'Have you done?' 'Yeah, yeah, we've done it.' So it was really hard for me to find out 'what could I do?' so I just went to the library and did that and checked the code and yeah, there were some mistakes, some typos on the code. So I had a little like an insecurity on my part at the beginning. I'm talking about for P3 and P4. We did P3 and P4 at the same time. So I said 'okay, I have to do something. What can I do?' So what I did was I just started typing the report, I just started typing. I said 'as you do your part, then email it to me and I'll just start putting it together.' So I started that. I started a format and I didn't want to do that because I didn't know if they were going to accept it or if they were going to agree on it or maybe it was wrong or whatever. But I said 'I just can't twiddle my thumbs anymore. I have to do something.' So I started and they liked it and that was the format that was followed throughout the (report).

While Barbie expressed frustrations with her group, she was also appreciative to have worked with them. "I just happened to be with good disciplined students and that really saved my life in the project because had I not been with people like that, I would have had to do more work and I would have probably had to like baby them and tell them what to do."

Perceptions of expectations

Barbie's desire to seek external help towards the end of the course when her team was stuck was based upon her understanding of the instructor's expectations.

> I don't think it really matters which way we go as long as we have, as far as Dr. Austin is concerned, I think as far as we have tried our best and used all our resources to do our report even if it's not right, I think he'll appreciate the effort. That's what I think. And I'm not trying to force my team to just turn in anything but I think we have to turn in something so he can look at it, give us a critique and then rework our understanding. That's what I wanted to do but no, they want to finish and they want to make sure everything's fine before they turn it in, so. And I know that Dr. Austin doesn't really want to see that number at the end. He wants to see effort and that we tried. …Because he's always said it's not the final product, it's how you get to it and what you use to get to it. He's always made emphasis that this is the way real life is.

Some of the frustrations Barbie experienced with her teammates may have been due to different understandings of what the instructor expected of them. She described how she did not share the same frustrations as her two teammates who worked so hard on P3.

> They both had the frustration where they still didn't know what to expect. I knew what he wanted. He just wanted us to write down on our learnings, our insights from our investigation, from having done P1, P2 and P3. That was easy for me. I could do that. The hardest part for me was to do the analysis of the turbo, of the bypass part. The turbo jet, I understood it very well, P2. But P3 was pretty hard so I didn't do much on that. They did most of it. But putting it together was really easy for me.

She thought these teammates were hung up on the right answer mindset.

> Yeah, that was their problem. They really wanted to have the graph look like it looked on the textbook or have it show that the plane could fly but, like I told them, 'Look, there's a lot of factors that we're all missing too, other contributors to the thrust that we don't know about. I'm sure the algorithm for a plane to fly, it's not a ten-page algorithm. I'm sure it's longer than that… I'm sure that there were a lot of assumptions that we were doing that in reality that's not the way it is. And Dr. Austin told us, 'I don't care for the answer. I couldn't even do it.' He told us up front. 'My plane didn't fly either. I didn't get the right curve either. I didn't get the thrust to equal the required thrust, the available thrust to equal the

> required thrust. No. But just write down what you found.' And that's why we took, we didn't start doing the project or the report on, it was due Friday, I think we started on Tuesday. We stayed there until twelve (midnight). And it was because we got kicked out of the computer lab, otherwise, we would have stayed there until the end.

Two of her teammates continued checking the code and "just kind of like going in circles" until a third teammate, also a strong student,

> stepped out. He just stepped on the side and didn't do much…I thought we needed to start writing something two weeks before that. I said 'Why don't we start writing something, turn it in to Dr. Austin and see what we get?' No, they didn't want to do that. They didn't want to do it until it was done *perfectly*.

Early in the semester Barbie described entering the course having heard negative stories about it from her peers.

> I was really scared when I came to Thermal Fluids because of all the stories I've heard but it's not as bad as I thought, so far…. I like this class because I understand it and I'm able to do the homework on my own. …I understand everything that's going on and the questions are only what, two or three or four at the most, and I can probably do them in three hours. Maybe. Last one I had a little problem with the analysis. But he clarified it and I got it. So I like this class better. I don't know if it's because it's easier. I don't know if I should consider it easier or maybe more to the ground….I've heard people say 'Well wait until you get to the project'. But I like it because I'm understanding it. It's not too much.

While Barbie wasn't sure what the professor expected them to do, she seemed confident as she described what she believed to be his expectations:

> I think what he wants us to do is kind of like do an algorithm for a unique design for a new airplane. …I'm not very familiar with the project. I don't think it's going to be too hard. Doing the algorithm is going to be hard. Hopefully somebody in my group knows (laughter). But getting all the information is not going to be too hard.

Barbie described the relationship between the concept and analysis questions and the project problems as close and as allowing for students to learn concepts separately then

put them together, in this case while applied to an airplane. She was optimistic that the project would help her understand the material.

By early October, Barbie felt she knew what the instructor wanted but didn't know how to get there because she didn't know how to use the formulas from class. She was beginning to see

> all these little pieces kind of coming together. It's getting complicated. I can see the whole, like the surface of everything, but I can't in detail like with formulas and everything, I can't really tell you how every single component works and things like that. But when Dr. Austin explains, I understand. It doesn't stay, all of it in here but I'm understanding it.

As she worked through the project problems, she found things were falling into place more. She saw the project problems building upon "what we've done for the past two weeks… Whatever our findings are after we do our P1, P2, and P3, that's what I'm thinking. And then we just put it all together and write a report and make our conclusions. Right?"

In early November, she described Dr. Austin's intentions in this course as "He's trying to prepare us for the job environment and teach us how to use resources." She recognized that he was grading effort.

> Actually he told me, 'I know that I have the ability to do that after thirty something years of teaching. I have the ability to grade on effort and I'm going to take that advantage and grade on effort.' ….When it comes to this type of environment, it's really preparing students to go out on the job and figure out or analyze problems by using resources. …. My husband, I was telling him about this class, and he said 'I wish I had a class like that.' They never had projects in any of his classes. Now he has projects at work. He doesn't know how to approach them. It took him a whole year to get into that.

Barbie did not feel that all the expectations for the course were clearly conveyed.

> I think that they were pretty clear as far as the professor's concerned because he, I understand his reason behind not to give us anything, not to spoon feed us everything. I can understand that being very clear but it wasn't clear for us to say 'Okay, I know what he wants. We'll do this.' No. For the project at the end,

> a little bit better but no, like at the beginning where he had laid out all the project, what we were going to be doing. No. I could understand half of it. The project problems, they were pretty clear, but when it came to project three and project four, no. And just putting the report together, we weren't sure how to, you know.

The list of hints for the putting the project together helped.

> Yeah, we used those. You know what really helped too? The list that he gave us at the end where we had to group our homeworks by sections (to put into notebook). That really was very helpful because that's how we divided our report. …It was very clear. That one I liked a lot. And we followed that. … Actually it was intended for the homework folder so we could put it together. So that's how we put it together. It helped. Yeah. The analysis questions, they were pretty clear. Like I said, if you're talking about your boss, then you want it to be more clear. But if you're talking about school, of course he wants us to learn and he wants us to work a little bit hard for it and he wants us to go see him in his office and ask him questions so that's why I understand that it's not very clear. That's why a lot of people complain about not being too clear but if you go to his office, he'll probably give you more hints. I went to his office and I got a lot more information from him. And even if you're talking about your boss, he might not even know how clear it needs to be.

Barbie found the class to be fair because the students were provided with the tools they needed.

> So I think it was very fair if that's the word. Fair because he gave us all the tools. He did give us all the tools. We just needed to pick them up and use them. So I think he took a lot of time to pick the analysis questions and to pick them very well. And the project problems and the concepts that were all linked together.

Barbie thought the professor's expectations were fair as well.

> I think they (expectations) were very fair. I just can't over emphasize it. The way that he graded was exactly what he told us at the beginning. That he would, that he was only interested on your effort and your attitude, your ways of relating information to your teammates, ways of using your resources, doing all those things as opposed to doing I guess quantitative stuff regarding thermal fluids. It was very qualitative. So, he did not ask for quantitative. And he actually graded that way because on the quizzes, he just wanted to see if you were up to date on

> the homework. That was the only thing. Other than that, he just kind of let you take your own pace.

While Barbie felt that she understood the instructor's intentions for the course, she recognized that her classmates might not have.

> I've talked to people who have taken his class semesters ago and they missed the boat too. They don't understand the reason behind Dr. Austin. They just thought he was a lousy professor. Before I signed up for this class, I asked around to see which professor. …'Dr. Austin, his homework is hard but he's a really bad lecturer. If you don't want to learn anything, take Dr. Austin.' Things like that, You know why? Because Dr. Austin is not too pushy when it comes to deadlines. If you turn it in, fine. If you turn it in late, he doesn't really care. He doesn't really care if you don't do it and come at the end of the semester and turn them in if you really show that you learn. He leaves it up to you. …. Dr. Austin is just like, individual education, personalized education. You learn and you get as much as you want, like a buffet. If you want to come in and take extras, that's fine. If not, that's fine too.

In January, Barbie reflected back on the course:

> The expectations were pretty similar from the beginning to the end. It changed a little bit in the fact that I thought that for the project he really wanted a solution and it seemed like he didn't because our solution was not, actually we didn't have a solution at the end of the course….our plane didn't fly. So I think that the course was based more about looking for resources as opposed to learning thermal fluids.

That wasn't what she understood it be like at the beginning of the course.

> So that was the only thing that changed because at the end I felt like he was very pleased with our work. So he was pleased with our work and our work did not have the perfect answer. So those expectations kind of changed towards the end because I thought 'okay, we have to turn homework in on time' and there's like tons of homework to do plus the project plus quizzes so but then my expectations changed a little bit. However since the beginning I knew that he wanted *that* which is learning how to work on groups, learning how to use your resources.

She knew this

> Because he said it since day one. One of the things that he always made emphasis on was 'I'm not interested on the outcome, on the particular answer….I'm just interested in how you work around solving your problem more than whether you know fluids, you know thermo, heat transfer, whatever.'

After the course was over, Barbie agreed that she felt more confident in attacking a problem now although she had been frustrated on the project "Because you don't know where to start. I didn't know what book to look for. I didn't know what to look for." She recalled her conversation with the professor when she turned in her homework binder and he had asked her

> 'Did you feel like you learned anything?' and I said 'I think so. I don't know how to measure it. I don't know how to say if it's good or bad or A or B or C. I don't know but I feel like I learned a lot. I can understand a lot of things now. I learned a lot about the mechanics of how an airplane flies', I told him, 'but mainly I learned about how to work in a group and how to do research and how to use resources. Even though I've used them and I've done it before, this time was for real.'

Barbie received an A in the course.

Bill's Narrative

Bill always seemed that he was holding back, perhaps speaking more favorably than he felt although little glimpses of possibly his true feelings surfaced on occasion, typically through brief moments of irony. While I believe that Bill was comfortable talking with me, we never developed as personal a rapport as I did with the other student participants. I realized when I wrote the narrative that I really did not know much about Bill beyond his classroom experiences. Bill struck me as very analytical. He did not offer insights without supporting data. He shared why he thought what he thought. I was pleased with these insights because they added such depth to the answers to my research questions.

Getting to know Bill

Bill grew up in far west Texas where he also graduated from high school. He began community college there as a mathematics major but decided that was "a little too easy." Next he tried accounting but eventually ended up at UT to do engineering. He attributed part of his interest in mechanical engineering to his father who is a mechanic. Bill liked "dealing with tools and machines."

Bill said he was really interested in this course, in part because he already knew about planes from taking pilot training. In pilot training they only talked about how the plane will react, not about the motor functions, "But this is specifically the engine and it's really neat. Most of the concepts are basically the same. They all trace back to the same thing. I'm pretty familiar with those. It's just how to apply them in different situations." Upon graduation at the end of the semester, Bill wanted to find a position doing design in the airline industry. His second-semester senior design project was also related to aircraft. He was taking this course along with K, the second semester of senior design, and described this situation as "Busting it. It's kind of difficult but I think I'll be able to manage."

Early in the semester, before the course teams were defined, Bill shared his views that he worked best with team members he already knew.

> I find that it works better for me if I know the people I'm working with. If I'm matched up with someone else then you have to go through the icebreaking and say you have to become friends with them. And then if you're not friends it causes even bigger problems. And I've run into this problem quite a few times. … I'm not totally against working with people I don't know but the work gets done faster if you know them.

Bill took the class with some friends with whom he has worked in previous courses.

> We all get together and do our homework together and help each other. I think that works a lot better than just doing it on your own…You give people help. You help other people out. It just strengthens your skills on how to solve problems. I think most of college for engineering is problem solving.

Course experiences

Bill worked on P1 with his friends in the class. "We got together that evening (the night before it was due) and kind of cranked it out. I'm not exactly sure if we did it correctly but we put our effort into it." Bill later described what he did for P1.

> Well I wrote down some comments, I don't remember if they were right or wrong. But this was the first one and he had asked us to do it but we were all unsure. What I did and what I think most people did was they plotted something, maybe commented a little on it and that's it. Didn't give any background. How did you get there? What did you write down? What do your equations mean? I didn't do that. I remember now that I didn't. I wrote down what the graph kind of represented, or what I thought it represented, and that's about it.

The problem description for P1 did not ask for comments. He thought the instructor should have told them to graph or plot it, then explicitly ask for them to comment on "how we got there and what we think it represents." Bill thought it was fair for the instructor expect the students "to understand that you have to write something down and you have to also show how you got there."

Bill and his friends had initially tried to do A8 by hand, not by programming it.

> We started to attack A8 by hand and it started to seem redundant and then we discussed putting it into a program and that worked a lot better. But the way that we were doing it, it was a different method and it was a longer method than what we were shown (later when the instructor showed his method) and I think we were arriving at the same answer.

The curves his program generated for A8 did not look exactly like Dr. Austin's curves but did look like his peers' graphs.

> I know some people who worked on writing a program for four or five hours, all day long (Friday) and they kept asking Dr. Austin for help and I saw what their graphs looked like and saw what Dr. Austin graphs looked like and they were not anywhere close.

A peer gave him some advice about how to make his graphs look more like the instructor's graphs.

> I got to talking with one other person and he told me we just need to modify some values in the program and that would modify it to kind of look like Dr. Austin's but I haven't had a chance to do that yet. That was just today. Hopefully that'll work.

Many students in the class had troubles with A8 so the instructor spent all of one 2-hour Thursday class addressing A8, mainly by having students work parts of it on the board. Bill liked that class.

> You know, when we're on our own and trying to think about it, we create more problems and then we go and talk to Dr. Austin or look it up and then we'll solve those and then it's just kind of a cycle. But when he goes through it, especially last Thursday I believe it was, we all worked it out as a class…That was pretty neat. Everyone started helping instead of just the professor up there. Everyone started getting into it. It stimulates the whole class, I think. One, you're scared you're going to get called. So everyone's paying attention. I think that helps because it changes the dynamics of the class. It changes the person, the tone, everything in the whole class….Whenever someone would get stuck, either the class would help or the professor would help. It makes everything go smoothly.

His class-assigned team worked on P2 together and turned it in as a team. But his team was late in meeting for the first time and he had had some concerns about falling behind.

> We're falling a little bit behind but we're comfortable with each other…it's all coming together, there's no problems, everyone has the same mutual feeling for each other…. I think we'll work good together. Just going to have to start a pattern of meeting times and probably more than once a week cause it's going to take some time to do this.

Falling behind caused Bill to reflect upon the instructor's flexibility with deadlines.

> I got caught up last week. I was a little bit behind but I think that it's kind of nice that he accepts late work and doesn't mind how it gets turned in as long as it does before the stuff's passed back. I think it's fair. It's a different approach. I think it has less of an impact if you don't finish work. If you don't finish your work then maybe you lose confidence in yourself, lose confidence in the course and ultimately end up failing it. This way you have a little bit more time to gain back your momentum in the class and catch up. I think that's better.

The instructor posted his solutions to P1 and A8 on Prometheus. Bill found these solutions useful.

> I think that was the big deal.…He gave us like what he was expecting on P1 and A8. He gave us his write up on that….It showed us what we were doing wrong as far as the analysis went and also kind of what he was looking for on the write up. So that really helped but if you didn't go back and read that or if you didn't even look at it then it would be a problem.

Bill compared his P1 to the solution the instructor posted on Prometheus.

> But Project Problem One, he took a different approach. I guess his would be more right than mine. Maybe I made some wrong assumptions compared to his. I'm assuming that he's worked this out before. This is my first time so I have something to benchmark against but I pretty much did the same practical steps.

Bill would have liked more feedback and clarification on the concept questions as well.

> He does a little bit in class but there's only so much you can write down or actually remember but getting feedback on these analysis and project problems really helps because you get to see his approach. It may not be the best way but it's just a different way to think about something as well. …. when you have something to compare against then it really helps out because you know where you went wrong.

Bill recognized that the project problems would affect the final project by providing tools.

> I think he said last Tuesday that these are tools, like P1 and P2 and our analysis problems are the tools we are going to be using to write our project and figure out exactly what we are going to have to do during the project. Yeah, I definitely see a benefit in doing them and keeping them on hand instead of just turning them in and not paying attention to it.

Once the teams were assigned, Bill perceived the expectations to be increasing.

> I don't know if this is true but the problems are going to be getting a little bit longer so maybe we're going to have to break it up or look at things on our own so that we can move quickly rather than everyone going and doing one task at a time. I've done certain projects that way where everyone works on the same task

> and I don't know if that's the way it's supposed to be done. Everyone learns just about the same but you go extremely slow. But if you designate certain tasks to certain people then they become good in what they did but you may not know how they did it.

Bill's experience with the final project was complicated by team problems and pressure to finish Wednesday night before his family came into town for his graduation. While he had expressed some early problems with his team falling behind, after the course was over he described more team problems. He and one other teammate did most of the work on the project. His other two teammates were working on their first-semester senior design projects and said they did not have time to work on this project.

> Between me and him we would split it up. Like he would write some and then he would work on something else and I would write some. Then we would read each other's stuff and we made it make sense in a fair amount of time.… We did the first 15 pages and our project written was about 19 so, four pages left to two guys, that shouldn't be too hard. Their claim was that they didn't have time, this and that. Well some people don't either. We had a test Wednesday night so after our test we came back here and we tried to do as much as we could. And said, 'Wednesday, we're done. We're not going to do it anymore.' So Thursday and Friday, 'whatever you guys want to put in. I didn't even read the finished report. I knew what we had written.

One way Bill and his team met their deadline was by finding a "cheap way out" and not doing P4. "We didn't do P4. Dr. Austin said 'get it done if you can.' I'm sure everyone in the class had something to do but some people said that they were going to go ahead and do it… we just went ahead and said 'we're going to cut it off here.'"

After they had finished everything else, they had only about 30 minutes to do P4 before the lab closed. His team finished their final project on "Wednesday night and Thursday we just had a few touchup things and then one of my team members turned it in either Thursday or Friday, whenever he turned his notebook in. So, yeah we had actually finished what we could finish on Wednesday night." Bill wasn't worried about not doing P4.

> I'm not too scared by it…. he can't fail the whole class. I think a lot of people just said 'we're not going to do P4.' I know of one group that did P4. I don't

know how many others did it. I know a bunch of people weren't going to have time to write it up….. I think that as long as you cover what was asked for, at least say something about it, not just entirely leave it out, then you'll be all right. But I think what some people were trying to do is just cut whole sections out of the paper. And I think that was just mainly because they were out of time. They'd started their project late and didn't get as far as they liked or just didn't understand something.

Bill seemed comfortable with their results on the final project.

The trend looked right. As far as the magnitude, the numbers were kind of off but the general trend was right so there might have been some sort of calculation error somewhere but the trend looked right. I think it was only off by like a multiple of two. It's significant but at least we got the general idea of what was supposed to happen. I think that if we had started at least a week earlier then we could have got the bugs worked out…. There's a lot of time put into it. Our write-ups for each project problem were fairly decent. We got good comments on our write-up. It's just that our analysis was kind of messed up so we went through, tried to fix our analysis and we just essentially cut and pasted our write-up for that part into our project and it turned out, we figured we got the idea right and we'll just turn it in and hopefully it'll work.. … We went through, he gave us like an outline of how our notebook should be set up. We kind of went through that and touched up on each topic and he gave us hints for our final report. We went through that and touched up on each topic except for the parts dealing with P4. I think we did a fairly good job of covering what he asked for in both of those documents. After we finished that, we said, "Alright, we could start P4 now.' but it was like 11:30 when we finished. We had thirty minutes. The lab closes at midnight.

Perceptions of expectations

Early in the course he felt he understood where the course was going.

As far as where we're headed with the course, I always question what we do every day. I can see what he wants us to learn. He's building. We're starting out slow, and each concept's building off itself, creating a whole base, and we're going to use that to apply everything that we learn there to sort of engineer something, or this is what I think is going to happen, to engineer some sort of engine, come up with some sort of specification for this engine. And all these concepts are helping us understand what goes into that. It takes a lot of time, or what I've noticed is it takes a lot of time to research what you want. You just don't go out and do it. You have to look into what you want to get at. From what I've noticed among some of my peers is not everyone is comfortable with doing that. They would much rather work out problems, a given set of problems.

In early October, Bill observed that the instructor "keeps saying that he is not there to give us the answer. He wants us to come up with the answer and he's not there to tell us what to do but he'll give us a hint what to do." When Bill would go to see him in his office, the professor would

> allude to an idea and say 'this is kind of what it is' and it's up to us to ask him another question or figure out what the heck he's talking about….I understand where he's coming from too because he's wanting us to not rely completely on someone telling you 'this is what you have to do.' … it's definitely good. I like to be given some hint but then you have to figure it out on your own. I think it sticks in your mind longer if you actually do it yourself. If someone tells you something or you do it yourself, you're going to remember it longer if you do it yourself. He wants us to interpret what we've done… He just wants to know how we did what we did and our thought behind each part….it's not the solution he's interested in but it's your way of attacking it… By explaining how you got to it, it shows that you understand what you did … I think it should be part of anyone's schooling to explain something like that because a bunch of people don't know how to explain what they've done. Actually a bunch of professors have that problem.

When asked after the course was over whether the instructor conveyed his expectations clearly, Bill chuckled. "He gave us insight on what he wanted. At the beginning of class he gave us everything. Everything was online and then he gave us the project so we knew what we had to do." Bill knew a lot of people didn't look at the project assignment.

> A bunch of people read it the first day but, you know, six weeks down the line you forget it. Not everyone's reading it all the time. I read it the first day and I read it like, I don't know, when we started P2, or actually when we finished P2 I read it again. We knew what we had to do. We just weren't aware of when it was going to be due or anything like that. But yeah, I think he did a pretty fair job on telling us what he wanted from us and when we didn't give it to him he sure let us know that we were wrong, what he wanted and then I think the class responded fairly decently. Like on P1, he gave us that. A bunch of people just turned in graphs like I did and he said 'well that's not what I want.'

When asked whether the instructor had told them what he wanted before then, Bill responded,

I think he did but we didn't, or I didn't really take it into account. I didn't understand at the time but when he gave back his P1, gave back our P1, got to comparing what we did and he did, definitely saw the difference so that really helped out on what was expected from everything else from there.

After the course was over, Bill reflected back on the course.

Well, it was pretty interesting, I just think that, closer to the end, it was not really stated accurately what Dr. Austin wanted. It just seemed like for the past two weeks, every day that we went to class, something else would be kicked off the list, 'okay, you don't have to do this now?' It was good news for the amount of work that we had to turn in. But I don't think we got robbed of learning anything. It's just that, I guess on some class like this you have to expect that that's going to happen because maybe what you wanted to get covered isn't necessarily going to get covered because the people aren't really understanding it. As far as being disappointed, I'm not. And from what he expected from us, I hope that we gave him what he wanted, what he was looking for. Looking back, I think, like I said, it has to be done where you have to look at it to where, 'I want to plan this and I'm going to tell them this is what I want', like he did and eventually he just gave in and said 'turn in what you have.' He's not bothered by it or I didn't see him very bothered by it (that they didn't have everything finished). …We didn't grasp the material as quickly as he would have liked us to maybe. Or we felt that we had too big of a load already. …It helped me understand more about what was going on, how to look into something. I don't think …we had to go into the depth that he was asking for the report cause for the report he just asked us to kind of explain what we learned. If we went into the depth that we did on the homework problems and on the analysis problems, it would have been a lot more work.

Bill thought his P1 would have been acceptable in other classes even though

I did a poor job on it and I knew I was going to get a poor grade… it wasn't off to a good start but I think some people, they turned in a pretty good portion of P1 but they still got a bad grade because it wasn't exactly what he wanted. But I compared with the people who sat around me. Saw what they had, saw their grade and it's like 'okay, well that's what he wanted. Now I understand.' I had an idea what he wanted but didn't quite understand what he wanted.

Bill thought the instructor

graded pretty fairly on it for the amount of work we did. Yeah, we had to get some graphs somehow in Excel or MATLAB or whatever but you still have to

> say something about it, at least give your idea where the concepts are or whatever.

