THE EFFECTS OF THE CLASSROOM FLIP ON
THE LEARNING ENVIRONMENT: A COMPARISON OF
LEARNING ACTIVITY IN A TRADITIONAL CLASSROOM AND A
FLIP CLASSROOM THAT USED AN INTELLIGENT TUTORING SYSTEM

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

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By

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ABSTRACT

With the rise of technology use in college classrooms, many professors are open to structuring their classrooms in innovative ways. The classroom flip (or inverted classroom) is one such innovative classroom structure that moves the lecture outside the classroom via technology and moves homework and practice with concepts inside the classroom via learning activities.

This research compares the classroom flip and the traditional lecture/homework structure in two different college level introductory statistics classrooms. In the classroom flip classroom, an intelligent tutoring system (ITS) was used to deliver the lecture content outside the classroom. Students completed active learning projects in the classroom that often required the use of a spreadsheet computer program to help students work with the concepts in the course. In the lecture/homework classroom, students attended lectures on course content that included PowerPoint slides, and then students practiced with the course concepts by completing homework from their books outside of class.

The learning environment and the learning activity in both classrooms are investigated in this study with respect to activity theory and learning environments research. Students were given the College and University Classroom Environment Inventory (CUCEI) to measure both their learning environment preferences and their learning environment experiences. In addition, data were collected via field notes.
classroom transcripts, student interviews, student focus groups, researcher journal entries, and student reflections. The quantitative data were analyzed using t-tests and MANOVA, and the qualitative data were analyzed using grounded theory methods.

The findings of this research show that classroom flip students were less satisfied with how the structure of the classroom oriented them to the learning tasks in the course. The variety of learning activities in the flipped classroom contributed to an unsettledness among students that traditional classroom students did not experience. Finally, the concept of student comfortability with learning activity is presented and developed in light of learning environments research.
Dedicated to my wife and children.
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CHAPTER 1
INTRODUCTION

Many college and university professors desire to change their instructional style from traditional lecture to a more active, student-centered style through the use of group projects, discovery activities, experiments, and class presentations (Baker, 2000). Until recently, however, some professors feared they would sacrifice course content if they utilized such active learning techniques during class. With the increased availability of web-based instructional technologies like Web CT and Blackboard during the late 1990s, professors began providing students with access to course content via video and PowerPoint lectures outside the classroom (Lage & Platt, 2000). With the delivery of course content secured via technology, professors felt freer to introduce activities inside the classroom that would give students the opportunity to engage material in an environment where other students and the professor are present to aid in the learning process.

This change in how course content is introduced to and engaged by students is a significant departure from the lecture-homework cycle found in more traditional classrooms. Perhaps the most striking departure is the physical location