Bill thought it was "important to have the students understand what the professor is asking." He had seen problems in the past where students were assessed on things they didn't understand the professor wanted.

> I don't think it's fair for them to expect you to learn everything there is when there's minimal coverage. If you have everyone thinking the same way then I think it builds morale in the class. You get more excited. You understand what you're going to learn.

Bill found written feedback or comments from the instructor on assignments to be an effective way to convey what was expected but Bill also found such feedback to be lacking.

> Well, see our insight I guess it kind of tells where we are standing on the problem but we have to turn it in and if we give insight, I think it would be good to get some sort of feedback saying if our, what we think or saying, is correct and what actually is correct so we can compare and say 'okay, this is what I was thinking and this is what I was supposed to be thinking.' …. I think it'd be good if we did have some sort of concrete type information saying 'this is the track you're supposed to be on.'

Bill found that receiving his graded P2 back "really helped a lot" for their final project.

> Our write-up for that was really good so that was like two pages of material that needed to be in the report that we just went ahead and inserted, fixed it to where it flowed well and made more sense. And then our analysis was kind of messed up and we went back and fixed the analysis and it turned out to work pretty good I believe. So getting that back, that really helped a lot.

The lack of feedback on A13 as they completed the course was a problem.

> I don't think anyone had back their A13. I don't think anyone had that back. Well, we had it in the computer but we don't know if that's right or wrong. So like what we did, we just went ahead and inserted it (into the project) and hoped for the best.

Bill also had problems with the assignments not being returned promptly, "like never." But he recognized that this was partly due to the relaxed deadlines.

> But I guess that's kind of our fault too because we were given leniency on when we could turn stuff in. At first I guess (the TA) was the one grading all our papers and he would turn them back pretty regularly and I guess he got caught up in his work and he fell behind and it got to be a problem. …It's kind of hard to expect someone to grade something in one day if you don't turn it on time to begin with.

Bill did not perceive the instructor to be stringent on deadlines which he appreciated because he did not like deadlines.

> To me, on homework, I don't think there really should be a deadline on homework as long as you can complete it cause one, you know that you did it. If you don't have time one week and you want to do it next week then you have a chance to and chances are you will do it. Otherwise, if they say 'oh, if you don't turn it in you get a zero,' probably not going to do it. So by extending the deadline or not having a deadline, you've got a greater probability of someone doing it.

As the semester progressed, Bill said that his perceptions of what the instructor expected had not changed.

> Still, it's still up to us, him giving us a dab and we have to come up with the whole explanation. He's kind of teasing us or guiding us in certain, to tailor us to what he wants us to get but I feel pretty much that everyone knows what is expected now, not that they're going to deliver it but you know (laughed).

Bill did have some concerns about how the final grades would be determined and the final role of participation.

> I'm kind of wondering like we're getting papers back with fives on them, whatever that means. I think it's kind of hard to put a value on the participation that we're doing right now at the end. I'm sure Dr. Austin is going to see what homework did you turn in, what didn't you turn in, what your quiz grades were and then he's going to say 'well, does this person stand out? What do I remember about them?'

Bill thought that effort would be weighed "a lot" in the grading.

> That could be good or bad. It's just a different style. No one's really used to it. I had professors before that they don't even pass back your homework or your tests and you're just left guessing, you have no idea. At least here we're getting some sort of feedback but even still if we did have some sort of test and scale to go by it really doesn't ultimately determine our grades because attendance pays a big part in a lot of people's class. This one it's especially important. I think Dr. Austin pretty much knows everyone in there. I think he's pretty good at recognizing the faces at least of most people. He knows who's there. I think it's important. A bunch of people don't think that you should have to attend class. Maybe you shouldn't but that's up to the professor to decide. You're paying for it, why not go. … Especially in engineering because you could read the book but that doesn't mean that's the easiest way or the best way or the way the professor wants it done….Attendance is important…I wonder if that should be influenced more on the first day of class. Maybe not saying that he takes attendance but that it's crucial….I guess a bunch of people were going in there not knowing what to expect. You don't know what to do.

Bill found some of the questions in the course to have not been clear about what was expected in response.

> But some of them were just worded funny like he wasn't really specific about what he was asking for. He'd just give us, like he said 'what's process path?' on one quiz question, but it was kind of like a homework question, it was just kind of vague. He wanted a specific answer and then the answer that the majority of people was giving was too broad for what he wanted. So he wanted it related to the class. But for the most part, I thought that they were pretty basic. He gave us like some sort of reading to look up and read and if you read that then the answer was in there. It was over about six pages but the answer was there. You had to understand what you were reading. As long as you got through that then it wasn't that big of a deal I don't think. The analysis problems is what really troubled me and a lot of other people just because, at first, it wasn't a lot of time and then we had to get used to spending quite a long time on them.

The instructor had warned them that this flip-flop would happen and

> It really did and it's kind of unexpected but on our part a lot of people were spending an hour or so on a problem and it turned into three hours. Well, you don't plan for something like that. But I don't know how you could let the students know that unless, like he said, 'now we're going to switch to where you're going to be spending more time.' But until you start doing it you don't

understand so that's not Dr. Austin's fault. It's just poor planning on the student's fault. I think he was pretty fair with what he asked and what we were required to turn in and the amount of work we did.

Bill reflected on the class.

This class has really opened my eyes. Not only on what it takes on some problem that you have not answer to but how to work with other people. How to know what to expect from other people and where to go to find the answer that you need to finish it out. It may not be the complete answer but you can use some sort of reasoning to come up with some sort of educated guess. I know I did that. I gave my own opinion on what I thought was right. I don't know if it was right but to me it's right. Until I get feedback telling me that it's wrong, then I'll understand where to go and look it up. It takes a lot to go and try to research something and then come back and find out that you didn't even know that. Or that what you're looking for was wrong or what you found was even wrong. It gave insight on where to go and what to do. As far as the project is concerned, it just doesn't have to do with this thermal fluids problem, I learned a lot about where to go to find resources for other projects. I don't know if that was Dr. Austin's whole outlook. I don't think he wanted us to stay focused on just this class. I think he wanted to open it up to where it's more general, to know where to go for a whole bunch of variety of different concepts. …How you get there, what you do to get there. I think that's real important. There's always much more to learn on where to go, what to do. I feel that I learned at least where to start and who to ask to at least suggest a starting point.

Bill feels that he will be more confident attacking a big problem like this.

I definitely do because before this class, I wasn't really the one to step up and say 'well, I'll be part of this. I don't even know what to do but I'm going to at least give it a shot and I know where to go.' I was never that person. Now, at least I can say I've had one project, I'll at least put my foot in and say I'm ready to take it on. I can at least give it my best shot now. I think that this class really helped.

Bill received a B in the course. After graduation Bill accepted an engineering position in another state but not in the aerospace industry.

Mary's Narrative

Mary was a very talented student with many interests and opportunities as well as a very supportive family with generations of engineers. Since she lived at home she could go to her father with questions about the course. She was very passionate about understanding the material and completing her assignments although this passion seemed to exhaust her at the end.

Getting to know Mary

Mary described herself as having been born to hippie parents on a goat farm on the edge of an urban area in Central Texas. She attended a private college-prep high school that was very intense but after graduation she was burned out and decided not to go to college. "I just decided that was enough school for me so I went to work for my dad who graduated from (the university of this study), engineering." However, she found that when she wasn't in school she really missed school. "Once I got away I wanted to be back so bad. It only took me a semester after graduating high school and never wanting to go to school again and I was like 'I can't stand this, I have to go back to school."

She went away to art school for six months. There she studied industrial design which she described as "about as engineering as you can get in the art area." She liked doing the art and being creative but was still really interested in science. She returned to Austin but not to school. Instead she spent some time working in a sushi restaurant. Realizing that she didn't want to work in a sushi bar the rest of her life, she turned to her family for advice. They steered her towards mechanical engineering and she has been happy with her choice. "I'm really enjoying engineering. I really like science a lot. I'm very driven to find out how things work and stuff like that so I'm pretty happy with my choice."

Mary was considering both employment and graduate school following graduation in the spring. She had an option of working for one of her dad's colleagues who had a company and had offered to hire her as his chief engineer right out of college. "So if all else fails, I'll go for that." She was also thinking about graduate

school. “I’m definitely thinking about it. I’m going to take the GRE so at least have that option open." As the semester progressed she became more absorbed in an entrepreneurial design project with friends and was talking about pursuing that fulltime after graduation.

She preferred doing projects to doing homework problems out of a book because she found figuring out how things work and making things like she did on projects to be a more effective way to learn than homework problems. “I hated like thermodynamics and machine elements where it’s all just book problems and you don’t see much relevance.” She felt that homework was almost like busy work where you don’t gain much from it. “You’re given all the equations and you just have to plug in the numbers. And I’ve always felt like that wasn’t a very appropriate way to learn." She could not remember much from classes where she just did homework but she had very vivid memories from her classes with projects “because I had to think about it so much more to figure out how to use the equations, to figure out which equations to use. ….I just think it’s a much more complete learning experience and more fun than plugging in numbers into equations.”

Still, Mary has perfected the necessary study skills for more content-focused courses, describing herself as an

> excellent crammer. I can cram like nothing else. But seriously, a week later, that‘s why I can’t remember any thermo or fluids equations because I crammed. I even do study along as I go but there’s always the night before the test, where I do all of the really memorizing which I think is horrible. You should really learn it. Keep it in your mind by learning it, not by memorizing it. I hate cramming.

Course experiences

While she did not initially understand the relationship between the concept and analysis questions, Mary soon figured out that

> a lot of the concept questions help you understand what is going on in the analysis problems. … It makes you think 'why is that the equation and what does it really mean?' so you can do the analysis problems better then.

At the beginning of the semester, Mary worked very diligently on the concept questions. Later she reflected that if she had it to do over again, she might not have spent so much time on the concept questions because others who wrote much less received the same grades.

> We'd go to the library, do lots of research and we'd turn in these books for our concept questions. And then we'd look over at our neighbors, 'You got the same grade as me. You have one sentence and I have ten.'

Still, she recognized that her hard work on the early concept questions probably paid off in the end.

> I guess for some things I probably understood them better because I had gone through the trouble at the beginning to have these very lengthy complete discussions of a question.

Mary turned in Project Problem One, P1, on the Tuesday on which it was originally due. The due date had been moved to Thursday but she went ahead and turned it in on Tuesday. She turned in two graphs with no comments, not realizing that the professor wanted them to write comments about the graphs.

> I turned in the graphs (for P1) without any write up at all. I turned them in the day they were supposed to be due before it was moved to Thursday. He actually told me later that week that I should go ahead and redo it because he realized 'why would I turn them in early and unfinished unless I did not realize that they were unfinished.'

She realized later that the professor wanted them to write-up this project problem as if it was part of the final project. She revised P1 by including "a little bit more background on the problem and a little bit more discussion on the results, and more graphs than he asked for which he seemed to like." and she received 8.5 out of 10. She did not know of anyone else who received that high a score, although she had not asked everyone in her class what they received for a grade on it.

While the analysis problems started out simple, they became more complicated as the semester progressed. Analysis problem 8, A8, required the students to model a

turbojet engine in order to plot different performance variables. Mary became very frustrated when her curves did not match those of the instructor although they looked like those of some of her classmates. She worked and worked on her model and still could not get the curves right. While project problem P1 hadn't been a "big deal" to her, Mary was very frustrated with analysis problem A8.

> Every person that I've spoken with has the same curve that I do but it's a different curve than Dr. Austin and all the textbooks have. So, either Dr. Austin told us something wrong or we're just all not nearly as intelligent as we thought we were or something (laughter). I mean no one has it and it's really starting to frustrate me. That problem has just owned my life this past week. It's really the first time that I've ever failed miserably on something that I've tried so hard on (laughter). It's been pretty frustrating.

She didn't believe the instructor's curves were wrong because "his looks like the curves in a lot of textbooks that I've seen so kind of thinking that his is right." Still, she didn't give up. "I'm going to probably go and camp out in his office again today until I get it right. " Later she found out that her curves were correct - she was just using a different scale from the one the professor used so the curves looked different plus she "had one tiny little mistake that all that did was just shift my graph up about ten meters per second so that made it perfect. And that was really frustrating. But at least I had it right." But all the time and frustration invested in the problem were not a total waste.

> I sure feel like I know the problem real well. I definitely know what's going on. Not that I learned more, maybe that I'll just remember it better. I learned it obviously because I did it right but I'm sure I'll remember it. I can throw those equations around now, not as well as Dr. Austin, but if working with my group I'll say something and someone in my group always has to look it up like 'are you sure?' But I have them memorized now. …I really struggled for no reason but at least I got it right.

Project Problem Two, or P2, was the first assignment that the class worked on in their class-assigned teams. Mary was very happy with her team and was glad that she was not on a team with certain other people in her class. She described how they had all had a test one night and then met in the computer lab after the test to work on P2.

> But we all worked on it and got what I think was a pretty good product. Dr. Austin actually made a comment to me, a couple of days ago just passing in the hall, that he had looked at our project problem and he appreciated the effort, that at least some people were getting it. So I took that to mean that a lot of people still weren't turning in what he wanted but we had managed to figure it out….I think he doesn't say that he wants a whole lot but he wants you to express that you understand everything so you need to include a lot. It's just that people are so used to being spoon-fed instructions that it is hard to switch over to a class like this where you don't have those instructions on exactly what to include or what to do.

She had done much of P2 already because she had MATLAB on her computer at home. However, her teammates were not content to just let her do the MATLAB model for P2. They critiqued and checked her model.

> I did do a lot of P2 because I was the only one that was able to because I had the program. And instead of everybody just saying, 'oh great' and letting me turn it in, they said 'Wait. Let me do it too.' and they picked it apart and found some mistakes. It's hard for you to see your own mistakes. It's so perfect. I can be 'do it all Dottie' but … everybody has sort of that 'do it all' attitude so everybody does sort of their own way about it and then we all compare and have discussions about what we've done, things differently, until we all agree upon one way of doing it but we've all gotten there by different means. It's really nice. I like the group a lot.

She hoped that all the problems leading up to the project problem meant that the hardest part was over by the time they did the big project. She described how if you had correctly done the analysis problems then Project Problem One took about twenty minutes to do.

> I think the analysis problems are the ones where you have to go through the big struggle of really understanding and figuring out what's going on. And once you've figured it out, you can apply it to the project problems and it'll probably come a lot quicker. That's just my experience from the first one. And from the analysis questions as they go along, until he introduces a new topic, the ones that follow them, they sort of start getting easier and a new topic comes like A8 and everything hits the wall. But I think the analysis questions are going to be digging for the information that's used for the project." For Project Problem One, it was the write up that took most of the time " cause you actually had to

> think about it and put it in real words rather than just saying you understood what the graph meant.

Mary and her team worked on P3 for weeks before it was due but their P3 program was not generating curves showing what she believed to be the correct trends. Again, she was very frustrated because "it doesn't fly and it's the wrong trend, it's just wrong everything." Regarding what the instructor wanted them to do,

> it's like he wants us to come up with the solution and really what I think the deal is, there's two groups, I think, that are really working on the problem…. and Dr. Austin wants everybody to try before they give up and I know there are groups that haven't started…..He's sort of secretly told (one of her teammates) and I that he has some information for the people that are giving it a real shot but unfortunately I haven't had time to go see him since then….We're just still plugging away, trying to work on it.

She wasn't sure if any other group arrived at the correct trends.

> Some of the groups said they did. I looked at some of their graphs and they weren't smooth curves. They were kind of oddly shaped. I think that there was some mistake in the code which we kept thinking was our problem but we went over it so many times. I don't think I saw anyone's that looked really exactly what Dr. Austin drew on the board, which is of course from his memory, but I remember some groups that were closer than we were at the end…. Well other people would say like 'oh, we've got the answer and I would look at it and point out a mistake and then it would be incorrect again. It's kind of hard with those graphs because a tiny little mistake in the code for producing the graph can completely change the trend. I mean we could have completely fudged the graph and made it look *just* like Dr. Austin wanted.

The final project, which included P3 and P4, was due at 6PM on a Friday. Mary's team turned their project in at 6:01 PM. They were not the last group to turn in their project. Other teams were still frantically working in the computer lab and asked them to stall the professor and not let him leave yet. Mary sounded disappointed in their final project because they never were successful in getting their plane to fly correctly. She described how they eventually just "lost steam" there at the end.

> We spent so much time on it, really, really wanted to have not just the right answer but close to the right answer, anywhere near it. I mean we were just completely wrong and we just tried and tried and tried and talked to Dr. Austin about every little thing. He'd give us three suggestions. We'd try them all. It didn't work. We'd go back. More suggestions. We'd try them all. It just never worked. We didn't give up but it was just so hard to spend three hours a day on it every day. It just sort of dwindled down and it finally got the point where we were sitting talking about what we're going to do for the final project. And I just kind of said to everybody 'Well I don't care. I'm not working on that project anymore. It's done in my eyes.' And everyone went 'yes, it is done.' We had done everything he had told us to do and couldn't come up with the right answer….. We just wanted the right trends in the graph. We wanted it to decrease with increasing Mach number and to be higher thrust than the turbo jet and ours was lower thrust and it increased. It was exactly opposite basically.

After the course was over, Mary reflected back on the final project paper.

> It got to the point where I don't think a single person ever read the report from front to back. It's pretty bad. I realized that right when we turned it in, 'Did anyone read that?' I mean it was really, 'no, no one read it.'" The final solution "wasn't acceptable to anybody on the team which was kind of odd that we were fine with turning it in. We were just so worn out having worked on this for so long. We wanted to get it done early in the week and we actually met on Sunday. We were here for like five hours and at the end of it we all said 'Okay, let's get together what we have. What else do we need to do?' Well we needed to do everything. We just hadn't done anything. Cause we'd been 'oh wait, I have an idea on P3. Let's try this.' and just kept going and going and going and that's when we finally realized that we weren't going to get anywhere. We just had to quit and compile what we had. Everyone was so distraught about it. It just didn't turn out very well at all. ….I feel very defeated about it… If I'd had just even another day with nothing else to do. Like if it had been due Saturday. Then at least the report could have been put together better. I don't think we had a conclusion or wrapped it up at all. It just ended. And it wasn't because that was an oversight. It's just because we were done.

After P2, Mary thought the professor would be more lenient grading the rest of the course,

> not necessarily for the project in general but for what your results are for P3 and P4 because I think he realizes that he's, yes he's given us an open-ended problem, but we can't find the solution in the time given and in the sort of the resources readily available. …it's the end of the semester, we all have other

> classes, he realizes that, … And we have tried. He knows that there are people in the class that have tried really hard and I think that he's going to look at effort. I mean, obviously, he doesn't look at final numbers, so he's going to look at effort.

She thought it was a fun class and noticed the attendance was high.

> Even in classes that have required attendance, I've seen lots of people skip out … But his class is really well attended which says something. The participation is only ten percent of your grade and I'm sure if you miss one or two classes, it's not going to be that big of a deal and yet everybody seems to show up all of the time.

This class required some different strategies than previous courses, including more self-learning.

> The majority of my professors lecture almost directly out of the textbook and I can remember the first couple of classes I took here, I was real gung-ho and I'd open up the textbook the day before class. I'd read the section he was going to go over and, I mean word for word, the lecture was just word for word, and I would be so bored and I wouldn't pay attention as well. I stopped doing that because of the way lecture was conducted. So, normally the only time I ever opened the book was to do homework. I learned well enough to make good grades in the classes but I don't really know where else to compare that to. But then this is so different. I have to read the book. …I've already been big on self-learning and I've come to feel that this class is a lot of self-learning. So I enjoy it. I think I'm learning more, I think I'm learning a lot more than I would in a regular lecture format. I'm not sure that the stuff I'm learning is ever going to be useful to me but I'm definitely learning more.

Perceptions of expectations

Mary entered the course with some idea of what to expect in the course from talking to her peers who had already taken the course. "

> Basically what I heard was that it was really hard and that Dr. Austin has a pair of dice in his desk and that no matter what you do all semester long, he takes out those dice and rolls them and figures out what your grade is (laughter).

While she had heard other people who had taken this course describe it negatively, she didn't agree.

> I've heard people talk about how worthless thermal fluids is. It's a pointless class is basically what I expected going into it. And the first couple of days, you know, when we were sort of reviewing the previous courses, it was kind of boring, 'maybe this isn't going to be such a great class.' But I think learning about turbo fan engines is awesome and learning how to do the open-ended analysis is really cool too. I have yet to have the experience that this class is worthless.

She believed that the active student participation in her course was a factor in making her section of the class worthwhile.

> We want to get things done and we know what we want Dr. Austin to tell us so we ask questions accordingly. I think it does have a lot to do with the way students react to the course….There're students that really like the class and students that really don't like the class. But I think that if you look at their grades, I hate to put the emphasis on the grades, but the students who like the class are going to be the ones that do well. It's not that they like the class because they are doing well but that they like the class *so* they do well…I think that if you try in that class, you would like it. I've talked to people in my class that don't like it all but every single person I've talked to that doesn't like it hasn't done most of the homework, doesn't ever pay attention so they're not caught up to where the class is so they can't ask any appropriate questions. They don't know what's going on so of course you're not going to like the class. It's going to be boring lecture where you don't know what every body's talking about… People that do like it are the type of people that have thrived in the past and enjoy this course because it kind of fits with the way they think. And so they're doing really well. And the people who don't like it would rather do book problems.

After the course was over, Mary described the instructor's top priority.

> I guess his number one priority would be (pause), he mostly wanted people to be able to problem solve with bringing in your knowledge from everything. I really thought that was a big focus of the class, was the fact that you're taking knowledge from a bunch of different disciplines, well, one discipline but we see it as different classes. So being able to take our specific knowledge and being able to apply it to a certain problem. I guess that's what I saw as his priority for this class. I know on the syllabus there were two priorities. One was to solve open-ended problems. And the other was to take knowledge from three different classes and apply it to a single problem. I think the second one was much more important just because we have had a few other open ended problem things and you can't really teach that per se.

Early in the semester she described the instructor's intent in the course as

> He's bringing together three courses into one, basically making a project out of it. I thought it was interesting for him to put the focus on that the class isn't necessarily about learning this thing in particular but having this experience… I think mostly Dr. Austin expects you to participate. I think that's really what he's looking for with people. He's also teaching J and even in there he said that attitude is sort of an important thing to him. Don't sit there and do crossword puzzles in his class because you're obviously not there for why he wants you to be there. I think he mostly expects people to be interactive… I haven't really looked at the project well enough to figure out what we're even doing in the project.… I've read it all the way through. I didn't understand. It was sort of like, 'so in order to do this, you need to do the following steps' but I didn't understand step one so?… I think he mostly expects that we'll try hard and participate.

Mary's understanding of what the instructor expected from them evolved throughout the semester. Initially she thought the course would not require a lot of work. Then she found herself spending a lot of time looking things up in books. However after P1 she realized that the instructor was going to be expecting a lot.

> He wasn't expecting you to regurgitate. He wanted you to learn. He wanted you to figure things out on your own, have your own insights, to talk about them, not just 'Okay, here's the graph.' … We didn't screw up too bad at least and by the end pretty much knew that effort was a really big deal and insights but it was definitely very different from the beginning (as far as what she thought he wanted.). It took me until he read through the project in class one day to really know what he wanted….With P1, I didn't really think about what he wanted us to do except solely within P1 and I knew that we were supposed to determine the thrust requirements so I thought 'okay, this is direct relation' which P1 basically was. It was really easy. It was basically just a cut and paste. And then P2, he wants us to analyze a turbo jet and then I looked back and it said like do some case studies, some simple case studies. I was like 'I don't know what that means. I'm just going to focus on P2. I don't know what he's talking about with the project.'

After the instructor's positive feedback about how her team had done P2, they felt they knew what he wanted from them,

> I think that's when we stopped trying really, really hard. 'Okay I think we got it now. Let's just keep going with this.' That's pretty much what we did for the rest of the semester and he seemed to like it." P2 became a template for the rest of their assignments. "I think we modeled P3 almost exactly after that (P2) and we never got to turn in P4 separately because of the time crunch. Our final paper was sort of, it was formatted differently, but it was pretty much all the same sort of information that we had always included."

Regarding what the instructor liked so well about P2, Mary commented

> I think we sort of went a step beyond. We had the two graphs that he asked for. We talked about the fact that velocity was decreasing or something like that. And then we said "Now, it's doing this because' and we graphed something else. …. We didn't just explain the graph. We didn't just say 'Velocity decreases as you increase in altitude.' We said 'it does it because' and we really went into the because." They used graphs that weren't asked for to support their arguments because "I think that was what he was interested in.

They tried to follow a similar process for P3.

> And then P3…was basically the same as P2. Finally he went over what he wanted for the project. It all made sense but then we couldn't do everything that he asked because we hadn't really accomplished all the goals in the project problems I guess. He really liked what we turned in for the second problem apparently. I mean the grades ranged from like a 6 to 9 and we got a 9…. I hope his view of us doesn't go down after this project but we really didn't make any startling discoveries. I don't know what he liked about P2. I went back and read it and it was very dry and straightforward. No revelations. It was just 'this happens because of this.' I guess that was really what he was looking for. And that's what we tried to include in the, actually we didn't include any of that in the write up. Oops.

By the time she had finished P2 and was looking at P3 and the final project, Mary was feeling confident about her understanding of what the instructor wanted from the students.

> Dr. Austin obviously wants us to complete all the assignments. And he's very interested in you learning material rather than getting the right answer. And for the project itself, basically the project problems set it up and that gets you all the information and then all you have to do for the project is wrap it all up and sort of come up with some of the overall insights and present it in sort of the way

> that he wants which I guess is to a manager, to a boss, who might not know, oh, no, it is supposed to be to ex-military air force pilots isn't it? …. I mean basically just complete the project problems and compile them into a format for the presentation. I don't know, I'm kind of confused as to why people have a problem with the expectations. I don't really seem to have a problem with them.

She liked not having a predefined format for the report. "I can handle making my own format." In fact, she preferred that way. "The checklist is nice but I'd really rather do it myself I guess. …I like to be a little bit more creative than just the standard turn in exactly what the professor asked for." She admitted she was probably unique in that regard,

> at least a minority. I think a lot of it is also that people would be scared to do it the first time. I mean if you've always had that checklist and you suddenly come up to a problem where you don't, you could be very timid about 'oh, well, I don't really know what to include.' and all that but once you get into it and you get validated by getting it back and getting a good grade on it then I think people would like it better.

But she had experience with presentations from art school.

> I also had the experience of getting a bad grade on a presentation cause I didn't do it well which is kind of frustrating. The first presentation I gave, I got a really bad grade on it and it was because I didn't include certain things and I was just like 'I didn't know I was supposed to include those.' I was so mad and then the more I thought about, 'I should have known.' …The thing that also helped was that I was frustrated and I wanted to get a good grade so I tried extra hard, just by getting that bad grade. I think if people would do it on their own just once or twice, they'd be a lot more comfortable with it.

Mary reflected on the role of the right answer in this course.

> I know that it's not about getting the right answer. It's about why it's the right answer … but you need to get the right answer before you can do all that why in the process because the process to the wrong answer means even less than the process to the right answer. … Because the process to the wrong answer is incorrect. You use it to learn from your mistakes but in a report like this, what's the point of 'well we did this and that's because of this and then this is all wrong but this is can what we did?' It doesn't really make much sense. I understand the process of getting to the right answer is important and usually there's a few

> wrong answers in between there but if you never get to the right answer, the process doesn't seem to matter. Yeah, we were pretty defeated by that.

Mary would like to see what the instructor's version of the project would look like.

> I'd like to see what he would give a ten out of ten for a project for. That would be interesting to read. One group would turn in projects that were, like the problems were about twenty pages long, and I know that that group got an 8 out of 10 and we got a 9 out 10 and ours was like 3 quick pages plus all the graphs. It was about a page written or half a page so I wonder exactly what he's looking for. I know he's not looking for a bunch of fluff. … He wants a lot of direct stuff. I want him to do the project. He should do the project. He should really do the project. I don't think he's ever worked it. He should do that because I think he would come across some of these problems that we came across. … That's what I would change about the class is have him do the project first. I think he would learn from it and be able to adjust the project appropriately.

Mary thought it would have helped her to understand his expectations more if the instructor had written comments on her paper.

> It really would have. I looked at some other people's papers that had gotten sixes and most of them really I think were just the graphs and maybe a sentence or two. But he, again, he didn't write anything on them. But that was pretty obvious because he talked about in class that he wanted more. But it was hard for the people that wrote and then he didn't write any comments and they only got a six or seven. It was kind of like 'Well I wrote stuff. What do you want me to write?' And that's sort of where I was but then when I realized that everyone else was getting much lower grades then me, I must be on the right track, maybe I should just write more. It's not like I was missing anything. I just wasn't complete, is sort of what I thought it was. But it would have been very helpful for him to have written some kind of comment. And I'm sure if I had gone and talked to him in his office he would have told me exactly what he wanted me, …I mean he would have elaborated much more. I don't know, I just didn't bother I guess." She pondered that maybe a reason he didn't put comments was that he wanted them to come see him. "That actually could be part of it. He *really* likes people to go to his office. And I found that mostly beneficial.

Mary received an A in the course.

Sami's Narrative

Sami was a very personable, charismatic young man yet I experienced frustration interviewing him because I could not get him to focus on the instructor's expectations. Sami liked to talk but it seemed Sami liked to talk about Sami, not the instructor. Sami was obviously a very intelligent student but his confidence seemed to verge on arrogance at time. As mentioned, one of the difficulties I encountered was not to play mother to the students by pointing out to them the errors in their ways, or beliefs. This was especially difficult with Sami because of his study habits of pulling all-nighters and missing class that I felt needed to be changed.

Getting to know Sami

Sami was born in a small town in Lebanon. He went to French schools in Lebanon and described the French system of education as much more challenging than the educational system in the United States. He earned both his French and Lebanese baccalaureates. While math and physics came easy to him, he didn't study for other courses such as geography, history, Arabic, and literature and consequently "

> I actually flunked them. And even remember getting zeroes on some for finals. I ended up with like an eighty, with a B. So I wasn't the genius because I didn't study but I just had fun, had a lot of fun.

His uncle who lived in the western United States suggested he come study there. Sami attended two semesters at a college near his uncle where he took twenty hours of humanities each semester to get those out of the way before he transferred into mechanical engineering at the university of this study. His mother was actually the one who chose his major and filled out all his paperwork but he has been happy with the degree she chose for him.

Sami said he does not worry much about grades.

> The best way to get an A is not to care about it. I think that whenever I do not care about the grade, I get it. Because you go into the exam and you're not stressed. And whenever I'm stressed and whenever I study extra for an exam,

> extra hard, and go in there and I mess up. So I kind of take the calm, easy way. ….but if I get a C, doesn't matter. It's not the end of the world.

While claiming to not care about grades, Sami did seem to take some pride in his GPA.

> I was a 4.0 and I had a year where I totally messed up and I took my GPA down to a 3.5 and I'm talking about three, four C's and three, four B's so a lot of people are amazed that my GPA is 3.5 still.

He wanted to keep his GPA a 3.5 so he could be admitted into graduate school, possibly in heat transfer.

Sami's academic habits were characterized by both a history of high absenteeism in his courses and a tendency to stay up all night before tests. His high absenteeism had resulted in lower grades in several of his courses, contributing to the decline in his GPA. He described his perspective on attendance.

> I kind of dislike this old fashioned way (counting attendance). I like it very easy going and as long as I'm doing the thing at the end, that's what I'm supposed to do. Like I know for sure that I miss classes but on the exam I really do good. Some of my classes, if you look at my exam grade, you say well 'that's an A student' but most of the time the professor ends up giving me like a B or a C just because (of low attendance).

Compared to his classmates in this course, he had lower attendance but from his perspective, compared to his attendance record in some of his other courses, his attendance was high. "You know I have a bad record of attending classes. So now I have a very, very good record according to me in this class." The reason he would miss class was that he stayed up all night working on his assignment or studying for a test in another class and then he would need to sleep all day.

> I do like coming to class and I missed it today because I really wanted to finish the project. …I was up and I started working on the project at five o'clock in the morning and since then I've been working on it. And I came in just to hand it in.

Sami did recognize that Dr. Austin expected him to attend class and that participation was part of his grade. However, he was surprised to find out that Dr.

Austin took attendance. Still Sami did not seem worried about his low attendance affecting his grade in this course

> Well, I'm doing my project and my homework and I did pretty good on the quizzes.… I do like coming to class. There are classes you like to come to and there's classes you really don't enjoy much…I like the professor and I like the class, the environment, the students…. you want to sit there and see what's going on. I felt bad about missing today.

Sami had a strong need to understand everything about a problem.

> 'Let's say we have a project and we divide it into pieces, everybody has a piece. Even at the end I'd like to know how the others got their system even if I didn't have time to do it… But I have to understand what's going on, even though I have the solution, but I have to understand what's going on. So that's the trick. When I start doing the project, I don't want to 'well what's that?' I don't want to have to go back to the book. I want to have everything in my head.'

Sometimes Sami stayed up all night studying just because he enjoyed the material.

> I remember one day I really studied very hard and I stayed up all night for this class. And I was reading a lot of things and opened the middle of my journal and I started writing… Once I get into it, I can't stop. And I finish it off. That's why I sometimes stay up all night without feeling the pain of my back or something like that because I'm so much into it. The hard part is actually opening the book. The hard part is actually getting me started. But once I get started, that's no problem. I won't stop. Getting me started is the problem. And I'll be like, 'okay, no, no, no, I'll eat some cheese and I'll have some toast with jam and I'll watch a movie and I'll sit back and relax. … then until I really have to do it then I start doing it." This is usually after midnight.

Course experiences

He received a grade of 6 out of 10 for the first project problem, P1, due to a lack of comments. Sami generated all his graphs in MATLAB but did not realize he was supposed to include comments. Sami asked whether there was a piece of paper stating this requirement. "I think because we didn't know, most of us didn't know what we were supposed to do on these project problems. I could have written a lot of things." Regarding the problem methodology the instructor provided at the beginning of the

semester, Sami said, “I don’t think anybody read it. Really, it was too long.” Sami was concerned that he might have been absent when the instructor provided instructions about including comments or that these comments were made after he had handed in his P1. Later, looking back at his P1, Sami commented that it all looked easy now. “This looks very easy. I can’t believe that, like when I was doing this, I thought ‘oh man, I don’t want to do this, where did I get that from?’ Now it looks so easy.”

Sami worked alone on A8 and even missed class to work on it, trying to determine where an error was occurring. He went to see the instructor after the class that he missed. The instructor pointed out that he needed to multiply by 1000 to keep his units correct.

> I kept doing this mistake over, I even did it in this project. I think the problem with it is you don’t get back your stuff in time you can’t really see what your mistake is and unless you really go and bother the professor.

He was very proud of his model.

> I’ve set up mine so that if he adds up anything, I won’t have to restart. I’ll just add to it….I can plot the results, whatever results he wants. ….basically I was redoing A8, A9 and A10 in a better organized way.

Sami attributed his work habits to working better under pressure.

> It’s just that I, if I’m not under pressure I just leave it and that can be a problem for this class. I am falling behind on concept questions. I have a lot of them to finish.

For this course, he is reading the chapter and the assignments. He didn’t use the library but worked at home.

> I do have the books. I have all the books. I’m a very homey person. I like everything to be at my house. If everything isn’t there, I won’t start working …It’s not like I’m a social person but I think I’m just a very homey person. I like to work in a place that’s comfortable and that I’m used to.

Sami had worked alone through most of his academic career. He missed his first team meeting to work on P2 because he had pulled an all-nighter the night before studying for a test in another class. He did not seem bothered about missing the first meeting since he had emailed his teammates at the last minute that he wasn't going to attend the meeting.

> I didn't miss it. I told them I wasn't coming because of this. ...So when I woke up, and I emailed them, it was too late. Nobody answered. And I thought 'well, they're just going to hand in something themselves.'… I woke up way late at night and at that point I couldn't email them, couldn't call them to see what happened with them so I just assumed that they already did it and they worked it out so I just started working by myself.

But he had finished his homework while his teammates did not. When he did finally meet with his team he found that "they hadn't done anything" so he helped them. "I had the project done at that time. I was going to hand it in but thought, 'no, if we just hand it in all together.'" His teammates wrote the conclusions. "It's just that I gave it time and set it up and wrote it in a nice way and all this." He was disappointed with one teammate.

> I told him 'all you have to do is just read it and change whatever you have to do, add some comments if you want, or just do whatever you have to do by Monday at 6 and that's because that's when I'm going to be working on it again'. That's a week after I actually worked on it. 'At that time I'll be adding all your comments' and he emailed me on Monday saying that 'Well, I'm going to be working on it tomorrow morning.' and I was like 'No, I'm not going to wait on you. I'm going to finish it up right now.' So I would say (this teammate) didn't do much. But I think that he knows what the thing is.

Regarding his other teammates, "They didn't do a lot but I think they did their fair share." They turned in P2 as a team.

By late October Sami admitted he had "slacked off" and was falling behind on his concept and analysis questions and needed to do some reading. He felt like he was running behind in class, missing class in an effort to catch up. He even missed a quiz. But he felt he was ahead because he was not as far behind as some of his classmates. He

had been handing his analysis problems in on time until A11. He attributed this recent lack of attention to this class to "other classes and organization of time really. I have a problem with that. But I'm getting back on track." At this point, Sami had mixed feelings about the instructor's flexibility with homework deadlines. He believed the instructor should put a limit on how long students had to turn in assignments. "I think he should state like 'two weeks is more than enough.'"

By early November Sami believed he now knew how to do the project problems and had 'more an idea of what the professor wanted.

> More organized. Like you look at my P1, it's really horrible. I don't know why I handed it in that way. I guess mostly like I said, I didn't know what he expected but I wouldn't hand it in like that. … I think pretty much that would be how he would need it. Okay, what's the given. The assumptions you used.

He realized what the instructor wanted after he read through the instructor's methodology but "that was after P1… I think I realized that he needed it after I handed it in. I'm pretty sure I did cause at that point, if he's this tough, why tell me?" But Sami had some issues with the instructor's methodology. "I think this is cruel. General equations, just writing them down. Why not just write it down when you need it? But I think assumptions are important." He followed the instructor's methodology on P2 but thought. "It was tedious because it takes all the fun out of doing the project." He described that for P2 he wrote the assumptions and governing equations for every component and he thought

> That's kind of better. Like what are you going to use this for? I kind of think that's better. I went through the process, I went through explanation of it, like how he got the equations, the efficiencies, if you take the efficiencies across small increments.…But on that analysis problem, I didn't write any comments. I think maybe that's why he dropped a point.

Sami recognized that the analysis problems were "not just plug and play kind of thing. You have to plug it in and know what's going on. …That it's going to prepare you for what's coming next?" Sami described the concept questions as "horrible" and thought that he would not need "most of this stuff' again."

While working on P3, he was feeling confident in the course but would have liked to have had his P2 assignment returned.

> The only thing is I'd really like to see how he graded P2 before I hand in P3. I'd like to see if he wants me to change anything in the way I presented my formulas, my plots, my analysis.

He had made changes in how he did P2 after his P1 was returned. For instance he typed up P2 but didn't type up P1. "And it took a long time because of the equations." "A13 was necessary for solving P3. While working on A13, he commented

> I know how to solve it (A13). So we got A13 solved and it's pretty much building on that. We just need to put it on Microsoft Word or put in the effort and to finalize it. And then solve for P3. It's the same as P2 isn't it? I'll probably know by tomorrow ….I think I'll know tomorrow if I'm comfortable or not, depends on how I solve it. I think I can do it. I've talked with the professor a couple of times regarding some of it and I feel comfortable about it.

Sami described P3 as

> pretty much A13 and 14 and this time basically everybody knows what they're doing. You know, they solve the problem. All we have to do right now, basically it's my job, is to put it in MATLAB, to come up with the plots…. So, probably that will be tomorrow and we'll be done with it.

Sami was the MATLAB person in his group and had the software installed at home. Sami was "pretty much" happy to be the MATLAB guy. His teammates didn't know MATLAB so he felt everyone was happy with the arrangement.

> I think I'm more like a mathematical person. I like to analyze, get the analysis done. Like the actual theoretical analysis more than the 'what does that tell us?'…The other guys focused more on getting deductions. They did more of the writing. I like working on MATLAB and getting your file all neat and then you push a button and everything comes up.

As his team approached P3, Sami was not concerned that his team did not meet regularly.

> Well, we don't have to, right? We don't have to really unless it's a project problem. P3 is due on Thursday and we're going to meet on Sunday…. I haven't even read the problem. Cause one of the teammates was saying let's meet Wednesday but if a lot of us are not on track and some of the other people are still doing project two and some of the teammates that were still A12 and A13 and I haven't even done A11, I can cram it. Most of A11 was put on the board.

For the final project, which included P3 and P4, Sami's team divided up the project and Sami did "the thing that's related to Project Number Four….In order to get Project Four, I had to do P3." Regarding the results

> I didn't have time to say 'well, is the results right or accurate or what the professor wanted?' I didn't even check. I did use the right equations I think…I got turbo fan to be much better than turbo jet which makes sense… I had it right. But the thing is, I did that like at the last second.

That last afternoon before they turned in their final project at 6 PM was a disaster. His MATLAB software at home was not compatible with the software on campus so they were not able to print his plots on campus. He had not slept, and then he was caught in Friday afternoon traffic when he tried to go home to print from his MATLAB program.

> All this happened at the last second. But I did write like a very small paragraph on what's happening on the graphs that I created. I told the professor that if he was to grade me on the MATLAB file, I'd get a full mark but I don't think I'm going to get a full mark. I didn't comment enough.

Perceptions of expectations

When asked directly what he perceived to be the instructor's expectations for him for this course, Sami admitted that he was avoiding answering this question. "Subconsciously I'm running away from this question." Sami seemed to think there was a specific answer he was expected to provide about his perceptions of the instructor's expectations. "Tell me specific what you want me to answer." He was not always aware of expectations the instructor expressed orally in class.

> I didn't pay much attention in the beginning of class, everything he was saying about the class expectations. I just thought 'if I want to know anything about the class, I'll just read the syllabus.' And I really didn't understand the gravity of the situations.

Sami's absenteeism resulted in at least one other occasion when he was not aware of assignments made in class. Sami missed the last week of class so was unaware of assignments for their notebooks made orally in class. His response when he found out that he was supposed to have included his reflections was that he did not get that form, but there was no form.

Early in the course he had a vague idea of the final project description.

> He's going to build up on this. I don't know how far he's going to take us. Is he going to give us like design issues on an aircraft? Or is it just going to the engine most of the work, thrust and drag and this kind of stuff? I'm really not sure where we're headed but I am pretty sure about where we are right now.

The instructor had told them that the analysis problems would now be requiring more time and the concept questions less.

> Give more time to analysis problems and that exactly happened naturally with me before he even said it. Before that, concept questions, I used to give them more time. Before that, I read through and this kind of thing and the analysis was very simple and just you solve it like that. And now it's kind of like flipped. And now the analysis problem you have to really look into it and find where that is from here and there in which book. As for the concept questions, I haven't looked at them, not much of them.

In early October, Sami described how he saw the course.

> Up til now, we're really working on an engine, a turbojet engine and it's oversimplified the way we're studying it and analyzing it as in the isentropic processes and the burner being the pressures being equal, that's not right. And a lot of things like that. I think what he's trying to do is he gives us a simple way of looking at it and then he builds up on that, step by step, and you can feel that through from A8 up to the project problem (two). If you can compare them, A8 was pretty much simple although it was a huge step but there are steps from A8 to the project problem.

By late October, Sami had read through the final project and related it to the project problems.

> I think you could answer like one question of it from P2. …I see where he's going with it…. It's a real problem as if you know some company hands you this thing and they want you to analyze this engine for them and you get all these kind of plots." He needs the plots "to get an understanding of what's happening on each component. How the pressure, temperature is dropping or increasing and how you can improve the engine based on that. … I think of the project as a combination of everything we're learning right now. Kind of like that.

He also agreed that this course was preparing him to be an engineer "more than the others."

Sami recognized that this class was different from other classes.

> As I said, it's the way you study for it. It's the way you prepare for it. You prepare more on a weekly basis or a daily basis, whichever way you like. Lecture-based classes you have to work like, you can manage opening the book maybe once a month. I don't think that works in this class.

After successfully cramming for classes most of his academic life, he was having to change his habits for this course.

> You kind of say 'Yeah, I can do it one day. You kind of depend on your smarts. You know what I mean? My mother always told me 'One time, it's not going to work for you. One time you're going to fall.'…That'll never happen.

While he is falling behind, he believes he can catch up.

> I usually don't worry much about things. I'll manage through it in the end. I think Dr. Austin doesn't care about deadlines which is a good thing. It's an extra thing I love about him. You know you kind of come in and hand in the homework that was due like at the beginning of class. I think he doesn't even mind as long as you do it.

Sami believed the lack of deadlines was because the instructor wanted them to learn more.

> I think it's, if it's a deadline and okay coming up, lining up the equations and doing something and you really didn't let it go deep in your mind as in really rest in your mind and settle, that's the word I'm looking for, settle in your mind, you just forget about it. …So you know would have to actually start working or actually have a draft by that time, but you know that you can go back and ask him questions.

One message Sami had perceived from the instructor in this course was the importance of self learning and preparing for class.

> I got this message that if you want to learn from this class you have to work by yourself. Basically you have to do your research and your reading and your homework because in class basically he is not lecturing so if you're not reading the chapter at home and you come to class and somebody asks a question and the student's probably confused so you're getting something from a confused point of view and the professor builds on that so you're not getting the whole thing from the class. I think that's a very new way of learning for me because as I said, I went to a French school. It's (the French school) pretty much lecture. Pretty much the teacher, centered around the teacher.

In general, Sami felt he understood what he instructor expected from him although the expectations were different from those in previous classes.

> It's totally different. First of all there's no lecture in the class. So you're going to class, it's more fun. You enjoy the class better because it's not just monotone lecturing that sometimes you're asleep and just 'okay, I can read this in the book later.' Know what I mean? You don't have to pay attention. But, in the question and answer kind of thing, a lot of times interesting questions come up. Sometimes things that you might not have known. And sometimes, some questions that are 'okay, why did he ask that question?' and this kind of thing but that's fine cause it happens in lecture too. It's not like a big difference.

Sami also felt the instructor was very knowledgeable.

Reflecting back on the course, Sami thought the instructor's number one priority was to

> know how an engine works. The turbo jet, turbofan. … Since the project was based on airplane design and engine design, so I think he wanted to teach us that, it was more like, it wasn't what he was teaching. It was more like the way, the way of thinking. The project itself. It's more realistic than your just typical

> problem solving kind of thing. So I think that was one of his priorities, to give us a real life kind of problem. And to give us a shot at solving it. There's not a right answer. Your friend can have different answers than you, different graphs.

Sami was comfortable with different people having different answers but felt others in his class were not.

When the course was over, Sami admitted that he had an attitude problem but still defended his absences.

> I was like 'I know what's going to go on. I have to come to class.' I have an attitude problem. Towards attending. …He probably will take off points for that. And I, the thing is, in the syllabus, it doesn't say attendance. It says participation. And whenever I attended, I did participate. Right? So if he takes points, I can go and argue. He already told me something about he has to be fair. But you can play on words there. Attendance is different from participation.….I'm not talking about participation. I don't care about that. It doesn't matter. If I did care about it I would come. But I think he, at the end the professor will look at a person and if you got a C and he says 'the guy impressed me,' then he will change it. I would. I would if I thought this guy, 'he did work, I saw him. Well, he didn't attend a couple of classes or he messed up on a couple of homework. Doesn't matter.' At least that's my way.

In the past, Sami had relied upon cramming and memorizing to prepare for tests in lecture-based courses.

> But as for this class, every week there's work. I think every week there's an exam because since I study only on exam days and I have to study for this class and I have studied for this class so every week is an exam for me so I think you learn. I am learning. I think I would learn more in this class than other classes or if it was a lecture based class.

Sami recognized that he was learning differently in this course but didn't know if he would have learned the material as well in a lecture based course. Sami also recognized that he could not use memorization and cramming strategies for this course.

He hoped to receive an A in this course

> but I don't know… What scared me, at the last second, I didn't know that we had to hand in all that stuff. (the homework binder.) "I was like 'what?!' And again I went back home and I came back right before we handed the project and

> we had to put all this stuff together and I didn't even put them the way he wanted. And there was this evaluation." (Sami also missed the last week of class, both days, and was not aware about handing in the reflection, etc, that were assigned orally in class the last week) Sami commented that he did not get the assignment about the team contribution and reflection on the course. I told him it wasn't a form, you just wrote it up. "Oh well, it doesn't matter really.

Late in the semester Sami expressed concerns about his grade for the course. While he had done well on his quizzes so far, his concerns were how his absences would affect his grade.

> Three of my quizzes that were handed back, I think I got a ten. I missed a quiz but he drops one. Last quiz he was asking about A13 and I think I did well. Whatever, I still have a very good grade on my quizzes. As far as the homework, I'm doing my homework… See the only thing I'm worried about in Prof. Austin class is that he might take off points over attendance. I'm not worried of getting an A in perspective of actually doing the stuff and getting good grades but I'm worried about if he took points over attendance. I tried to talk to him about it but he said he has to be fair to everybody else. But the way he said it, he doesn't have a rough kind of thing like I take off ten points for every class you miss. It was more like, ten percent participation. Well that is very vague, by itself is very vague. When I miss a class doesn't mean I don't usually participate in class because I do. Whenever I have something on my mind I say it. I think that's participating. 'Okay, he missed classes but he's participating when he's here.' It kind of balances out.

Sami received a B in this course.

Chapter 6: Discussion of Results

The purpose of this study was to explore how the interactions between the instructor's behaviors and students' behaviors affected the students' learning behaviors in a project-based engineering classroom. According to the theory of planned behavior, a student's intention to engage in a behavior is the best predictor of that student's actual engagement in that behavior (Ajzen, 1991). Therefore, for a student to engage in an instructor's expected learning behaviors requires four occurrences as shown in Figure 11 below.

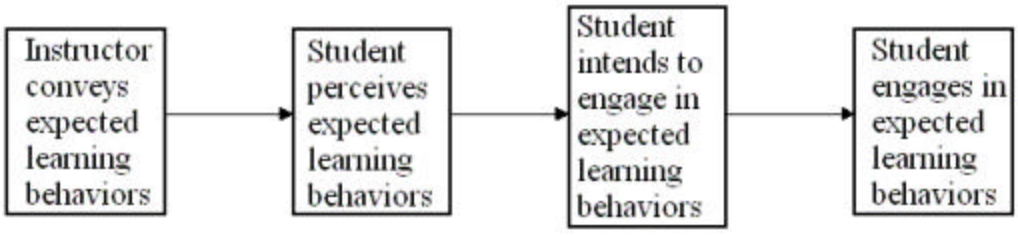


Figure 11. Necessary occurrences for students to engage in expected learning behaviors.

The four research questions proposed for this study were related to these four occurrences.

1. How does an instructor convey his expectations of student learning behaviors to his students?
2. How do the students then perceive his expectations for their behaviors?
3. What learning behaviors do the students then actually choose to employ?
4. Why do students choose those learning behaviors?

In this chapter, I use the results presented in Chapters 4 and 5 to propose answers to these four questions. Answers for the first three questions came directly from my observations of the classroom and interviews. Answers for the fourth question were more speculative. In interviews I focused mainly on Research Question 2 and did not address Research Question 4 directly. To answer Research Question 4 I had to rely more upon interpreting the students' actions and comments in interviews based upon existing behavioral theory. In responding to these questions I grouped the first two

questions and the last two questions together for continuity and clarity. I also looked at how the gap between instructor expectations and student perceptions of those expectations was narrowed. Finally I compared how the results of this study supported the model that I proposed in Chapter Two.

1. HOW DOES AN INSTRUCTOR CONVEY HIS EXPECTATIONS OF STUDENT LEARNING BEHAVIORS TO HIS STUDENTS?

2. HOW DO THE STUDENTS THEN PERCEIVE HIS EXPECTATIONS FOR THEIR BEHAVIORS?

In the Classroom

A learning environment including clearly conveyed expectations has been shown to be a strong predictor of student satisfaction (Lizzio, Wilson, & Simons, 2002). Based upon my classroom observations and interviews with the instructor, the most obvious method the instructor used to convey his expectations to his students was to explicitly tell them what he wanted either orally or through text. He devoted most of the first day of class to describing his expectations and the pedagogy of his classroom. He explained to them what he expected as far as their learning behaviors.

He further clarified his expectations in the course syllabus (Appendix A) where he explicitly defined the objectives of the course as well as how the course was structured and the instructional pedagogy to be used. Scattered throughout the syllabus were requirements or expectations of the students such as to keep a journal and a homework binder as well as the need to do their homework.

The instructor further emphasized his expectations of the students, and the importance of the syllabus, with the first quiz. The two questions on this first quiz were:

a) What are the two primary objectives of this course?

b) Why have we adopted a different pedagogical style in this course?

Both of these questions had been addressed on the course syllabus and orally in class. The class average was high for this quiz but then the instructor had told me

> I think on this quiz, I'm going to give high marks to everybody…This is the point at which a good attitude, going along with me, is going to get you a good grade, and so I'm not going to ding anybody in particular.

The lowest grades on this quiz were 4 out of 5. The positive response on this quiz might be taken to indicate that the students do pay attention to the syllabus, contrary to evidence by Smith and Razzouk (1993) suggesting that students do not pay adequate attention to the syllabus.

Based upon classroom observations, the students seemed to take what the instructor wrote - on paper or the board - more seriously than what he just said in class. Observing the students in the classroom, many were not writing when the instructor was just speaking but picked up their pencils and began taking notes once he began writing on the board. Sami seemed especially prone to expecting all assigned tasks to be in writing and to discarding as unimportant anything that was not on paper. Or perhaps this was his way absolve himself from responsibility when he failed to perform an assignment given orally in class and at a time when he may not have been present.

Outside the Classroom

The instructor encouraged his students to visit him outside the classroom and he made himself very available, not just during his office hours. Barbie commented that "he's the first professor that I've ever heard that gives out his home phone number for students so that tells you how committed he is to his job." His conversations with the students outside of class were critical for expressing his expectations to the students. All four participants sought information from talking with the instructor in his office outside of class. Mary mentioned several times his casual but very positive comment to her in the hallway about her team's efforts on P2. She described how this casual comment not only communicated to her that her team was on the right track but that the other teams were not turning in what he wanted. But not all students visited the instructor in his office. "Heavy D" told me that he only went to see Dr. Austin in his office once and that was with his team.

Problem-Solving Methodology:

The instructor tried to convey the need for an organized methodology for problem analysis and solving. He provided a copy of his problem-solving methodology (see Appendix B) very early in the semester yet the students did not seem to pay much attention to it, or not at first. Some students considered it a waste of time. On the posttest, one student talked about the redundancy the instructor wanted with his methodology. Perhaps the students who did not adopt the methodology did not see how it would be beneficial to them. If they didn't see the task of using the methodology as beneficial then they might not choose to use it. Students value a task if they see it as being useful in reaching their future goals (Miller, DeBacker, & Greene, 1999). Eccles expectancy-value of motivation theory also relates students' beliefs about a task and their expectancies for success on that task "directly to their achievement behaviors: performance, task persistence, and task choice" (Warton, 2001, p. 156). Still, some students did start using the methodology, particularly after P1. Perhaps they began to extrinsically value the methodology when they realized that using it might please the instructor thus helping them reach the proximal goal of completing the course with a good grade.

Modeling

Brookfield (1990) claims that teachers are significant role models to their students even though they modestly underestimate the significance of their action. Dr. Austin consciously modeled the learning behaviors he expected his students to exhibit. For instance, in class he would look up information in a book. Standing in front of the class, he would open the book, look up a subject in the index then go find the desired content, consciously modeling for the students learning behaviors he expected them to follow. However, I'm not sure how well the students grasped what he was doing. I asked students in the focus group about this practice.

Researcher: When he doesn't remember stuff, he goes and looks it up in the book. What do you think?

Student 1: I think that's all right.

Researcher: When he's doing that, do you think he's trying to model anything for you?

Student 2: Oh is that what he's doing? (Laughter)

Researcher: Maybe when you don't know something you go to the index and look it up.

Student 2: Oh yeah, he has mentioned a little about that.

While they seemed to grasp what he was trying to do, they weren't particularly enthusiastic about this practice.

Through the solutions to A8 and P1 the instructor posted online, he modeled for the students the problem-solving process he expected them to follow based upon his explicit problem-solving methodology handed out the first day of class. Bill particularly mentioned how these examples were helpful for both showing what the students may have done wrong as well as what the instructor was looking for.

Grading

Grading was another way the instructor conveyed his expectations. For P1 he used grading to get his message across that comments were important. Students who did not include comments earned a score of 6 out of 10, even though their graphs were correct. When they submitted plots with no comments then lost points for not having comments, they realized that the instructor expected them to include comments, consistent with research suggesting that students' learning behaviors are affected by how they believe will be assessed (Marton & Säliö, 1976). While Barbie didn't understand what he originally wanted on P1, she did feel later that she not only understood what he wanted but that if she polished it up she was sure he'd take it.

Grades or other assessment practices in the classroom influence student behaviors. For instance, courses with harsh evaluation practices may drive students towards more performance-avoidance behaviors to avoid failure (Church, Elliot & Gable, 2001). While students and instructors often share the same views towards learning and grades, they often misjudge the value the other party places upon grades (Pollio & Beck, 2000). The students and the instructor in this course did not seem to

share the same perspectives on grading. The instructor tried to focus on student learning. He did not like grading which might be one reason he was not prompt about grading and returning assignments. He tried to be objective when grading by using student identification numbers instead of their names. Still he structured quizzes and other components into the course to provide opportunities for grading.

The students were very focused upon their grades, supporting earlier observations that sometimes students care more about a high grade than learning the material (Pollio & Beck, 2000). Many were seniors interviewing for jobs. In a discussion I held with the class one day (See Appendix P) when the instructor was out, the students were very emphatic about the importance of their GPA's for getting a good job upon graduation.

While the instructor may not have intended this, the students also sought to understand his expectations by comparing how they were graded with how their peers were graded. For instance, Mary talked about how she wrote extensively on the concept questions and received the same grade as other students who wrote much less. The instructor also expressed concern that some students were overly anxious about how their grades compared to their peers' grades.

Affirmation

The students wanted affirmation that they were on the right track. Lunyk-Child et al. (2001) also found this "need for reassurance" (p. 121) in nursing students exposed to self-directed learning. The students in my study expressed a desire for more feedback and comments as a way of knowing if they were meeting the instructor's expectations. However they expressed disappointment in the lack of comments from the instructor and teaching assistant on their papers. Bill expressed the need to have something to benchmark against. The instructor's solutions for A8 and P1 helped provide such benchmarks. When the course was over, Mary expressed a strong desire to see how the instructor would have done the final project.

Students also determined instructor expectations and sought affirmation that they were on the right track by looking at what their classmates had done. Both Mary

and Bill talked about communications with classmates on other teams about what their curves looked like. Barbie seemed to spend more time working with the instructor and TA than classmates. Sami spent some time with the instructor but for the most part seemed to be a loner. He did not mention seeking help on his model from other classmates.

This need for reassurance may be related to affective factors such as self-efficacy and anxieties. Recall from Chapter 2 that students' self-efficacy beliefs affect their rate of performance and energy expenditure on a task and influence the stress, anxiety and depression they feel towards a task (Zimmerman, 2000). Hancock et al. (2000) found that highly anxious students perform better in a more teacher –centered classroom where they can receive more direct attention from the teacher. The student-centered environment of this classroom may have increased levels of anxiety in some students, possibly more so in those students with lower self-efficacy when addressing open-ended projects. If they felt they were going to fail at the assignment then they might not continue to put forth the necessary effort. Encouraging feedback that their efforts were worthwhile may have been important for those students building their self-efficacy beliefs for performing open-ended projects.

Survey Results

Based upon the results from the interviews with students, the focus groups, and the data gathered from the pretest and posttest surveys, the students did appear to increase their understanding of what the instructor expected of them. The thirteen categories that I derived from the student responses to the first item on the pretest and posttest (See Appendix J) suggested a change in their understanding of the instructor's expectations. The first twelve of the thirteen categories can be considered to coincide with expectations the instructor expressed in class, in text, or in interviews. Based upon the results of this survey, the instructor's methods for conveying his expectations must have been effective, at least for some students.

Category	Mid-semester (% of respondents)	End-semester (% of respondents)	End-semester – Mid-semester (% of respondents)
1. Make engineering decisions	46	29	(-17)
2. Design/analyze engine	60	26	(-34)
3. Effort and initiative	20	29	9
4. Skill, understanding and knowledge gains	6	45	39
5. Not about right answer	14	32	18
6. Solving (open-ended) problems	40	45	5
7. Importance of process	14	26	12
8. Real world applications	29	32	3
9. Seek and use external resources	26	29	3
10. Work with others	20	23	3
11. Increase understanding of Thermal – Fluids	63	29	(-34)
12. Make connections	29	19	(-10)
13. Dazed and confused	34	13	(-21)

Table 5. Categorical results from Pretest and Posttest.

The responses on the pretest were weighted more strongly towards traditional expectations than on the posttest. For instance, 63% of the respondents mentioned increasing their understanding of thermal-fluids on the pretest but only 29% of the students mentioned this on the posttest. My interpretation of this change was that at the end the semester the students were more focused upon other newer expectations and this more-traditional expectation was no longer as important to them. Responses in

other categories such as the importance of process and that this class was not about right answer – less traditional expectations that the instructor emphasized throughout the course – increased on the posttest. These changes correspond with the changes Barbie described that she made in her understanding of the instructor's expectations of her as she realized that the course was "more about looking for resources as opposed to learning thermal fluids."

The biggest increase from pretest to posttest was in category 4, skill, understanding and knowledge gains. The respondents who identified this category as an instructor expectation jumped from 6 to 45%. The decline in category 11 corresponds to this increase in category 4. The difference between the two categories is that items counted under category 11 specifically mentioned an increase in knowledge in thermal fluids courses while category 4 was less specific. Had the two categories been combined, these two trends might not have been apparent.

One interpretation of the shift in expectations from the middle to the end of the semester would be that this shift indicates that the students changed their understanding of what was important in the course. In responding to the open-ended request to describe their understanding of the instructor's expectations, I made the assumption that the students responded with those expectations they valued most or at least considered most stressed by the instructor. Nunan (1995) proposed that the gap between teacher and instructor expectations may be due to while "the teacher is busily teaching one thing, the learner is very often focusing on something else (p. 134-135)." These results suggest that the gap between what the instructor was teaching and what the learner was focusing upon may have decreased over the semester, at least for some students.

3. WHAT LEARNING BEHAVIORS DO THE STUDENTS THEN ACTUALLY CHOOSE TO EMPLOY?

4. WHY DO STUDENTS CHOOSE THOSE LEARNING BEHAVIORS?

I paired these two questions together because describing "what?" seemed to naturally lead to the question "why?" While the behaviors the students engaged in were

apparent through personal observation or conversation with the students, why they chose the behaviors was not so apparent. In retrospect, I don't recall explicitly asking the students why they chose any of their learning behaviors. If I could go back in time, I would ask them. But since I didn't ask them I can only draw from what they did say to propose possible answers.

Learning Behaviors

Students did seem to make changes in their behaviors and began to engage in the instructor's desired learning behaviors such as putting comments on their papers, particularly after P1. Still, they expressed some resistance to following the instructor's methodology. Sami and Mary both seemed to view aspects of his methodology as unnecessary or as getting in their way. Sami referred to the instructor's methodology as cruel and tedious and described it as taking all the fun out of the project. Mary did not like using an explicit problem-solving process. She told me that when instructors defined a problem-solving process in the past, she would solve the problem on scrap paper then go back and fit her solution to their process. Their behavior seemed to reflect the basic postulates of expectancy value theories in that they did not seem to value the instructor's methodology as beneficial so did not choose to use it.

Mary exhibited learning behaviors that could be described as meeting the instructor's behavioral expectations – reading and researching, coming to class, working with classmates, working on assignments, visiting the instructor in his office. These are learning behaviors that are typically associated with academic success. Unfortunately, the learning behaviors Mary engaged in led her to frustration and burnout at the end of the course. Mary experienced extreme frustration – something new to her – when she did not think her computer models were working correctly despite significant effort. While such feelings of frustration have been described as normal for students transitioning to student-directed learning (Lunyk-Child, Crooks, Ellis, Ofosu, O'Mara, & Rideout, 2001), Mary may have transitioned too far. Mary seemed very focused on the correct answer, or at least correct trends, even though she recognized that the correct answer was not the instructor's intent for the experience. Adding to her frustrations was

her apparent definition of the right answer as being how the instructor did his model. Since the instructor didn't necessarily create all the models, or not until after the students completed their models, Mary was not able to find the right answer for comparison because it literally did not exist.

Still I did not interpret Mary's drive to find the right answer as rejecting what the instructor had said about the intent of the course not being to arrive at the right answer. I interpreted this drive towards perfection as due to a real desire to meet a personal challenge of successfully completing the learning task as she defined it. Mary seemed to be an autonomous learner with high self-efficacy regarding the assignments. In later conversation with the instructor, I asked him which was more important– learning the material or producing a final product to turn in? He chastised me for even having to ask such a question and emphasized that learning would always take precedence over product.

Sami could also be described as an autonomous learner with high self-efficacy for this task. Sami was very focused upon learning the technical content without an apparent awareness that the instructor also expected him to develop team skills as well as to come to class rather than pull all-nighters then miss class because he needed to sleep. He understood that his instructors expected him to attend class but he did not seem to see this behavior as important to his learning. He did not seem aware, other than acknowledging his poor time management practices, that some of his learning behaviors might be detrimental.

Both Mary and Sami seemed ingrained in using the same learning behaviors that they used coming into the class. Bill and Barbie seemed more open to changing their learning behaviors in response to the instructor's expectations. Both Bill and Barbie seemed to use the instructor's expectations as an aid to help them focus upon what they needed to do. They seemed to take what he said or wrote more literally in trying to find a way to trim down their tasks. For instance, towards the end of the project Barbie was very frustrated with Mary and another teammate who were very focused upon getting their team's computer model working perfectly. Barbie felt they had spent enough time working on it unsuccessfully and that they should seek external help. She believed this

was what the instructor would want them to do. Barbie needed to use her time efficiently and didn't have time to waste seeking perfection, especially when she didn't think that the instructor wanted perfection. She used her perceptions of the instructor's expectations to help her justify the behavior of seeking help.

Bill used the instructor's expectations to lessen his workload. He mentioned how his team saved a little time by not doing P4 since the instructor had made P4 optional. Still, Bill was very explicit in distinguishing, or perhaps rationalizing, what his team did by not doing P4 from what other teams were doing by shaving off required parts of the final project. He seemed to still be trying to meet the instructor's expectations to turn in a complete project and not slip something by him. But then he also didn't have time to do anything that was not absolutely required.

Workload

Student perceptions of a heavy workload can lead to more surface learning approaches (Lizzio, Wilson, & Simons, 2002). The students perceived the workload in this course as heavy. Bill and Barbie's workloads were not limited to the demands from their courses. They seemed to share a plot of getting through the course as they juggled the rest of their lives. Because of their personal conflicts – family, work, job hunting – Bill and Barbie were not always able to do what was expected at the moment. Barbie was married and a mother. Bill was engaged and actively interviewing. Sami and Mary seemed to have less demands on their time. Neither Sami nor Mary worked. They were both single. Sami and Mary's workloads were more restricted to their coursework. They were able to focus their energies upon school. Barbie and Bill did not have this luxury to focus all their energies on school.

Barbie frequently described frustrations with classmates who wasted her time or expected her to adjust to their time schedule that did not work for her. Barbie had a young daughter to put to bed at 8 PM. She wasn't available to meet at night like her younger, single classmates. She missed class for a week when her daughter was sick. Managing her time was a continual struggle for Barbie. Her limited time was probably a

factor in her desire to seek external help at the end of her project. She didn't have time to seek perfection with the project like Mary did.

Bill was working much of the semester, interviewing for employment, and trying to finish his senior project. He described that semester as "busting it." He had worked at a local department store for four years while in school but had to quit towards the end of that semester due to the demands of his senior design project. The instructor mentioned that "the guys in K all madly did everything the last week or so after K finished and turned in all their back homework." Bill was one of the K guys. Then at the end of the semester, he couldn't be in the lab until 6 PM on Friday the day the project was due like other students because his family had come into town the day before for his graduation the next morning.

Two students in the focus group talked about how the workload affected their attitude towards the class. One student commented "I was a fan at the beginning but I just became overwhelmed (rest of group agreed). I got behind. That was the whole problem. Being behind and then trying to catch up was the hard part. That's what's frustrating." A second student responded "I agree. In the beginning of the class when I was caught up with everything and just being able to do all the concept questions and all the analysis, yeah I liked the class but now I don't like it so much."

Motivation and Achievement Goals

The classroom environment created by the instructor can affect student motivation (Ames, 1992; Church, Elliot, & Gable, 2001). For this course the instructor tried to create a classroom environment that promoted learning. He saw the course as being about teaching a process for learning. He stressed effort. These are expectations to evoke student behaviors associated with mastery goals and intrinsic motivation. But he also had to give grades. Grades are associated with performance goals and extrinsic motivation. The students were concerned about grades because they perceived high GPA's as being related to getting a job in a shrinking job market.

Achievement goals appeared to affect what learning behaviors students chose to engage in for the course. All four students exhibited behaviors that might be associated

with both mastery and performance goals but when comparing the students' behaviors, Mary and Sami appeared to be more oriented towards behaviors I associate with mastery goals and Bill and Barbie appeared to be more oriented towards behaviors I associate with performance goals (see Appendix N).

Students' interest in the content presented in the course is linked to motivation and achievement goals. Glasser proposed that using content of intrinsic interest will turn on internal motivators in the students (cited in McCluskey & Thomas, 1996). According to Ames (1992), meaningful tasks that are personally interesting and challenging to students are more likely to elicit mastery goals. Similarly, Church, Elliot, and Gable (2001) claimed that mastery goals, but not performance goals, are related to lecture engagement or how interesting the students find the material. Bill described how his personal interest in the subject matter affected his performance in class. "I think I don't even spend that much more time on the class, it's just that I'm more interested in it. So the interest is there. You're going to retain it more I think. I think that's a big deal. You have to keep the interest of the student in the class. Once they lose focus, what's the point?"

All four student participants expressed interest in the content of the course. But while Bill and Barbie both seemed motivated to perform the assignments, neither seemed to share the same intensity to master the material that Sami and Mary demonstrated. For instance, Sami and Mary both seemed nearly obsessed with their computer models. Mary was intent on getting her model to produce the correct trends while Sami, who had correct trends, seemed to enjoy perfecting his model. In contrast, Bill described getting together with classmates the night before P1 was due and "kind of cranked it out. I'm not exactly sure if we did it correctly but we put our effort into it. There's like four of us working on it so hopefully we did good enough to do good." I interpreted this statement to not be so much about learning but about meeting grading requirements and time demands. Did the greater demands on their time motivate Bill and Barbie towards a more performance goal orientation rather than mastery goals? What influence does total, not just classroom, workload have upon achievement goal and motivation preferences?

Bill's responses on the screening survey suggested an inclination towards mastery goals. In class Bill showed great interest in the material. He had taken some pilot training and was interested in working in the aerospace industry upon graduation so the assignments might have been assumed to have personal meaning for him. Perhaps if Bill had taken the course in an earlier semester, as specified in the curriculum, he might have had fewer other pressures to juggle and maybe a more supportive team. These differences might have allowed or encouraged him to exhibit a stronger mastery orientation.

Sami and Mary's mastery goals orientations might also have been indicative of greater prior knowledge. Prior knowledge has been shown to promote deeper learning strategies (Prosser, Trigwell, Hazelk, & Warehouse, 2000). Sami particularly seemed to focus upon deeper learning, staying up all night just to understand the theory behind what was being discussed in class. In contrast, Barbie mentioned how she learned thermodynamics during this course, having memorized content (a surface learning strategy) when she took the introductory thermodynamics course. Also, Sami, and probably Mary too, had taken the courses that provided the most relevant prior knowledge more recently than Bill and Barbie so they had had less time to forget.

Team Dynamics

The students in this study seemed to have had similar team experiences as the students in a study by Lovgren and Racer (2000). The group activities did help them learn but as a team they didn't have the necessary social skills for functioning effectively as a group. Mary was always positive about her team while her teammate Barbie expressed frustrations with her teammates. Bill's attitude was that everything was going fine with his team but then when the class was over he began alluding to the problems that had existed on his team. Sami's team problems seemed to consist of teammates who didn't do what he told them to do. But Sami's teammates apparently had some issues with him.

Different motivations or personality differences have been shown to be a source of difficulties in group activities (Skala, Slater, & Adams, 1997). The students' different

motivations and achievement goal orientations in the course both helped and hurt their teams' progress. Neither Sami nor Mary seemed to be aware that their intense but solitary activities working on the computer models might be depriving their teammates of the learning experiences afforded by collaborative learning. But then, they also helped their team's overall performance. Without Sami and Mary's diligence their teammates' may not have progressed as far with the project resulting not only in lower grades but fewer knowledge gains. Prior research has found that a teammate with a high GPA or good laboratory skills can raise the score for all teammates (Hunkeler & Sharp, 1997). "Heavy D," the student interviewed when the second focus group failed, was also a teammate of Sami's. He described how Sami didn't show for their first meetings but "then he finally did show up and he had pretty much done most of what we did, like all three of us, on his own. We wound up combining all of it and it worked out pretty good." Barbie commented about her good fortune being on a team with such strong teammates like Mary even though she had a difficult time finding a way to contribute to her team.

Task allocation appeared to be an important team behavior. Lovgren and Racer (2000) found that some teams were more focused upon the team's technical performance and not on the team as a whole. These teams allocated the most important tasks to the stronger members while others performed less critical tasks. All three of the teams represented by the participants seemed to have engaged in this same type of task allocation. Both Mary and Sami seemed to have self-allocated the most challenging task of developing the computer models to themselves. Barbie, Mary's teammate, then found herself in the role of performing the less technical tasks such as writing the report because Mary had already assumed the more challenging task of creating the models. Sami also chose to do the programming tasks and left the writing to his team and his team apparently accepted this allocation. Because of the lack of performance from two of his teammates, Bill and one other teammate ended up with almost all the tasks. In all three situations, there did not appear to be a formal or consensual decision about who would perform which tasks. The focus appeared to have been more about complete the assignments than a concern with the learning benefits of the individual team members.

Perhaps different team assignments might have resulted in different student learning behaviors. Barbie did not spend much time working on her team's model. Barbie tried to find other ways of contributing to her team such as checking code, researching in the library, or writing the report. Sami worked on the MATLAB model and left the rest of the writing to his teammates. Sami implied that this arrangement was fine with his teammates. While Mary, Sami and Barbie seemed to have had team situations that did allow them to share the workloads of writing the report and creating the models, poor Bill and another teammate seemed to have been stuck with the bulk of both these activities, perhaps contributing to his team's decision not to do P4. If Barbie had been on Bill's team, she might have spent more time modeling. If Sami and Mary had been on the same team, would they have worked together on one model or ended up with two models?

The students' differing goal orientations also influenced their team dynamics. Mary wanted to continue working on the project until the last minute while Barbie felt they had wasted enough time "going in circles." Mary's desire to continue working reflected the mastery goal belief that effort leads to success while Barbie's desire to give up was more typical of performance goals (Cross & Steadman, 1996). Or Mary and Barbie's different choices of learning behaviors in this situation may been due to Mary being a more autonomous learner. Recall that autonomous learners have enough belief in their own competence to take risks in pursuing tasks while those with less belief in their competence may not be willing to take these same risks (Fazey & Fazey, 2001).

Grading

Nunan (1995) believed the gap between instructor expectations and student performance was due to different agendas. In this study grading seemed to be an area where different agendas were present. The students seemed to believe that their grade depended upon how they performed relative to their teammates, perhaps evidence of the notorious reputation of engineering as being a very competitive major. This is also an attitude related to performance goals and surface learning (Pintrich & Schunk, 1996).

As students fell behind in their homework they seemed to reassure themselves of success by noting that they weren't as far behind as their classmates. Bill commented "he can't fail the whole class." Heavy D described how if his classmates didn't turn in their work then it would be okay for him to turn in less work because "the curve" would take care of it. But due to the flexible deadlines he didn't think this class was going to be affected by "the curve." The flexible deadlines would allow most of his classmates to turn in all their work so he would have to as well. The students seemed to exhibit an attitude of academic survival of the fittest. If you were one the stronger members of the class then you were safe. Such behaviors suggest performance-approach goals.

The instructor for this course did not seem to stress a strong evaluation focus. For instance, the instructor did not enforce deadlines, allowing students to hand in their work late without penalty. According to Church, Elliot, and Gable (2001), an environment with relaxed evaluation focus should encourage mastery goals. Harsh evaluation has been shown to positively predict performance avoidance goals while negatively predicting mastery goals but not predict performance-approach goals (Church, Elliot & Gable, 2001). A perception of the evaluation as harsh might have motivated some students to adopt performance avoidance goals. Something that I did not explore in this study were the students' perceptions of the evaluation focus.

NARROWING THE GAP

One of the premises of this study was that a gap did exist between the behaviors the instructor expected of the students and the behaviors the students perceived the instructor expected of them. Project Problem One, P1, at the beginning of the course supported the existence of this gap. The instructor wanted comments on students' graphs. The students, for the most part, didn't comment or didn't comment to his satisfaction. When the class average was six out of ten points the students then realized that he wanted comments. The gap was narrowed.

Choosing Behaviors

Based upon my limited data, my perception was that the gap between the instructor's expectations and the student behaviors was not so much a result of the students not perceiving the behaviors the instructor expected of them as due to the students just choosing not to engage in the expected behaviors. Parr and Valerius (1997) also suggested that the gap between instructor expectations and student behaviors might be attributed in part to students choosing not to engage in the desired learning behaviors. The data demonstrated that students can repeat what the instructor has told them he wants or expects. In that sense the instructor successfully conveyed his expectations. Now it was up to the students to act. Sami knew the instructor wanted him to attend class. Mary knew that the right answer was not the goal. Yet their pursuit of mastering the material drove them to engage in behaviors that might be considered contradictory to the instructor's expected behaviors. Is this a matter of personality? Was it good or bad? Can it be changed? Perhaps the gap of greater concern is the gap between the student's perceptions of what the instructor expects and the actual behaviors they choose to engage in.

One instance that seemed to indicate this rejection of the behavioral expectations occurred with the posttest. I initially thought one of the longest, most accurate, responses to the inquiry about what the instructor expected was written by one of the more outstanding students, although I was intrigued by a slightly caustic edge to his writing. I was quite surprised to find that it was actually written by a student who received a "C" in the course. This student didn't choose a pseudonym but I'll call him "Max." Max was a student who obviously had more to offer, as expressed by the instructor in private conversation during the semester, but who just never seemed to quite engage in the class. I can even remember him sleeping in class. Yet, as indicated by his summary on the posttest, Max "got it" as far as what the instructor wanted. So why didn't he meet those expectations? His comments on the posttest about the required methodology being "almost redundant in repeatedly restating why events happened, re-explaining equations, etc." might indicate that he did not see a need to perform as expected. Maybe he didn't value the tasks so didn't do them.

Conveniently for me as the researcher, Max had participated in the focus group with his team so I received some potential insight into his reactions to the class. In the focus group he had talked about his confusion due to this course being different from other courses, particularly with respect to one right answer.

> I've been pretty confused. It's really hard to tell which is the most correct answer whenever I'm doing the homework and stuff because you have all these different sources to pull from which Dr. Austin encourages but then each source might have something a little different. And so, you know, when you're working out of one textbook for the whole semester as we do with other classes, there's only really one right answer and with this it's different…. and it makes you doubt yourself whenever you can't find the exact right answer, or makes me doubt myself at least, whereas if we were doing thermo, we were in fluids, you just use that one book and really there is just that one right answer.

The open-endedness of the assignments lead to Max doubting himself which led back to the students' need for reassurance or affirmation discussed earlier.

Max also mentioned an unfortunate experience when he did ask a question in class. "I got shot down once …I'm not used to being shot down." I remembered this incident and I don't think the instructor realized that this particular student reacted with rejection. This student also mentioned putting "weak" comments about the graphs on P1 and earning a 7. He described how, as the semester progressed, his interest in the course declined as his other courses and interviewing began to compete for his limited time. Perhaps Max was using a triage approach to his time management and choosing to engage in those behaviors most likely to bring success.

While the behaviors students chose to engage in may have been obvious, why they chose to engage in these behaviors was not so obvious. Several motivational theories suggest reasons why students may have chosen not to engage in the expected behaviors. Expectancy value theory (Tollefson, 2000; Warton, 2001) provides one possible reason. Students might be looking at the tasks they are being asked to perform and then weighing the effort required to successfully complete the tasks. Is it worth it? Since these students are juggling other courses as well as other demands on their time, they might choose to focus their efforts on those tasks where they believe they are most

likely to succeed. Or maybe the students just didn't understand the reasons why they were being asked to perform the tasks. Nunan (1995), in citing research by Block, described how the biggest contributor to the gap between instructor expectations and student perceptions of these expectations appeared to be student misconceptions or misperceptions of the rationale for performing learning activities.

Self-efficacy seems a very likely factor in why students don't engage in the desired learning behaviors. According to social learning theory, we eagerly engage in those activities where we believe we can succeed and avoid those activities where we believe we will fail (Tollefson, 2000). In accordance with social learning theory, students may recognize the behaviors necessary to be successful in class but, due to their interpretations of prior feedback, believe that they personally are not capable of successfully performing the necessary behaviors (Tollefson, 2000). A mid-semester conversation with Barbie correlates with this theory. Barbie was not a confident student. She described how in previous classes she was discouraged after feeling she had lost her opportunity for an "A" early in the semester but didn't feel she had lost her chance for an A in this course. She felt she was doing well, even with limited feedback, and the instructor encouraged her. "Dr. Austin always pumps me up and he's always making me feel like I'm one of his stars so that, mentally and psychologically, makes me think, makes me go when I do the homework, 'I can do this.'" Barbie earned an "A" in this course.

Students' self-efficacy beliefs affect the stress, anxiety and depression students feel towards a task (Zimmerman, 2000). Students who are highly anxious have been shown to have higher achievement in teacher-centered classrooms rather than student-centered classrooms (Hancock et al., 2000). If low self-efficacy leads to higher anxiety then these students might be less likely to engage in the appropriate learning behaviors in a student-centered classroom. Remember Max's self-doubts about what is the correct answer when there were so many possible sources?

According to attributional and effort expenditure theories, students attribute their success or failure to their effort and abilities (Tollefson, 2000). Students who believe that ability is stable and outside their control while effort is controllable but unstable

can then protect their sense of self-worth through how much effort they expend. If they do not feel confident in their abilities to succeed, they can withhold effort. Then when they fail they can attribute their failure to their lack of effort, not their lack of ability (Tollefson, 2000). A student such as Max could attribute his "C" to putting his efforts into his other classes and interviewing rather than into this class where he was "shot down."

Some students might also be less willing to work in teams. Sami did not seem particularly eager to work with his teammates. All four participants experienced problems with teams, either prior to or during this course. Previous research has not indicated a high level of enjoyment in undergraduate engineering students working with others in collaborative working groups (Jones, 1998). Female engineering students may enjoy working in collaborative groups even less than their male peers (Jones, 1998).

The TA (teaching assistant) for the course offered his perspective about the students' lack of understanding the goals of this class. "I don't think that the students understand that the goal is to be able to analyze a complex problem and to be able to actually practice engineering." He offered three reasons why this so. "One, it's maybe not been conveyed clearly to them. Two, it's a new idea to them. And three, there's too much distraction in the course work. The course work doesn't back that up."

EVALUATING MY PROPOSED MODEL

Prior to this study, I proposed the model shown in Figure 12 as potentially accounting for the classroom behaviors I expected to see in this study. Recalling from Chapter Two, according to the theory of planned behavior a person's intent to perform a behavior depends upon the individual's own personal attitude towards the behavior, what the individual thinks others think about the behavior (subjective norms) and how easy or hard the individual perceives the behavior will be to perform (perceived behavioral control) (Burak, 2002). So in order to affect the students' behaviors the teacher's behaviors must influence the student's attitudes, subjective norms and perceived behavioral control. Hopefully the student is then influenced to at least intend to engage in the desired learning behaviors. If these behavioral intentions then become

actual actions then the desired learning outcomes are met. My model proposes that the students are also affecting the instructor's behaviors by affecting his attitudes, subjective norms and perceived behavioral controls.

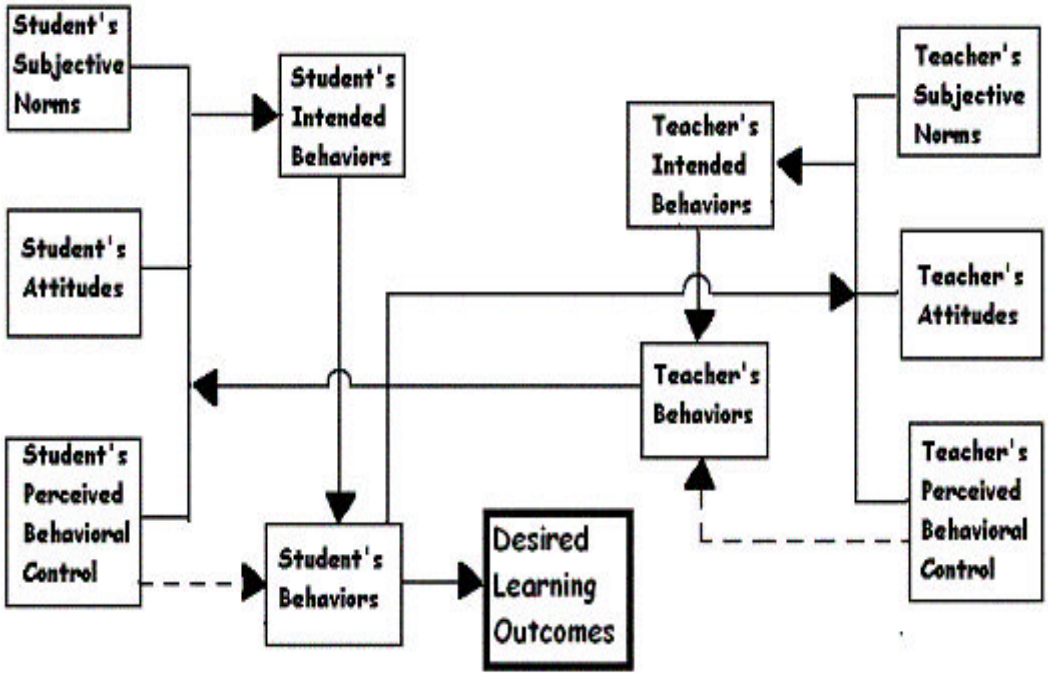


Figure 12. TPB applied to the classroom.

I did find evidence from my study supporting the basic philosophical tenets of my proposed model. Quite obviously, the instructor affected the students' behaviors. For example, when the instructor took off on their grades for P1 for no comments, students started using comments. The students realized that the instructor wanted comments and at least some changed their behaviors to meet his expectations. When the instructor took off points for no comments on P1, he affected the students' subjective norms, convincing the students that he believed that writing comments was an important and valued behavior. If a student cared about his grade then his attitude was probably affected as well so that he believed that writing comments in the future would result in a more positive outcome. Finally, if the student believed that writing comments

was within his volitional control then he not only intended to but then actually wrote comments on the assignments after P1.

But what about those students who never seemed to fully engage in the instructor's desired learning behaviors? Based upon the students' understandings of the instructor's expectations expressed on the pretest and posttest, some students were still focused upon typical instructor expectations of a traditional teacher-centered course. Even those students who were able to accurately describe Dr. Austin's expectations of them may not have fully integrated those expectations. Even those students who did fully integrate Dr. Austin's expectations might not have believed that writing comments was something within their perceived behavioral control. I was only able to observe student behaviors that actually occurred. Unless a student explicitly told me he or she was intending to perform a behavior I had no indication of intended behaviors so cannot determine if they were or were not executed. If the student did not write the comments that he knew the instructor wanted and that would lead to his success, did he not write them because he believed he could not successfully execute this task or did he just not think the task of writing comments was important? The influence of perceived behavioral control seems to be critical in answering Research Question 4.

According to the right side of my model, students also influence the teacher's behavior by influencing the teacher's attitudes, subjective norms and perceived behavioral control. The students did affect the instructor's behaviors but such changes were not necessarily positive experiences. While he began the course with very high expectations, the instructor admitted that his expectations of the students eroded during the semester. At the beginning of the semester, the instructor raised his expectations because he felt like "like there were some pretty good vibes coming back from the class." But later the work handed in by many students did not meet his expectations so he lowered his expectations. Lowering his expectations affected his attitude, or maybe a less positive attitude lowered his expectations. Lowering his expectations because students were not performing as anticipated may have also reflected a decrease in his perceived behavioral control as he realized how hard it would be to achieve the desired results.

The most challenging aspect of analyzing my model was determining whether the students' behaviors affected the instructor's subjective norms. Recall that subjective norms refer to social pressures related to behaviors (Ajzen, 1991). I believe the instructor's subjective norms were affected by the students' behaviors in expressing their beliefs that the workload for the course was too high. On the departmental survey at the end of the semester of this study the students indicated that the workload was high. The instructor described these ratings. "Student rating of course workload, zero for insufficient, zero for light, two for average, I thought that was interesting, twelve for high, and sixteen for excessive." When the students complained about the heavy workload they were expressing disapproval of the task assigned by the instructor. So the social pressures on the instructor were that the workload required to meet the instructor's course requirements was too much. The instructor then made efforts to reduce that workload the next semester, indicating that he valued the social pressures from the students to lessen the workload.

Since this study focused upon the interactions between the instructor and student, my model did not consider how students' behaviors affected other students' behaviors. However, the impact of classmates upon student behaviors became apparent in this research. Students compared their results with their classmates. Or, as discussed earlier, the team dynamics was also very influential in determining student learning behaviors, including affecting the students' perceived behavioral control. For instance, Barbie didn't seem to believe she could work on the model so looked for some other way to contribute to her team. The student-to-student interactions were significant and probably should be included as a third dimension in this model.

CONCLUSIONS

This study was inspired by my observations of students' difficulties in perceiving the instructor's expectations in a very open-ended, project-centered undergraduate engineering classroom. My four participants did not seem to have such problems, or not to the levels of frustration I had witnessed in earlier classes but other students such as Max and Heavy D did seem to have frustrations. I would have been

surprised, and disappointed, if a student I met with every two weeks to discuss their perceptions of the instructor's expectations failed to grasp what the instructor expected of them. Qualitative research accepts and expects that the research will have an effect on the participants and I believe this was true for my study. Not only were the four student participants affected but so was the instructor as well as, to a lesser degree, the other 32 students I did not select as participants. But what, if any, influence did my presence have on my participants? When asked, the student participants did not seem to think there was some impact from talking to me regularly. According to Barbie, "By talking to you I was able to understand why they were being assigned and where he was coming from because I was able to understand his philosophy and his plan for us." Bill thought our conversations helped stimulate his thinking. In conversation with the instructor during the spring semester following this study he joked about the positive influence of my presence the previous fall. Was there some sort of Hawthorne effect on the class due to my presence? If so, then this effect only serves to support the importance of placing a conscious emphasis on conveying expectations.

This course lasted one semester. During this time I was observing students' behaviors as well as changes in their behaviors. But is one semester long enough to see such changes in behavior? Assuming that the students in this study had experienced two, maybe three, years of predominantly teacher-centered college courses and that this was their first exposure to a student-centered course, was it realistic to expect to see many changes? Perhaps they needed a germination period for the requirements of this new learning strategy to sink in. While they might have been able to quote back what the instructor expected of them and thought they understood what he wanted, was this the same thing as really understanding what he wanted? What responses would I have from these students if I could go back and survey them again in a year or two?

Major Contributions

The results of this study suggested some encouraging findings, especially for instructors choosing to use a student-centered pedagogy. The results showed that students can perceive new instructor expectations that are different from previous

courses. The students were not so totally immersed in one traditional understanding of what is expected of them that they couldn't recognize new expectations. These results should encourage instructors to try using new instructional strategies such as student-centered learning in their classrooms.

A less encouraging, but hopefully not discouraging, result was the evidence that even when students clearly understood the instructor's expected learning behaviors they still did not choose to engage in those learning behaviors. Evidently, when students do not perform as expected of them, they may understand what is expected of them (or at least be able to recite what is expected of them), they just choose not to do it.

Suggestions for Instructors

While the existing literature seems to focus upon dealing with difficulties with students in the student-centered classroom (Winter & Yackel, 2000), my research suggests some classroom practices that might prevent these difficulties. The following suggestions, based upon the results of this study, are intended for instructors introducing new instructional strategies such as student-centered learning into their classroom:

- Instructors should explicitly focus upon conveying their expectations of their students. When conveying their expectations of students, instructors should use more than one method of communication to emphasize the importance of their expectations.
- Instructors need to be aware of the students' needs for affirmation that what they are doing is what is expected. Students may be forming their self-efficacy beliefs for these new assignments and positive feedback such as comments on their assignments may lead to higher self-efficacy. Instructors also need to be aware that they may be providing feedback even when they don't realize they are. A casual comment in the hallway or an action in class may lead students to believe that their learning behaviors are, or are not, what is expected.
- Instructors need to help students to see the personal benefits of new processes and methodologies, perhaps by connecting to the bigger picture. What is

obvious in importance and application to the instructor may not be so to the student.

- Instructors need to recognize that while some frustration and even anxiety is probably to be expected as students transition to self-directed learning, students need to be monitored and supported to ensure that their frustration and anxiety do not impede their learning.
- Instructors need to remember that grading is a powerful way to convey their expectations and anything graded might be used for this purpose.
- Team dynamics affect student learning behaviors. Instructors need to be considerate of team composition and alert for unhealthy team dynamics.
- Project-based courses often have a reputation for heavy workloads. Instructors need to be aware that students do have other courses and recognize that too heavy a workload may be detrimental to deep learning or may even discourage students from engaging in the expected learning behaviors.
- Instructors need to be consistent in their expectations. If their expectations change then instructors need to be sure to clearly convey these new expectations with an awareness of how these changes might affect their students.

Implications for Faculty Development

The results of this study show that introducing projects into the classroom is not simple. Dr. Austin was a very experienced instructor with over thirty years experience teaching undergraduate mechanical engineering students. Yet he faced challenges using open-ended projects in his classroom. So what would be the challenges a junior faculty member might encounter? While the challenges in the classroom might be expected to be similar in many ways to those experienced by Dr. Austin, a junior faculty member seeking tenure would have a different set of challenges including the threat of lower course instructor evaluations. For instance, Science Education faculty members who use projects in their classrooms frequently receive lower evaluations than their peers who use more traditional methods (J. P. Barufaldi, personal communication, July 9, 2003). Also, junior faculty may decide that the increased instructor time required for project –

based courses takes away too much time from their research. From an expectancy-value theory perspective, they don't see the value in or anticipated personal rewards from the task of using projects in the classroom to be worth giving up time potentially spent on research so they choose not to engage in the behaviors necessary to bring projects into their classroom. Unless the academic reward system, including the tenure process, relaxes in recognition of the challenges of using projects in the classroom, junior faculty may have little incentive to stray from the accepted methods of the traditional lecture-based classroom and a focus on research rather than student learning. Because the junior faculty are typically younger and represent the future of educational practices, if they don't make the transition towards projects in the classroom, then who will? Will projects become a luxury that only mature, tenured faculty can employ in their classrooms?

Recommendations for Future Study

Why do students who understand what is expected of them for classroom success choose not to engage in the behaviors that will bring them success? This was the most perplexing question raised in this study and the one that screams for further study. Do students not engage in these behaviors due to low self-efficacy for the task, or perhaps not understanding why the task is important? Or could not engaging in the desired learning behaviors be a display of student resistance to the power structure of the classroom? The answer is important to all courses, not just those featuring projects.

I interpreted two of my student participants as more mastery goal oriented and two as more performance goal oriented although all four students exhibited behaviors characteristic of both orientations. The two students who seemed more performance goal oriented also seemed to focus more upon the instructor's expectations to define their workloads. Yet, rather ironically, the instructor's goals for student learning behaviors were probably more oriented towards mastery goals. How do achievement goals affect students' reactions to changes in classroom pedagogies, and vice versa?

Another intriguing topic for future research is the role of deadlines in undergraduate engineering educational experience. In the course of this study the

instructor did not strictly enforce deadlines. The student participants seemed to find the relaxed deadlines to have a positive effect on their learning. But what about the role of projects in preparing engineering students for their roles as engineers in the real world where meeting their deadlines will probably be critical to their success? Do relaxed deadlines in the classroom convey a message to students that deadlines are not important? How do deadlines support or discourage master and performance goal orientations in the classroom? What role should deadlines play in a project-centered engineering class promoting mastery and life long learning while at the same time preparing the students with other professional skills they will need after graduation?

Another area of research suggested by this study is the effect of team dynamics on students' choices of learning behaviors. I noted that the team dynamics appeared to be a factor in what behaviors the students chose. Barbie had to try to find something to do since Mary and another teammate appeared to dominate creating the MATLAB model, the bulk of the project. Bill and another teammate did the bulk of their team's project because two other teammates said they didn't have time to work on it. Sami's team seemed willing, according to Sami, to let him do all the modeling for his team. How does team composition affect student learning behaviors?

Project-based instruction is still a relatively new learning strategy. Faculty who dare to try using this strategy are often doing so with much trial and error and little support. Further research is needed to help determine what are the most effective, and least effective, methods for using projects in the undergraduate engineering classroom. Recognizing that there are engineering faculty who have already determined some successful practices for using projects in their classrooms, a focus also needs to be made upon disseminating this information about best practices to other engineering faculty, particularly junior faculty. But studies should not be limited to just classroom practices. Programs and curricula that have successfully integrated projects need to be studied as whole entities to determine any successful changes that were made to accommodate projects. For instance, was the tenure-track criteria modified to allow more faculty time for teaching instead of research? Were junior faculty members using projects in their

classrooms paired with senior faculty members experienced in using projects in the classroom?

Student-centered learning practices such as project-based learning require a different belief system for both students and instructor about learning and the learning process. Project cannot be successfully integrated into the classroom if students and instructors believe that learning is achieved in ways not represented by PBL. For instance, a student who believes in a transmission model of learning where he sits back passively while the instructor puts knowledge into his head is not going to understand the value of the tasks in an active learning environment such as PBL. If he doesn't understand the value of the tasks then he might not engage in them and if he doesn't engage in these learning tasks then the learning experience is likely to be a failure for him. Research into what both students and instructors believe to be the learning process and who is responsible for learning is critical for successful integration of projects into the classroom.

I also think that my proposed model deserves more study as well. Any future studies of this model should also include the effects of classmates upon student behaviors. A better understanding of how the dynamics between students' and instructor's behaviors affect each other might aid instructors in bringing out the best in their students. Ideally, the instructor's higher expectations for the students will result in higher student achievement but unfortunately the students' behaviors may lower the instructor's expectations. Further study might provide suggestions for positively increasing the instructor's influence on student learning behaviors while lessening the students' negative pull on the instructor's expectations.

CLOSING

The purpose of this study was to explore how the interactions between the instructor and students' behaviors affected the students' learning behaviors in a project-based undergraduate mechanical engineering classroom. The study successfully sought a richer understanding of the dynamics between instructor and student. While the students seemed to enter the classroom with preconceived notions about the behaviors

that lead to success in a traditional engineering classroom, they changed these perceptions as the course progressed. However understanding the instructor's expectations was not always enough to motivate the students to engage in these expected learning behaviors.

In our closing interview, Bill gave his perspective about the importance of effectively conveying instructor expectations. "I think it's important to have the professor and the students on the same track cause it helps. Then you know what's going to be expected of you. And Dr. Austin helped us out with knowing what he's going to ask us by laying it all out in front of us. It was up to us to see what he was going to ask. I think that helps out." I agree that the students and instructor need to be "on the same track." The four students I interviewed were on the same track as the instructor and did well. Students such as Max and Heavy D were not as much on the same track and seemed to experience some added frustration.

This study showed that while students may understand what the instructor expects of them they may still choose not to engage in the learning behaviors required to meet those expectations. This decision may have nothing to do with ability but have to do with factors such as self-efficacy, motivation, or achievement goals. In the course of this study it seemed that grades were in part a reflection of a student's choice of learning behaviors. The four students who participated in my study engaged in the expected behaviors and I think succeeded – they all made A's and B's. But what about students like Max from the focus group? He could accurately describe the instructor's expectations but didn't engage in them so he received a C in the course. Was his C due to lack of knowledge and ability or lack of engaging in the desired learning behaviors? What about Mary and Barbie's friends who had taken the course earlier and "missed the boat?"

I believe the issues of conveying instructor expectations raised prior to and with this study are important for establishing valid classroom assessment practices. Grades, typically the most apparent classroom assessment, are often interpreted as representing knowledge and ability. If the results of this study can be used to facilitate more students to engage in the desired learning behaviors then grades can become more a measure of

knowledge and ability. Otherwise grades may only represent how well students are comprehending the instructor's expectations.

Appendix A – Course Syllabus

ME xxx THERMAL / FLUID SYSTEMS Fall '02

COURSE OBJECTIVES: This course has two primary objectives: 1) to introduce you (the student) to processes and procedures for the solution of open ended problems and 2) to integrate and apply information form three basic thermal /fluids courses to the analysis and design of systems in which thermal and fluid processes are critical. In addition this course will introduce a few new concepts and tools. These include: compressible flow and friction losses from fluid mechanics; 2nd Law analysis (exergy), ideal gas mixtures, psychometrics, and combustion (analysis of reacting mixtures) in thermodynamics; and heat exchanger design in heat transfer.

A different pedagogical style will be employed. It is learner centered, rather than instructor centered, and intended to extend your capability to solve the kind of open ended problems encountered in 'real world' engineering practice.

PREREQUISITES: ME xxx (Thermodynamics), ME xxx (Fluid Mechanics) and ME xxx (Heat Transfer).

TEXT: The textural material used will be those books used in ME xxx, ME xxx and ME xxx, (hopefully you still have these books)
Fundamentals of Engineering Thermodynamics by Moran & Shapiro, McGraw-Hill, Fourth Edition, 2000
Fundamentals of Fluid Mechanics, by Munson, Young and Okiishi, Wiley, 1998
Fundamentals of Heat and Mass Transfer, Incropera and DeWitt, 4th Ed., Wiley, 1996
and Jet Propulsion. A simple guide to the aerodynamic and thermodynamic design and performance of jet engines, Cumpsty, Cambridge, 1999.
An optional reference text is also available at the Co-op
Aircraft Performance, Mair and Birdsall, Cambridge, 1992

INSTRUCTOR: Dr. Austin
(information deleted for confidentiality)

OFFICE HOURS: MTuWF 4:00 - 5:30 PM, by appointment, or any time I am in my office.

EVALUATION: STUDENT PERFORMANCE

Homework (concept questions and short problems)	15%
Project problems (extended homework problems)	25%
Project Report and peer evaluation	25%
Quizzes	25%

Class participation 10%
There will not be a final exam.

The final Course Grade will be based on a set scale (A = 85, 75 = B = 84, 65 = C = 74, 55 = D = 64 , F = 54. I reserve the right to make adjustments if the class average falls below 75.) This grading scheme should result in a class GPA between 3.0 and 3.2. Partial credit will be given on quizzes and homework problems.

INSTRUCTION:

A formal evaluation of instruction will be conducted at the end of the semester according to the policy set forth by the College of Engineering. Students may also be asked for informal (anonymous) feedback during the semester.

CLASS ROOM PROCEDURE: This class will be conducted using a pedagogical style that may be new to you. Research has demonstrated that students come to better understand the material covered, and therefore retain much more of it over time, in "active" versus "passive" learning environments. Thus our objective will be to create an "active learning" environment.

One approach to achieving this is what Felder and Brent refer to as student-centered instruction and others as inquiry based learning. (see www2.ncsu.edu/ unity/lockers/users/f/felder/public/Papers/ Resist.html). They offer the following introduction:

"In the traditional approach to higher education, the burden of communicating course material resides primarily with the instructor. In student-centered instruction (SCI), some of this burden is shifted to the students. SCI is a broad approach that includes such techniques as substituting active learning experiences for lectures, holding students responsible for material that has not been explicitly discussed in class, assigning open-ended problems and problems requiring critical or creative thinking that cannot be solved by following text examples, involving students in simulations and role-plays, assigning a variety of unconventional writing exercises, and using self-paced and/or cooperative (team-based) learning. In traditional instruction, the teacher's primary functions are lecturing, designing assignments and tests, and grading; in SCI, the teacher still has these functions but also provides students with opportunities to learn independently and from one another and coaches them in the skills they need to do so effectively. In recent decades, the education literature has described a wide variety of student-centered instructional methods and offered countless demonstrations that properly implemented SCI leads to increased motivation to learn, greater retention of knowledge, deeper understanding, and more positive attitudes toward the subject being taught".

READING and CLASS Reading assignments are given in the syllabus and a topical outline for the course will be handed out. The reading assignment for a given

DISCUSSION class day is to be done before class. In addition you will also be required to do some library and/or internet research on topics related to project work. This outside reading / research is an essential part of the class. Concept and context questions are assigned and should be reviewed prior to reading to help you identify to the most important concepts you will be reading about and make connections between the material we cover and the 'real world' of engineering practice. Mark your text or jot notes in the margin to indicate where you have questions, would like further examples to clarify, or simply do not understand. We will address such questions and provide clarification in class.

Come class prepared to ask questions. We will have some lecture but the bulk of the time in class will be devoted to answering your questions, class discussion and group work. I will be keeping track of your class participation and as noted above it will be part of the assessment of your performance in the class.

INDIVIDUAL WORK

JOURNAL: It is suggested that you keep a bound Journal (8"x10") to summarize reading and lecture notes, list important equations and analysis procedures, note questions you have, etc. Your journal will be checked occasionally in the discussion section and you will be asked to turn your journal in for a more lengthy review at least once during the semester. These reviews will influence the 'class participation' portion of the assessment process.

The Journal is an important part of this class. It will provide both you and I with a means of keeping track of your progress. It will also give you the opportunity to reflect on the concepts we are covering.

As an additional incentive you may use your journal for reference during the quizzes if you adhere to the following guidelines in its preparation.

1. entries are confined to notes on reading, research and discussion sessions, reflections, questions asked and responses given in class, equations and procedures for problem solution
2. entries do not include extensive copies (Xerox or otherwise) of martial prepared by someone else.

If you have any questions about my intent here please ask in class or stop by my office.

HOMEWORK: The homework you turn in will be graded. Doing homework is absolutely necessary if you are to achieve an understanding of the design and analysis of thermal/fluid systems. I urge you to form groups to study with others and to formulate homework solutions.

There will be three types of homework; concept questions (a short written answer is expected), analysis problems (the usual sort of homework problem) and project problems. I would encourage you to work together on your homework but expect that each of you will turn in your response for each assigned concept question or analysis problem. You may work on the project problems as a team (or with other students) but each individual must turn in a separate project problem, models (or the computer codes that embody them) and resulting tables and graphs may be common to the

members of the group but the introductory comments and conclusions must represent individual work. Some form of homework will be due each class period.

The TA will be available as a consultant and will be available to work with you in the discussion session each week. We will also discuss the homework in class, answering any unresolved question before it is turned in. However homework turned in for a grade must represent each individuals understanding of the material and not be a copy of the work of the TA, other students or the class discussion.

Please keep your homework in a separate a 1" or 1 1/2" 3-ring binder. I will ask you to turn in your homework file for my review at the end of the semester. It must be done neatly and communicate clearly.

QUIZZES — Quizzes will be given covering reading assignments, homework, and project material. You will be able to use your class Journal (see above for the definition of 'Journal') and homework file for reference during each quiz. You will not be allowed to use any loose sheets or copies for reference. If you need other reference material or property tables I will provide copies of those in the texts. You may drop one quiz. Make-up quizzes will not be given, if you miss a quiz that will be the one you drop.

FINAL EXAM: — I am requesting permission to not give a final exam in this course. The basis for the request is the extent of the project work we will be doing during the semester. I expect permission will be granted but I can not announce that there will be no final until I receive a response form the Dean's office.

TEAM WORK:

TEAMS: — You will be assigned to a team to work on the project. Teams will consist of 3 or 4 students.

PROJECT ACTIVITIES — Project Problems and Project Report will be due as noted in the syllabus. We will discuss and decide on the format for these problems and reports in class.

PEER EVALUATION — Each member of the team will be asked to participate in a peer evaluation (that is provide evaluation and comment on the performance of the other students on the team). This will be considered when assessing each individual students performance in the class.

SUPPORT SERVICES: — There are a number of other opportunities for class support. A TA will be available and will hold office / tutorial hours. I will also set up a class web site.

UNIVERSITY POLICIES — Standard University policies relating to accommodation for students with disabilities and to scholastic dishonesty will be followed in this course. Information regarding these policies may be found in the General Information Bulletin or on the web at:
www.utexas.edu/cons/student/facultyinfo.html

Appendix B – Instructor's Problem Solving Methodology

An Approach to the Solution of Problems in Thermodynamics

The primary duties of an engineer relate to the design of engineering systems and / or to the analysis of the performance of these systems. In the design or analysis of thermal systems three types of problems are commonly encountered:

1. Problems in which a process with prescribed (or idealized) internal constraints and boundary interactions is specified and the objective is to determine how the properties of the system vary.
2. Problems in which the objective is to determine what specific process and interactions must be carried out to effect a specified change in the properties of the system. (This is the inverse of type1 problems)
3. Problems in which the objective is to determine the efficiencies, with respect to the resources available, of the various processes and interactions which bring about changes in the properties of systems.

Although problems in each of these categories may vary in application and complexity there is an approach to solving them that seems to maximize the information obtained and minimize the difficulty encountered. This approach involves first an initial definition of what the problem is and then the application of a systematic, step-by-step process of evaluation and solution. Utilizing this structured procedure for examining and solving problems in no way limits or inhibits creativity. To the contrary it frees the mind to view and test the widest possible range of solutions.

Procedure:

One approach which has proven useful will be presented here. It is surely not the only approach that could be used, nor is it guaranteed to be the best in all circumstances, but it works well often enough to recommend it's use as a standard approach in thermodynamics. The reader should however realize that in the end the time required to obtain a solution,
and the adequacy or effectiveness of that solution, always depend more on the judgment and skill of the designer or analyst than it does on the solution approach chosen.

The steps recommended for design and analysis in thermodynamics are:

1. Define the system, system boundaries and the environment.
2. Identify the interactions that can take place at system boundaries.
3. Identify appropriate property and force relationships (constitutive relationships).
4. Model the processes through which the system and environment pass.

a. Identify initial and final states.
b. Model possible interactions.
c. Model the path of the process, or processes, selecting appropriate pattern processes for the various components or elements in the system.

5. Apply the laws of thermodynamics to the models to solve the problem
   a. Space continuity and conservation of mass
   b. First law of thermodynamics
   c. Second law of thermodynamics.
6. Review the solution and the problem statement to evaluate the solution. Repeat steps 1-5 as necessary.

Discussion:

1. Definition of System, Boundary and Environment

The first of the steps, the definition of the system, system boundaries and the environment is perhaps the most critical. In thermodynamic analysis or design the goal is always to define the problem as simply as possible. However the desire for simplicity must be balanced by the need for accuracy. A problem definition must be of sufficient detail to provide adequate information about both the problem and the solution. Deciding how much, or how little, detail should be included in an analysis is often a challenge. An appropriate definition of the system can save a great deal of time and provide the all the information necessary. An inappropriate definition of the system can lead to a great deal of wasted time and frustration.

In defining the system one must identify both what is of interest in the design or analysis and what is not of interest, or is superfluous, in the analysis. The system definition must be as simple as possible, it must focus attention on only those characteristics that are of interest in the solution. It must provide a means of clearly defining the processes occurring within the system and any interaction between the system and its environment.

It is usual to classify systems as open or closed. A closed system has a fixed mass and is subject to only work or heat transfer interactions. An open system is subject to the transfer of mass, and the energy that is transported with the mass, as well as work and heat transfer. Closed systems are often referred to as control mass (CM) systems and open systems as control volume (CV) systems. It is often clear from the outset which type system model should be selected. However occasionally it is not clear. In general the closed, or control mass systems are easiest to analyze.

A system consisting of a single component enclosing a fixed mass, such as a tank or a piston - cylinder device should clearly be modeled as a control mass. A device consisting of one or more components experience a steady flow of mass through these components should be modeled as one or more control volumes. Examples of

components typically modeled as control volumes are pumps, compressors, turbines and heat exchangers.

Some devices, particularly those consisting of only one or two components and experiencing unsteady mass flow, which at first would appear to be best modeled as open systems may be easier to model as closed, or fixed mass systems. The decision as to which is best depends on the characteristics of the mass flow. The distinctions will be illustrated in examples following this general description of the design analysis process.

2. Identify Boundary Interactions

There are three possible types of boundary interactions; work, heat transfer and mass transfer. In the present review we will consider only three type work interactions, boundary displacement, shaft work and flow work. Electrical energy transfer will be considered a form of shaft work. As flow work is directly and inseparably connected to the mass flow it is also usually associated with the mass transport of energy rather than being included as a separate work term. This is accomplished by combining the flow work (pv) with the internal energy (u) in the form of enthalpy ($h = u + pv$). Thus the energy transported with mass is expressed as the sum of the internal energy (u), kinetic energy ($V^2/2$), and potential energy (gz) and flow work as

$$(u + pv + V^2/2 + gz) \text{ or most often as } (h + V^2/2 + gz).$$

Heat transfer occurs as a result of a temperature difference between the system and it's environment. It is important to note that heat transfer requires time, and the amount of heat transfer that can take place is limited if the process occurs quickly. One usually assumes that a very fast process (one that takes place in seconds as opposed to minutes) is adiabatic. One also usually neglects heat transfer and assumes a process is adiabatic if the amount of energy transported as heat is small compared with that transported with mass or as work. Thus pumps, compressors turbines are generally modeled as adiabatic devices.

Recall that work and heat transfer are not properties of the system and can only be specified at the system boundary. Also remember that the amount of work and the amount of heat transfer are dependent on the processes that are occurring. There are a number of processes for which either the work or heat transfer interaction is zero. These situations should be specifically noted in setting up the system model as they simplify the calculations significantly. In other cases a separate means of defining the work or heat transfer interaction is required. For example one can describe the amount of work at a moving boundary by defining the relationship between force and displacement, frequently in the form of a pressure (P) - volume (V) relationship. Relationships for heat transfer in terms of T and s are available, but only in the case of reversible processes. Therefore one generally attempts to find a specific applicable Pv path relationship to provide a means of specifying the work interaction.

3. Identify Property Relationships

Selecting the appropriate set of property relationships for the problem at hand and specifically noting any assumptions involved in applying them is a critical step in the solution process. Property relationships will be discussed at length elsewhere.

4. Model the Processes Through Which the System and Environment Pass.

This involves identifying initial and final states of the system components, modeling all possible interactions at the system boundary and modeling the path of the process, or processes through which the system and its environment passes.

There are six or sever pattern processes that are frequently used in thermodynamic design and analysis. There are four basic processes each related to a constant value of one of the thermodynamic properties; constant volume, constant pressure, constant temperature (isothermal), and a reversible adiabatic constant entropy (isentropic) process. Each of these process fall into a category referred to as polytropic processes where Pv^n is constant. The values of n for these four processes are 8, 0, 1 and k respectively. The fifth pattern process is a general polytropic process where n takes a value other than 8, 0, 1 or k. These general polytropic processes are used to model some compression and expansion devices and values of n are determined experimentally. The sixth of the commonly encountered pattern processes is a constant enthalpy throttling process (expansion through a valve). The seventh, and final process is an irreversible adiabatic process. Here the work is specified by the 1st law rather than a direct expression for work. These processes are idealized representation of what actually takes place, but it is surprising how effectively they cam be used to model thermodynamic systems.

The models used are generally mathematical statements which are manipulated and finally solved to provide the needed information. Again the selection of an appropriate form for these equations is an essential element of the procedure. Whether or not appropriate forms are selected depends to a great extent on experience and good common sense.

5. Apply the Laws of Thermodynamics

Applying the laws of thermodynamics is part of the modeling and solution process. The mathematical statements of the laws are incorporated in the model and are solved to obtain the necessary information. The laws that are almost invariably part of the solution process are:

a. Space continuity and conservation of mass
b. First law of thermodynamics
c. Second law of thermodynamics.

These equations may be solved individually or in combination. They must always be considered as part of the solution process.

6. Review the solution and the problem statement to evaluate the solution. Repeat steps 1-5 as necessary.

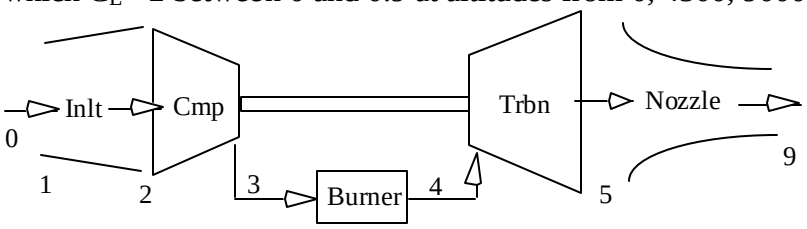
This final review is an essential part of the solution process and should be taken seriously.

Appendix C – Project Assignments

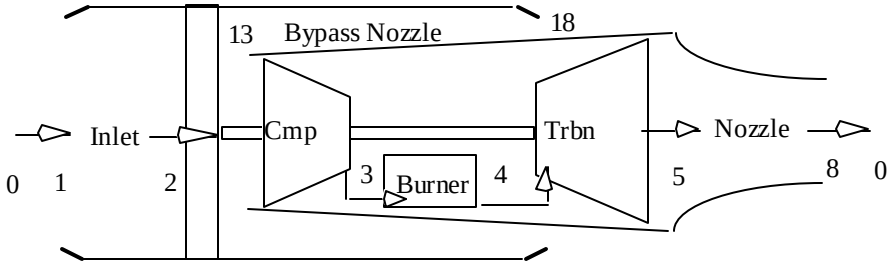
MExxx **PROJECT PROBLEMS FALL 2002** 03 Sept. 02

p1. Problem a3 noted that the drag coefficient for the lrca can be represented as $C_D = C_{Do} + KC_L^2$ for flight at a Mach number less than 0.82 (the drag divergence Mach number, M_{DD}). Beyond that Mach number the contribution of the drag due to the formation of shock waves on the upper surface of the wing begins to increase dramatically. Assuming that the increase is linear with increasing Mach number (up to M = 0.92) plot the drag for the lrca over a range of Mach numbers for which C_L <2 up to 0.9 for flight at 4500 m, 9000 m and 13500 m. Assume that the weight of the lrca is 98 % of take off weight at 4500 m, 96% at 9000 m at the beginning of curse and 76% at 13500 m at the end of cruse. Note: assume C_{DO} = 0.015 and K = 0.054 for M = 0.82 and C_{DO} = 0.015+0.1167(M - 0.82) and K = 0.054 for 0.82<M <0.92. Also plot the drag a sea level conditions for 0.2<M<0.9.

p2. Using the information developed in analysis problems a8, a9 and a10 determine how the thrust of the engine designed for 68000 N with a pressure ration of 24 and a enthalpy ratio of 5 varies in flight with aircraft Mach number and altitude. Plot thrust vs Mach number as a function of altitude for the range of Mach numbers for which C_L <2 between 0 and 0.9 at altitudes from 0, 4500, 9000 and 13,500 m.



p3. Evaluate the performance of the turbofan engine described in a13 and a14 over the same range of parameters and flight conditions specified in problem p2. Compare and contrast the turbofan performance with the turbojet performance. Compare thrust available (from p2 and p3) with the thrust required determined in p1.



p4. Extend the analyses of p2 and p3 to evaluate the specific fuel consumption of the turbojet and turbofan engines examined. Discuss how these result effect the range

and endurance of the aircraft. Assume the lrca can carry a maximum of 19,000 kg of fuel rated at a combustion enthalpy of 44,300 kJ/kg.

ME343 Project - CORPORATE JET AIRCRAFT ENGINE

Project Statement

Your employer, the Aircraft Enterprises (AE), has been successful in the development and manufacture of small, short-range high performance aircraft for the flying enthusiasts. The company founders, and most of its board of directors, learned much of what they know about aircraft and propulsion systems as military pilots. The company and its investors have decided that it is time to move into the design and production of innovative long-range corporate aircraft. This means that they will have to start paying attention to issues of range and fuel economy. As a part of a newly formed Advanced Design engineering section of the company you have been asked to develop a 'technical briefing' for company management and airframe designers to bring them up to date on these issues. They will need this information to work effectively with engineers from engine companies as part of the design team. Your section manager has asked you to complete the following tasks:

1. Assist the airframe design section develop plans for the new aircraft. You should focus on determination of thrust requirements, fuel consumption and range for the proposed aircraft mission.
2. Create a 'simple' algorithmic model of both turbojet and turbofan aircraft engines.
3. Exercise the model to demonstrate the effects of engine design and operating parameters (including, at a minimum, pressure ratio, temperature ratio, component efficiency, bypass ratio, velocity and altitude) on engine performance.
4. Prepare a report that presents you model and analysis results in a way that clearly links aircraft performance, engine design and operating parameters and engine performance (thrust, fuel economy and range) with the company's objectives. The report should present the model (discussing the merits and limitations of the algorithms used and all the assumptions and approximations employed), present the results of the resulting analysis in graphical form and explain both the results obtained and their significance.

Background:

Long-range Corporate Aircraft and Engines:

The market for long-range corporate aircraft (lca) is quite promising over the next fifteen to twenty years. Two aircraft serving this market are selling quite well, the Bombardier Global Express and the Gulfstream V. There are a number of good sources of information on these aircraft on the internet or in print form in the Engineering Library. Jane's All the Worlds Aircraft which is on reserve in the library provides quite extensive specifications on both these aircraft. There are also a number of texts in the library covering topics such as aircraft design and gas turbine engine performance

Turbofan engines are most frequently used for longer-range commercial aircraft. But AE management want you to be able to contrast the performance of turbojet engines with the turbofan engines as well. A relevant example of these engines can be found on

the Pratt & Whitney, GE and Rolls Royce web sites. A significant amount of information is also available at NASA and University sites. A general description of gas turbine engines can also be found in a number of texts (by way of discussions of the Brayton cycle in most any Thermodynamics book).

Algorithmic Models:

A dictionary description of the term algorithm is

> Algorithm n. Mathematics.
> A step-by-step problem-solving procedure, especially an established, recursive computational procedure for solving a problem in a finite number of steps.
> American Heritage Dictionary (Electronic Edition)

In the present context the algorithmic model of a turbojet given in Moran & Shapiro, Section 9.9 and Example 9.12 provides a rudimentary example.

Algorithmic models can be implemented in a number of ways. For example functional models of each component, and state of the gas as it passes through each component, can be entered into the cells of a spread-sheet, the response to changes in input variables calculated in a recursive manner and the results presented in tabular and graphical form. Feel free to choose any other modeling process you would feel more comfortable with.

A simplified thermodynamic system modeling program tied to our thermodynamics text (Moran & Shapiro) is available on many of the computers in the ME LRC. It provides the means to do repetitive calculations (parametric analysis) quite quickly. It does take some effort to learn but it surely beats using a calculator. MatLab could also be used.

Results and Project Summary

Your report of project results should, at a minimum, include the following

1. Your definition of aircraft thrust requirements for take-off, climb, cruse and landing. Your algorithms must accommodate changes in take-off and landing environmental conditions (altitude and temperature).

2. A complete definition of fluid states (temperature, pressure, enthalpy …) in and out of each engine component. It will be useful to use engine schematic and process path diagrams to identify both the physical locations of these state points and the process paths between them.

3. An algorithmic model for the engine that will allow you to calculate output design and off design performance parameters as a function of at least the following parameters:

   Input operating parameters: Ambient temperature and pressure, flight velocity and aircraft lift / drag , climb and acceleration requirements

Input design parameters: overall pressure ratio, fan pressure ratio, bypass ratio, fuel characteristics and desired turbine inlet temperature and maximum static air flow rate.

Output parameters: temperatures and pressures at each of the labeled states

Output performance parameters: cold jet (fan) thrust, hot jet thrust, total thrust, specific fuel consumption, specific thrust

4. Results of your algorithmic model exercised over a reasonable range of design and operating parameters. The results should be presented graphically. You may include text or tabular summaries as well.

5. A summary description of your model, reflections on the results obtained, comments on any residual concerns you have about the results and the modeling process, and a discussion of what you could / should do to improve the model to address your concerns. Comments specifically addressing any insights gained or surprises encountered in carrying out the project.

http://www.geocities.com/TheTropics/Shores/3098/distance.html

Appendix D – Screening Survey

Gender: _____ Male _____ Female Born in the USA? _____ Yes ____ No

Age: ____

GPA: ____ < 2.5 _____ 2.5 to < 3.0 ____ 3.0 to 3.5 _____ > 3.5

1. Have you ever worked for an engineering employer as a co-operative education student, intern, designer or similar capacity? ____ yes ____ no

If yes, how long have you worked for an engineering employer as described above: ___<= 1 year ___> 1 year

For the items below, circle the number that best corresponds to your response.

2. I am a:

1	**2**	**3**	**4**	**5**
good leader.				good follower.

3. I consider myself to be an:

1	**2**	**3**	**4**	**5**
introvert.				extrovert.

4. While working on a project, I am more driven by:

1	**2**	**3**	**4**	**5**
using the project as an opportunity to dig deeper and learn.				making sure that I am doing everything the professor expects so I can earn a good grade.

5. I prefer a classroom environment:

1	**2**	**3**	**4**	**5**
w/ lectures				w/ projects

6. I:

1	**2**	**3**	**4**	**5**
hate working on teams				enjoy working on teams

7. After graduation, I plan to:

1 **2** **3** **4** **5**

stay in the technical side of engineering — move into management

8. I like a classroom environment that :

1 **2** **3** **4** **5**

let's me be creative and do things my way — has lots of structure where I know what is expected of me

9. When I am really crunched for time with lots of assignments due,

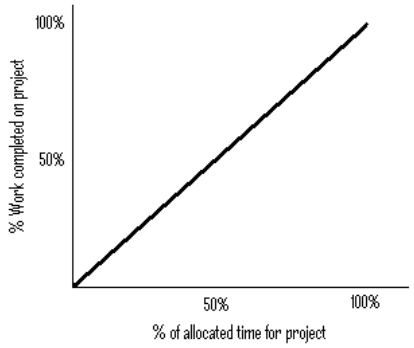
1 **2** **3** **4** **5**

I spend my time on those assignments that I think are most important for reaching my goals. — I try to evenly divide my time between all my assignments because they are all important.

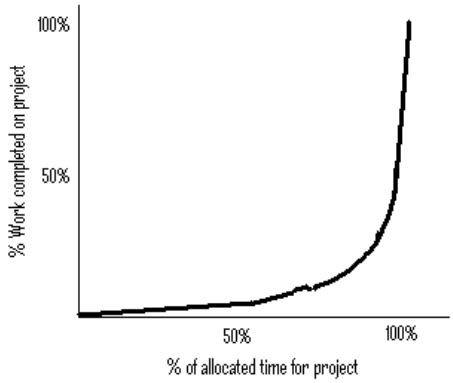
Check the appropriate response:

10. Which graph best represents your time management on a project? _____A. _____B.

A.

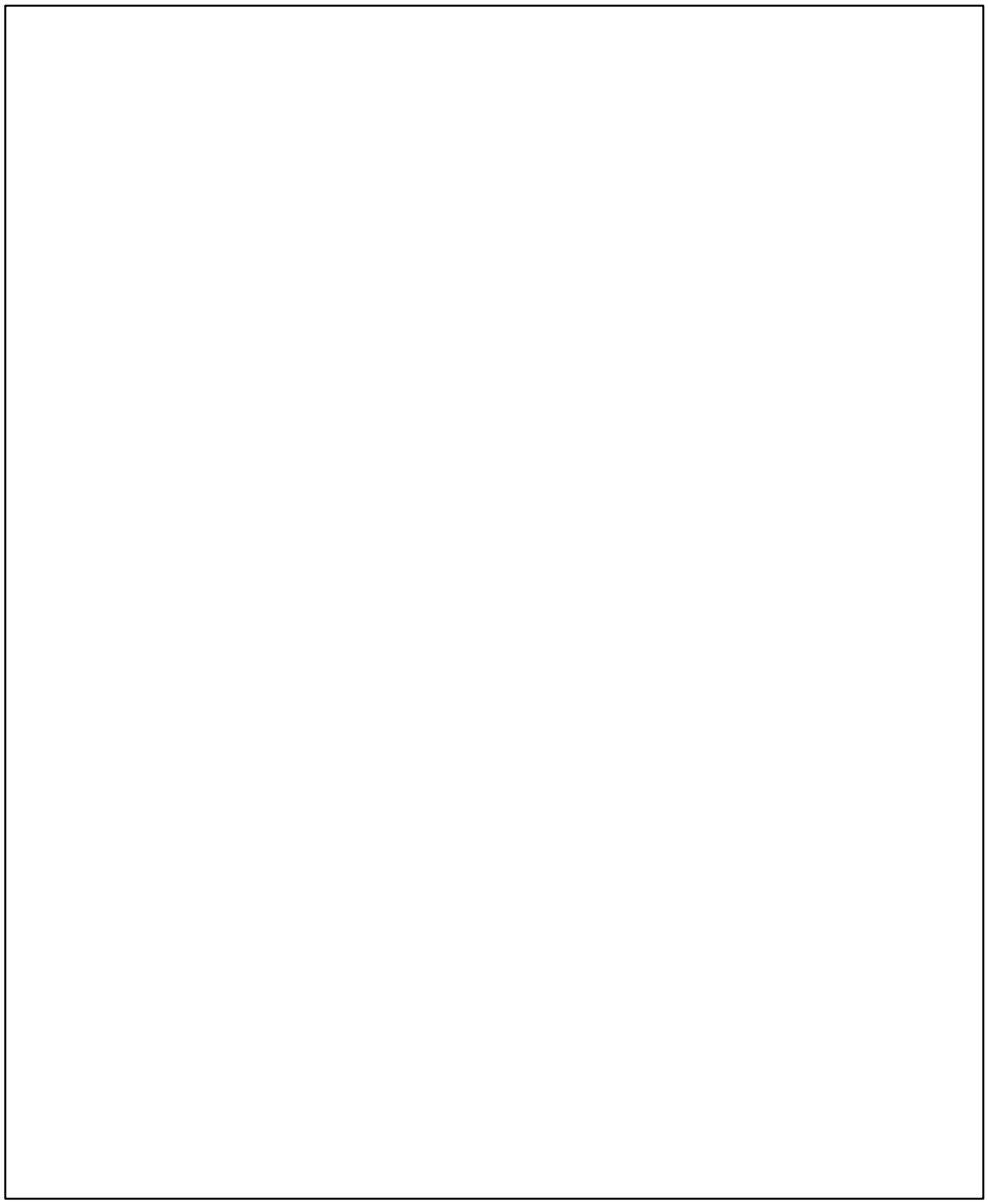


B.



Appendix E – Pretest

1. In the box below, please write your understanding of what your professor expects from you for this project:



Continued on back ⟶

Circle the number that best corresponds to your response.

2. I feel:

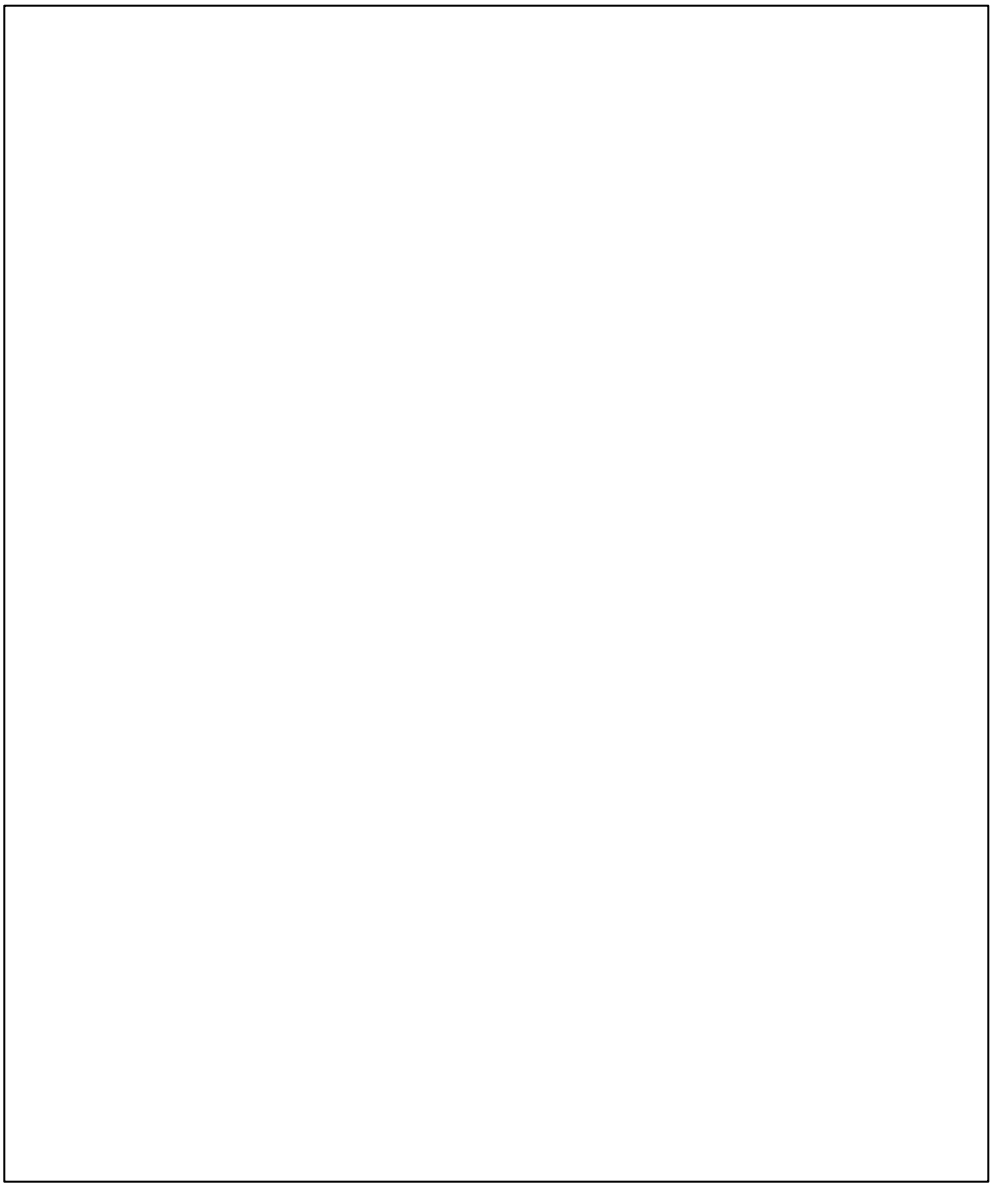
1	**2**	**3**	**4**	**5**
very comfortable with my understanding of this assignment			very uncomfortable with my understanding of this assignment	

3. My attitude towards this project can be described as

1	**2**	**3**	**4**	**5**
I am very excited and can't wait to get started			I am dreading every moment	

Appendix F – Posttest

1. In the box below, please write your understanding of what your professor expected from you for this project.



Continued on back ⟶

Circle the number that best corresponds to your response.

2. I felt

1	**2**	**3**	**4**	**5**
very comfortable with my understanding of this assignment				very uncomfortable with my understanding of this assignment

3. My attitude towards this project can be described as

1	**2**	**3**	**4**	**5**
I will miss working on it				I am so glad it's over

4. I prefer a classroom environment that is:

1	**2**	**3**	**4**	**5**
Teacher-centered w/ lectures				Student-centered w/ projects

5. I:

1	**2**	**3**	**4**	**5**
hate working on teams				enjoy working on teams

6. After graduation, I plan to:

1	**2**	**3**	**4**	**5**
stay in the technical side of engineering				move into management

7. I like an environment that :

1	**2**	**3**	**4**	**5**
let's me be creative and do things my way				has lots of structure where I know what is expected of me

Appendix G – Cover Letter for Surveys

COVER LETTER
Student Surveys

Pilot study of assessment tools in mechanical engineering courses
at The University of Texas at Austin

You are invited to participate in a study exploring assessment tools in mechanical engineering courses at The University of Texas at Austin. My name is Theresa L. Jones. I am a graduate student pursuing my Ph.D. in Mathematics Education at the University of Texas at Austin. I am also a licensed mechanical engineer. From this study, I hope to learn about effective assessment tools for use in mechanical engineering courses from the perspective of both instructors and students. The data from this pilot study may also be used in my dissertation research.

You were selected to participate in this study because you are currently a student enrolled in a mechanical engineering course at The University of Texas at Austin. There will be no compensation provided for your participation. Participants will benefit from this study by contributing to the development of improved assessment practices for mechanical engineering courses.

As a participant in this study, you are being asked to fill out a survey. No serious physical risks or discomforts are associated with this survey. This survey will take approximately 15 minutes to complete. Your decision whether or not to participate will not affect your future relations with The University of Texas at Austin or any other schools where you may be employed or otherwise affiliated. You may refuse to answer any questions on the survey. Any information that is obtained in connection with this study that can be identified with you will remain confidential. By your action of filling out the survey, you are indicating that you have read this cover letter and have decided to participate in this exploratory study with the understanding that the data may also be included in my dissertation research. Any data that is obtained in connection with this study that can be identified with you will remain confidential – available only to myself and my faculty advisors -- and will be disclosed only with your permission. You are being asked to provide your 9 digit student id number on the surveys. This is necessary for connecting your survey data to your final grade and other information that might be used for statistical analysis.

I will be glad to answer any questions you may have about this study or the survey process. You may contact me at (512) 471-5727 or email at tljones@mail.utexas.edu or my faculty advisor, James Barufaldi, Ph.D. at (512) 471-7354 or email at jamesb@mail.utexas.edu.

ppendix H – Consent Form for Interviews/Focus Groups

CONSENT FORM - PARTICIPATION IN STUDY
Student Interviews and Focus Groups

Pilot study of assessment tools in mechanical engineering courses at The University of Texas at Austin

You are invited to participate in a study exploring assessment tools in mechanical engineering courses at The University of Texas at Austin. My name is Theresa L. Jones. I am a graduate student pursuing my Ph.D. in Mathematics Education at the University of Texas at Austin. I am also a licensed mechanical engineer. From this study, I hope to learn about effective assessment tools for use in mechanical engineering courses from the perspective of both instructors and students. The data from this study will be used in my dissertation research

You were selected to participate in this study because you are currently a student enrolled in ME 343 at The University of Texas at Austin. As a student participant, you may be asked to fill out surveys, be interviewed or observed in your classroom or working in groups. There will be no compensation provided. Participants will benefit from the study by contributing to the development of improved assessment practices for mechanical engineering courses. Participants will also benefit from the opportunity to discuss and reflect upon their classroom experiences.

No serious physical risks or discomforts are associated with this study. You are being asked to participate in a series of six interviews which should last 30 to 60 minutes. I will be recording the audio of these interviews and transcribing the content. The tapes will be coded to hide identity and stored in a locked container either at my home or on campus and erased after transcription. You may refuse to answer any questions and you may have the interviewer strike any response from record. You may terminate the interview at any point.

As a participant, you may also be asked to fill out surveys or questionnaires. As with the interviews, you may refuse to answer any questions on these surveys and questionnaires. I will also be looking at your classroom artifacts – quizzes, homework, journals, final project reports and final grade.

Any data that is obtained in connection with this study that can be identified with you will remain confidential – available only to myself and my faculty advisors -- and will be disclosed only with your permission. You are being asked to provide your 9 digit student id number on the surveys. This is necessary for connecting your survey data to your final grade and other information that might be used for statistical analysis. Any

direct quotes from the interviews used in any publications or presentations will be masked through the use of pseudonyms, however, even with the use of pseudonyms, a risk does exist that other students or faculty members might be able to determine your identity.

Your decision whether or not to participate will not affect your future relations with The University of Texas at Austin or any other schools where you may be employed or otherwise affiliated. Your signature indicates that you have read the information above and have decided to participate in this exploratory study with the understanding that the data may also be included in my upcoming dissertation research. Once your permission is received, I may be contacting you to set up an interview or focus group at your convenience. The interview will only take place once your permission is received. You may withdraw at any time after signing this form, should you choose to discontinue participation in this study by contacting me at (512) 858-7345 or email at tljones@mail.utexas.edu.

I will be glad to answer any questions you may have about this study or the interview process. You may contact me at (512) 471-5723 or email at tljones@mail.utexas.edu or my faculty advisor, James Barufaldi, Ph.D. at (512) 471-7354 or email at jamesb@mail.utexas.edu.

I have provided you with two copies of this form. Please sign one and return it to me and keep the other for your records.

I hereby agree to participate in this study.

_____ _____

Signature of Participant Date

_____ _____

Signature of Researcher Date

Appendix I – Variables from Surveys

Item Description	Variable Name		
	Screen Survey	Pretest	Posttest
Gender 1 – Male 2 – Female	**Gender**		
Birthplace 1 – US 2 – nonUS	**Birthplace**		
Age (years)	**Age**		
GPA 4 – >3.5 3 – 3.0 to 3.5 2 – 2. 5 < 3.0 1 - < 2.5	**GPA**		
Work (Experience) 1 – yes 2 – no	**Work**		
I am a: **1 2 3 4 5** good leader. good follower.	**Lead1**		
I consider myself to be an: **1 2 3 4 5** introvert. extrovert.	**Int1**		
While working on a project for a class, I am more driven by: **1 2 3 4 5** using the project as an opportunity to dig deeper and learn / making sure that I am doing everything the professor expects so I can earn a good grade.	**Drive1**		
I prefer a classroom environment: **1 2 3 4 5** that uses lectures / that uses projects	**Pref1**		**Tc2**

I: **1 2 3 4 5** hate working teams enjoy working on teams	**Team1**		**Team2**
After graduation, I plan to: **1 2 3 4 5** stay working in the technical move into management	**Plans1**		**Plans2**
I like a classroom environment that : **1 2 3 4 5** let's me be creative and do things my way has lots of structure where I know what is expected of me	**Env1**		**Env2**
When I am really crunched for time with lots of assignments due, **1 2 3 4 5** I spend my time on those assignments that I think are most important for reaching my goals. I try to evenly divide my time between all my assignments because they are all important.	**Crunch1**		
2. I feel: **1 2 3 4 5** very comfortable with my understanding of this assignment very uncomfortable with my understanding of this assignment		**Pre2: (Austin Only)**	
3. My attitude towards this project can be described as **1 2 3 4 5** I am very excited and can't wait to get started I am dreading every moment		**Pre3: (Austin only)**	
Now that I have completed the project, I feel **1 2 3 4 5** very comfortable with my understanding of this assignment very uncomfortable with my understanding of this assignment			**Post2, Com2**

My attitude towards this project can best be described as: **1 2 3 4 5** I will miss working on it I am so glad it's over			**Post3, Att2:**
Grade (final) 1 – A 2 – B 3 – C			**Grade**

Table 6. Description of variables used for data collection

Appendix J - Creating Categories from Pretest and Posttest Data

Creation of Pretest Categories

1. Use Cognitive Activities and Skills

- engineering judgment
- think
- think beyond what is expected
- show initiative
- think for ourselves
- explain thought process and results
- derive solutions rather than copy from book
- active discussion in classroom rather than lecture
- interaction and awareness
- preparation before class

2. Seek and Use External Resources

- use information
- raise issues in class for discussion
- find outside resources
- be prepared to consult instructor/TA
- learn where to look for answers
- find sources
- do research outside of class
- go to library
- go see TA and prof
- how to collect information
- where to go

3. Participate in Group Work

- work together
- work as team
- team skills for professional success
- work as a group
- share information and knowledge

4.Purpose is Preparation for Real World

develop tools for life

- become engineers
- prepare for real world
- prepare to survive in real world
- won't be spoon fed info

5. Develop Understanding of Engineering Concepts

- grasp major concepts
- make connections
- demonstrate knowledge of engineering concepts
- demonstrate firm knowledge of subject
- integrate engineering knowledge from previous courses
- broad understanding of course

- understanding of project and components more important than right answer
- understand the process to design a jet engine
- attain understanding of what goes into design of an engine
- connect concepts to build broad knowledge
- understand design constraints
- evaluate and learn about turbojet engines
- not expected to remember everything from prior courses

6. Exhibit Problem Solving Process

- solve open-ended problems
- develop tools for problem solving
- outline approach
- process of arriving at answer
- good problem solving techniques
- construct problem statement
- use problem solving skills rather than book smarts

7. Exhibit Analytical skills

- presentation of analytical models
- ability to analyze results
- expects invaluable insights from students on how to approach engineering p
- see alternatives
- Parametric analysis
- balance parameters to optimize performance
- understand parametric requirements
- be able to manipulate data
- problems
- make comments on our analysis

8. Don't know what is expected

- don't really know what is expected from project
- vague directions create challenge
- vague idea of what project is about
- haven't read the project handout

9. Process over product (this has been emphasized by prof throughout semester)

- effort over right answer

Creation of Posttest Categories

1. Decision Making/Independence/Trust self

- be able to analyze a problem w/out any guidance, or very little guidance
- didn't want to spoon feed us
- no longer spoon fed with problems with direct answers
- go out on limb and make decision in final paper
- explore all options available and choose best option
- take every concept we learned and apply towards developing and recommending specifications for an engine
- develop our engineering intuition so can discern when reached appropriate, acceptable solutions
- trust our independent research and stick with our answers
- figure out everything on our own, no direction

2. Design an Engine

- learn how jet engine works
- design an engine
- determine performance parameters
- create an algorithmic model
- vary design parameters to find optimal value
- fully explore analysis of engines

3. Effort

- keep students on their toes at all times
- keep up pace of class and ask questions
- expected a lot with little time and unclear directions
- expend as much effort as possible
- a lot of effort
- show initiative
- ask questions
- be thorough in answering problems

4. Learning/Skills Improvement

- learn something, take something away with them
- see what we learned from class overall
- demonstrate cumulative knowledge we've gained through analyzing jet aircraft
- write a paper demonstrating everything we learned throughout the semester
- professional report to determine how well grasped material
- show him what we know
- where we stand, to show progress and why the project behaves as it does
- for creativity and organization
- how to administer time effectively
- determine a bunch of meaningless numbers and graphs

5. Not about right answer

- material covered is not main focus
- not specifically looking for an "answer" but explanation of analysis process
- Is it the right answer?
- less interested in correct results than he was the learning experience
- final project not necessarily to provide "correct" answer
- prof more interested in what learned than right answer
- break from old teacher centered prefab problems that have solutions kind of class
- didn't expect assignments on time – most important that had good grasp of subject
- find useful trends rather than meaningless numbers

6. Open Ended Problems

- understanding of how to solve this problem
- gain experience to solve open-ended problems
- apply all of what discussed and learned to open-ended problem
- understand, analyze an d solve open-ended problem
- finished product, overall conclusion to open-ended question
- learning how to approach open ended problems
- use understanding of thermodynamics, heat transfer and fluids to address open ended projects
- explore situation where answers aren't known and may not even be attainable

7. Process

- material was tool for going through setup of class
- process was most important part or project

- prof interested in analytical thought process
- correct solution desirable – experience gained
- work through analysis and conceptual idea not necessary given or discussed in class
- utilize information learned through analysis question solutions
- get theory from concept questions, use this theory to answer analysis problems then project problems
- put together concepts from concept questions, analysis problems and project problems into final project

8. Real World Application

- real as possible – actual business world
- opportunity to explore real world problem
- real life engineering problem
- practice for real world situations
- learn how to attack real world problems
- apply what is learned in classroom to actual engineering problems
- apply (thermo fluids) principles to solve real world problems
- like work will be doing in work force
- learn how to convert open-ended, poorly constrained problem statement from real world into a problem statement suitable for engineering analysis
- use fundamentals of thermo, heat transfer and fluid flow to solve problem

9. Resources

- use all the resources we could find
- do lot of research
- research planes currently being used to determine performance parameters
- gain better understanding of resources available
- be able to research independently with minimal direction from instructor
- most importantly, showed us that there are resources outside of the professor's head
- look for resources
- go ask questions
- research problem
- use tools made available such as ref books, internet, office hrs, disc sessions

10. Teamwork

- try to solve problem as a team
- work with others
- teach teamwork, comradery (sic) and communication skills
- learn how to work in teams

11. Thermal Fluids Content

- have thorough understanding of turbojet/turbo fan engines through assignments
- utilize thermal fluids background to solve engineering problems
- analyze open-ended T-F problem
- use our skills and material learned in previous classes
- understand and apply knowledge of subjects covered in this class
- stretch basic understanding on thermal fluids – higher and more in depth
- gain understanding of jet engines
- find and uncover information about the system -> plot results

Pre Test Categories	Post Test Categories
Use Cognitive Activities and Skills	Decision Making/Independence/Trust Self
Seek and Use External Resources	Design/Analyze an engine
Participate in Group Work	Effort
Purpose is preparation for real world	Learning/Skills Improvement/Knowledge
Develop understanding of engineering concepts	Not about right answer
Exhibit problem solving process	Solving Open-ended problems
Exhibit Analytical Skills	Process
Don't know what is expected	Real World Application
Process over product	Resources/Research
	Teamwork
	Thermal Fluids Content

Table 7. Categories derived from pretest and posttest.

A fellow graduate student reviewed the pretest and posttest responses and defined the main topics. They matched very nicely with my 13 categories. In Table 8 below, I have matched her emergent themes to my categories. All her categories except for "feel proud" were consistent with my categories. All my categories except for number 11 were matched. This peer is not an engineer and is not familiar with the material covered in this course.

My Category	Peer's topics
1. Make engineering decisions	make decision
2. Design/analyze engine	analyze creativity
3. Effort and initiative	a lot of effort
4. Skill, understanding and knowledge gains	learn something explore all options stretch understanding
5. Not about right answer	no answers (or many answers)/ not correct answer
6. Solving (open-ended) problems	open-ended convert open-ended problem
7. Importance of process	process
8. Real world applications	like workforce
9. Seek and use external resources	resources/tools research
10. Work with others	communication skills teamwork
11. Increase understanding of Thermal – Fluids	
12. Make connections	put together concepts skills/material from previous
13. Dazed and confused	unclear directions/vague meaningless" numbers
	feel proud

Table 8 . Comparison of my 13 categories with a peer's themes.

Appendix K -Descriptive Statistics of Variables

Variable	Mean	Std. Dev	Mode	Median
Age	22.3	3.1	21	21
Work1	1.27	0.45	1	1
Lead1	2.48	0.87	2	2
Int1	3.24	1.3	4	3
Drive1	3.45	0.87	4	4
Pref1	3	1.09	3	3
Tc2	3.09	0.91	3	3
Team1	3.7	0.98	4	4
Team2	3.76	0.97	4	4
Plans1	3.39	1.82	4	3
Plans2	3.30	1.41	5	3
Env1	3.58	1.23	4	4
Env2	3.28	0.1.05	3	3
Crunch1	2.59	1.41	2	2
Pre2	3.05	0.82	3	3
Post2	2.70	0.95	2	2
Pre3	3.25	0.80	3	3
Post3	4.15	0.97	5	4

Table 9. Descriptive statistics for all variables (based upon all responses, not just paired)

Variable	Number of occurrences of value				
	1	2	3	4	5
Gender	28	5			
Birthplace	27	5			
GPA	0	9	16	8	
Work1	24	9			
Lead1	4	13	12	4	0
Int1	3	8	7	8	7
Drive1	1	3	11	16	2
Pref1	3	7	13	7	3
Tc2	0	6	13	6	2
Team1	0	4	10	11	8
Team2	0	3	7	13	4
Plans1	5	6	6	8	7
Plans2	3	5	6	5	8
Env1	2	5	7	10	9
Env2	1	5	9	6	5
Crunch1	9	9	4	6	4
Pre2	0	7	16	10	1
Post2	1	16	10	4	2
Pre3	0	5	17	12	1
Post3	0	3	4	11	15
Grade	11	12	16		

Table 10. Number occurrences of each value per variable

Appendix L - Sample of Raw Transcripts

From second interview with Bill, October 8, 2003.

(R: is researcher; B: is Bill)

R: How did Project Problem one go? I think when we talked last it was due in two days and you hadn't started.

B: Yeah. We got together that evening and kind of cranked it out. I'm not exactly sure if we did it correctly but we put our effort into it. There's like four of us working on it so hopefully we did good enough to do good. I guess we'll get that back Thursday so give you an answer then.

R: You have your teams now. I recall your team was you, and XXX, and YYY

B: YYY and ZZZ. He was absent today. We actually haven't met yet. I think we have a little bit of time. We'll probably meet either later on this week or get together early next week and start something important we've got to start on soon.

R: When is project problem two due?

B: You know, I haven't, he printed out a syllabus but I haven't even looked at when it's due.

R: It's not Thursday then?

B: No. Not Thursday.

R: That'll be a team project then?

B: Right. I'd like to work on it as a team. I don't know if we will.

R: Because you and XXX, y'all have been working together so you have that relationship to start with. Do you know the other guys?

B: I'm not sure who YYY is.

R: He sits next to Sami, quiet guy.

B: Oh yeah. And ZZZ, we know who he is. We talk to him. Actually had him for a class before. I guess it's all, the camaraderie is there, not a problem with meeting people.

That kind of helps. As far as group work goes anyway.

R: You had mentioned that you liked working with your friends because you already were established.

B: Right, but I don't really know who these people are so it won't be that bad.

R: So have your perceptions of Dr Austin's expectations changed any.

B: No, but he did say that the concept questions were going to be trimmed down the analytical questions were going to be stepped up.

R: Kind of a flip.

B: Yeah, I don't know if that's happened yet. To me the conceptual questions, he assigned four of them this week which isn't all that much, but compared to the amount, we still had A8 and A9 to do, and that was a big part.

R: Well A9, I guess if you get A8 going

B: yeah you just plug in the efficiencies for A9 into A8

R: Did your curves on A8 look like his?

B: Not exactly.

R: Somebody was saying they had not talked to anyone who had curves like his but everyone that he had been talking to had the same curves but none like Dr Austin.

B: Everyone looked the same but none like his?

R: So I don't know if this person had talked to you or not.

B: I know some people who worked on writing a program for four or five hours, all day long (Friday) and they kept asking Dr Austin for help and I saw what their graphs looked like and saw what Dr Austin graphs looked like and they were not anywhere close

R: And your's had some similarities?

B: well, with my peers' but not Dr Austin. I got to talking with one other person and he told me we just need to modify some values in the program and that would modify it to kind of look like Dr Austin's but I haven't had a chance to do that yet. That was just today. Hopefully that'll work.

R: It sounds like your group that you work with, y'all have been working pretty close.

B: Yeah, we've had this group for a year and a half, two years now.

R: So you schedule all your classes together as best you can?

B: Yeah, as best we can. If we're not in the same class, at least taking the same class with a different professor and normally the workload's about the same.

R: Really makes a difference. I look at some of the people in that class who seem like they are going solo

B: Oh yeah, it's rough. It's terrible to do it alone. I don't know if anyone works alone these days.

R: I think some people still do. You said when you first came here you did because you didn't' know people.

B: But you start meeting people that you see on a regular basis. I've seen some people try to work on stuff alone. That's just too hard. I guess it could be done. It's not for everyone.

R: I think you learn more working with other people too.

B: Oh yeah. Working alone and you make a mistake and you believe that your mistake is right it's going to propagate through the entire thing but if someone points that out to you early then you'll be able to correct yourself so I think that's a great advantage of being able to work with other people.

Appendix M -Process of Converting from Transcription to Summary to Narrative

The path from the raw transcripts to the summary to the narrative was not linear. It was a synthesizing process. An example of interpreting the data from an interview with the instructor to a summary to the final narrative is shown below. R was the researcher and I was the instructor.

Transcription

R: And you handed back project problem one today. You said the average was a bout a six. I assume that's out of ten.

I: Yes.

R: Your comment was that there wasn't much comment on there.

I: That's right, they just gave me stuff and no explanation, no insight, no understanding. And Theresa, I really felt like I had made that point beforehand. The problem is they don't believe it. I think we've gone through this before.

R: Yeah. When you were saying they didn't do much comment and you said something like "maybe I didn't make that clear," and I wanted to say something at that point like what! I think you did!'

I: (A student) reacted without thought using some very bad language when I talked about the project problem one being the first section of their report. It was enough to upset him so he must have heard so why did I still, and I don't know whether

he gave me any comment or not, but in general, after that, well after that, that was early in the process. If it elicited that kind of knee jerk response and horror, it must have meant something to them.

Summary

He handed back project problem one in class earlier that day. The average had been a six out of ten due to a lack of comment. " they just gave me stuff and no explanation, no insight, no understanding. And Theresa, I really felt like I had made that point beforehand. The problem is they don't believe it. I think we've gone through this before….xxxx reacted without thought using some very bad language when I talked about the project problem one being the first section of their report. It was enough to upset him so he must have heard so why did I still, and I don't know whether he gave me any comment or not, but in general, after that, well after that, that was early in the process. If it elicited that kind of knee jerk response and horror, it must have meant something to them.

Narrative:

He was disappointed with the results of P1. The class average was six out of ten due to a lack of comments. The instructor felt " they just gave me stuff and no explanation, no insight, no understanding. I really felt like I had made that point beforehand. The problem is they don't believe it. I think we've gone through this before." He described how one student had "reacted without thought using some very bad language when I talked about the Project Problem One being the first section of their report. It was enough to upset him so he must have heard … If it elicited that kind of knee jerk response and horror, it must have meant something to them."

Appendix N – Sample of Interpretation Process

With qualitative research, the researcher's interpretation of the data is accepted as one possible interpretation of the results while recognizing that others might interpret the results differently. Since the researcher has been a witness throughout the research process, the assumption could be made that she has more qualifications for interpreting the data. Regardless, understanding the researcher's process of interpretation is important to establish validity. I describe below an example of how I interpreted some of the results of my study.

Achievement Goals

In my last chapter, I make a distinction between the achievement goal orientations of my four student participants. I interpreted Mary and Sami as appearing to be more oriented towards exhibiting behaviors I associate with mastery goals while Bill and Barbie appeared to be more oriented towards engaging in behaviors I associate with performance goals.

Students who are mastery goal oriented "strive to acquire new skills and expand and develop their competence" (Ames & Ames, 1991, p. 249). These student value challenge and hard work and sees effort as part of an incremental process of learning. Mastery goal oriented students view mistakes as part of the learning process. Mastery goal oriented students are performing in response to self-directed standards (Ames, 1992). Mastery goals are also often associated with higher intrinsic motivation (Church, Elliot, & Gable, 2001).

Students who are performance goal oriented "strive to obtain positive judgments of their ability, avoid negative judgments of ability, and generally document and validate their competence to themselves and to others" (Ames & Ames, 1991, pp. 249-250). They value high grades, especially in comparison to others. Errors produce anxiety. Performance goal oriented students perform in response to expectations of others (Ames, 1992).

Screening Survey:

At the beginning of the semester, I administered the screening survey (See Appendix D) to the entire class to provide me with some background about the students in the class. I used this information when choosing my four student participants, trying not to choose four students with similar distributions of their responses. Their responses are given in Table 11 below.

Student	Gender	B'place	Age	GPA	Q1a	Q1b	Q1c	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Bill	1	1	23	3	2	2		2	4	2	3	3		3	2	5
Mary	2	1	22	4	1	1	2	3	5	2	5	4	1	1	4	2
Sami	1	2	21	4	2	2		2	4	3	2	2	3	4	1	4
Barbie	2	2	28	3	1	1	2	2	5	4	5	4	4	4	2	5

Table 11. Student participants' responses on the Screening Survey.

Questions 4 and 8 relate to goal orientation, especially Question 4.

4. While working on a project, I am more driven by:

1 **2** **3** **4** **5**

using the project as an opportunity to dig deeper and learn

making sure that I am doing everything the professor expects so I can earn a good grade.

The lower end responses were more oriented towards mastery goals while the higher end was oriented towards performance goals. Both Bill and Mary answered with 2, Sami with 3 and Barbie with 4.

A second question that provided insight was Question 8:

8. I like a classroom environment that :

1	**2**	**3**	**4**	**5**
let's me be creative and do things my way of me				has lots of structure where I know what is expected

Again, the lower end responses might be associated with mastery goals while the higher end responses could be associated with performance goals. Bill responded with 3, Mary with 1 and Sami and Barbie with 4.

I thought Mary answered both questions with responses that indicated a mastery goal orientation while Barbie answered both questions with a response that indicated a performance goal orientation. Sami and Bill were more in the middle with Sami actually leaning towards performance goals and Bill towards mastery goals.

However, my final interpretations of the student participants' goal orientations were not based upon the self-reported responses on the screening survey. My final interpretations were based upon the students' behaviors in the course, mainly as reported through the interviews and classroom observations. Note that none of the four students exhibited strictly mastery or strictly performance goals but that my interpretations were made based upon what seemed to drive them most. Table 11 below (Pintrich & Schunk, 1996, p. 240) compares behavioral characteristics for mastery and performance goals. Using this table, as well as the other references on achievement goals, I interpreted the student participants learning goals based upon their behaviors and our interviews. In Table 13, I have shown how I viewed each participants' behaviors and attitudes relative to each goal definition or outcome.

When reflecting upon the behaviors of my four student participants, Sami and Mary both jumped out as being focused upon working on the computer models for their groups. Mary seemed almost obsessed with creating a model that reflected the correct

engine performance trends. Sami also seemed to obsess with his model but more from a sense of enjoyment as he perfected it and made it more adaptable to changes that might need to be made with future assignments. He used the word "fun" several times in talking about his academic experiences. For example, the professor's methodology took the fun out of the project. I associate "fun" to indicate enjoyment of learning and intrinsic motivation. Sami would stay up all night engrossed in the material then miss class. He described how he would lose track of time and the pain in his back as he worked. Both Mary and Sami seemed to be less concerned about what the instructor wanted them to do and more focused on doing what they wanted to do in addressing the course material.

Bill and Barbie both struck me as being in a situation of trying to just make it through the course as they juggled the rest of their lives. While all the students expressed some comments about grades, Bill and Barbie both seemed interested in doing what was necessary for their grades. Barbie was concerned about what others thought of her performance and wanted to contribute to her team. She described how she told the instructor that the peer pressure was good. "I like it because it makes me feel bad with myself it I'm not prepared and it makes me 'gosh, I have to think. learn, learn, learn.'" Bill commented that the instructor could not flunk them all. Both Bill and Barbie described the instructor as fair which I interpreted to indicate a concern about how students compared with each other. Both Bill and Barbie used their interpretations of the instructor's expectations in defining their workload. They were both concerned about what the instructor thought of their performance but also seemed willing to let someone else define their performance. Sami and Mary seemed less willing to let someone else define their performance.

Definitions/Outcomes	Mastery	Performance
Success Defined As….	Improvement, progress, mastery, creativity, innovation, learning	High grades, better performance than others, higher achievement on standardized tests, winning at all costs.
Value place on	Effort, attempting challenging tasks	Avoiding failure
Reasons for effort	Intrinsic and personal meaning of activity	Demonstrating one's worth
Evaluation criteria	Absolute criteria, evidence of progress	Norms, social comparison with others
Errors viewed as	Informational, part of learning	Failure, evidence of lack of ability or worth
Outcomes associated with different goals		
Attributional patterns	Adaptive, failure attributed to lack of effort, outcome is seen as contingent on personal effort	Maladaptive, failure attributed to lack of stable ability
Affect	Pride and satisfaction for effortful success Guilt associated with lack of effort	Negative affect following failure
Cognition	Use of "deeper" processing strategies Use of self-regulatory strategies including planning, awareness and self-monitoring	Use of more surface or rote learning strategies
Behavior	Choice of more personally challenging tasks More risk-taking, open to new tasks Higher levels of achievement	Choice of easier tasks Less willing to take risks, try new tasks Lower levels of achievement

Table 12. Goal Orientation and Other Motivational and Cognitive Outcomes. (from Pintrich & Schunk, 1996, p. 240)

Definitions/Outcomes	Mary	Sami	Bill	Barbie
Success Defined As….	M: Working model	M: Efficiently working and flexible model	P: Mentioned tweaking model, based upon classmate's advice, so would look correct	P: Completing assignment, good grade
Value place on	M Near Obsession with computer model	M: Near Obsession with computer model	P: Completing assignment on time	P:Contributing personal share of work towards project
Reasons for effort	?: the right answer - working model	M: fun	P: Complete course and graduate	P: Wanted to do her share of work towards project
Evaluation criteria	M: Wanted absolute criteria – instructor's working model P: Looked at peers' models	M: Confident telling instructor that he (instructor) is wrong	P: Looked at peers' models "he can't flunk us all"	
Errors viewed as	P: Frustrating	M: uncovered in visit to instructor's office, didn't seem concerned, bump in the road	M: not great concern	M: worked w/ TA for P1 to resolve
Outcomes associated with different goals				
Attributional patterns	M: Would have been able to complete if given enough time			P: Felt not as smart as some teammates
Affect	M: Interested in topic	M: Interested in topic	M: Interested in topic	M: Interested in topic P: Didn't like seeing GPA go down

Cognition		M: Would stay up all night trying to understand content		?:“think, think, think” worked alone
Behavior	M: Performed most challenging aspect of project by choice	M: Performed most challenging aspect of project by choice	P: Had to do most challenging tasks or fail P: Chose not to do P4 when option given Low risks	P: Writing on report, checking model (easier tasks) P:Let other team members do model P: Sought external help when stuck (less risk taking?)

Table 13. Student behaviors matching goal definitions and outcomes.

Barbie also seemed to distinguish between smart students and students who weren’t as smart. She included herself in the latter group. She even spoke of some students being lucky with grades. Seeing ability as something static instead of something that can be affected through effort is characteristic of students with performance goals. Bill was very interested in the material as evidenced by questions he asked in class and afterwards .If he had taken the course another semester when he did not have the demands of his senior project, finding a job, and graduation I think he might have been able to focus more on mastering the content and perhaps would have been less performance goal oriented.

Appendix O – Excerpts from Researcher's Journal

(edited to protect confidentiality)

Wednesday, October 9, 2002

I just remembered conversation w/ Dr A yesterday afternoon. I had stopped by his office to discuss the "professional development" on teams I'll be doing next Thursday. Anyway, he asked me about how I thought it went when he put his solution up in class. I told him that if I had been a student I probably would have been frustrated because the text was too small to read. He said something along the lines of this being his intent. He wanted them to follow his process, not write it down. I conveyed to him that what I am hearing from students is they all have the same curves but they don't look like his and they're frustrated, maybe what they want to be able to do is compare step by step, his solution to theirs. He said something along the lines of maybe he needs to post it then. I need to try to remember to discuss this with him Thursday.

Sunday, October 13, 2002

[paragraphs edited out]

I conducted the pretest on Thursday. I have some concerns that I gave it too early. Many (most, all?) students have not read it. I should have asked them indicate whether they had read the project description which was handed out at the beginning of the semester. The instructor wrote out his expectations – five items:

Expectation is that students

(1) Think through the problem to the point of understanding what the problem "is"

(2) Plan a logical approach to the problem (using background from ME 326, 330 and 339 plus assigned reading and class discussion)

(3) Execute the plan (asking questions and gains further background by reading, internet, etc)

(4) Present results of analysis and reflect on the meanings of their results

(5) Discuss what was learned

I went through each student's pretest and recorded on a yellow post-it, stuck to the paper, which of these five I thought they had included. I felt I was fairly lose in my

interpretation and tried to consider the students' intent. These are recorded in an excel spreadsheet.

I also went through all the papers and recorded the ideas each student expressed, paraphrased or direct quote. I am now in the process of grouping those together into probably six or eight major categories. I will then go through and record in an Excel spreadsheet the number of students who responded under each broad category. Many of these are related to expectations the instructor has expressed in class and I will seek to make that correlation.

Looking over the pretest, so many of the students seemed restricted to understanding content, not the skills and abilities the instructor is also stressing. I just wonder how much of this is the teacher-centered mindset. Maybe I need to look for a correlation between these students and their responses on the screening survey. I can't help but believe that some students are so ingrained with the lecture/teacher-based mindset that they cannot "relax" for the student-centered environment.

Appendix P – Sample of Classroom Observation Notes

Classroom Observations – September 5, 2002

The instructor had a doctor's appointment at 2. I was scheduled to administer the screening survey that afternoon in the "work" session at 4. We switched and I administered the survey at 2. I also briefly presented some of the educational theory behind the course – the roles of the student and instructor in teacher vs student-centered courses. The class was very talkative, especially the windows side. We engaged in what I considered some very good conversation. The subject of grades seemed to be the most lively topic, bringing in more students who had been quiet to that point. In discussing what is more important, grades or learning, I tried to ask about what will be more important in five years but they seemed very focused on the present with good reason. The attitude I perceived was that the gpa is important now to get a job. Five years from now is irrelevant if you can't get a job due to low gpa. Two students came up to talk to me after class. They had been relatively quiet in class. At the beginning of the 2 pm session, one student was very vocal about wanting to change the second session beginning time from 4 to 330. The rest of the class joined in. I told them they'd have to ask the instructor. I also passed around a crude template for the seating chart.

The class returned at 330 as directed. Some had stayed since 240 when I dismissed the first session. The instructor arrived about 335. A student requested that the section session be moved from 400 to 330. Interestingly, the student who had been so vocal about this earlier in the day was silent through the whole discussion with the instructor. The instructor agreed to changing the start of the "work" session to 330 but would not move it to 315. He stated they needed fifteen minutes to move around after and hour and fifteen minutes of class. ST asked about number 11, friction factor. Instructor wrote equations on the board. Good two way banter.

3:47 – students quiet and watching
3:55 – students very quiet, one or two questions in last ten minutes
note: seems more laughter, at ease

instructor draws an airfoil and asks question
comments that he needs to stop while ahead , not prepared to do a fluids lecture off the top of his head

4:00 shuffling of feet, quiet

"Is this helping?" "Sure" with sarcasm; students joke some when he left board

4:08 – real quiet, arms crossed

Students on the window side of the room much more talkative (this is what I noticed when I was presenting earlier. I felt drawn to the windows side of the room, sitting on the front table and talking to the students. then I realized that I might be leaving out the door side of the room so I walked over there. that's when the class seemed to die. were they tired or was it because I wasn't directly in front of the windows?) The instructor was leaning against the lectern near the windows, also talking mainly to the windows side of the room. The windows side of the room is three females and the rest males, mainly white. The doors side of the room has more nonwhite students, several foreign students. Does this affect the ease of talking.

4:18 Students ready to go. Maybe they think they should be out at 415 since started at 330? Feet are tapping. Quiet.
4:20 Students responsive to questions about nautical miles.

"That's what we're going up against folks (referencing the planes they had looked up on the internet per hw assignment). We want to build a better airplane than what they've got." (problem definition, expectations?). Instr standing in front of windows side. The windows side is alert, the doors side is not so alert.

I: "Would you get upset if I changed numbers in the homework problem?"
S: "You haven't given us hw problems"
I: "Yes I have. It's on Prometheus."
S: "Oh" (more than one response)

Students went around the room and introduced themselves and said something about themselves. Many talked about where they were from, their work experience. The introductions started on the front row of the windows side. The students on the windows side joked more. One male couldn't think of anything to say about himself so the female next to him embarrassed him by saying who his girlfriend is. This was quite fascinating. Students have an interesting range of backgrounds. One student was in AF and worked on planes. (This is something instr and I had discussed doing. He wanted me to wait until the session where he was going to be there)
Students left the room laughing. (Will they enter the room today laughing) Some students came to the front with questions for the instr.

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Vita

Theresa Louise Jones was born July 2, 1958 in Decatur, Alabama, to Ruth Sneed and Maurice J. Jones. After graduation from Decatur High School she attended the University of Alabama in Tuscaloosa where she was also a co-operative education student at NASA/Marshall Space Flight Center. She received her Bachelor of Science in Mechanical Engineering and moved to Houston, Texas, where she worked for Fluor Engineers. After earning her Master of Science in Mechanical Engineering from The University of Texas at Austin, she worked at International Business Machines for 12 years. She began her career veer into education by earning her Master's of Arts in Developmental and Adult Education from Southwest Texas State University. She then enrolled at The University of Texas at Austin to pursue her Doctorate of Philosophy in Mathematics Education.

In addition to being a teaching and graduate research assistant in both the mechanical engineering and mathematics education departments, she worked as a graduate research assistant at the Charles A. Dana Center and in the Learning Technology Center at The University of Texas at Austin. She has presented at the Conference for the Advancement of Mathematics Teaching and at the American Society for Engineering Education Conference.

She is currently teaching Developmental Mathematics at Austin Community College where she has been employed as both a tutor and instructor while pursuing her doctorate. She has a strong commitment towards continued research into the effective integration of projects and other student-centered learning strategies into the engineering classroom.

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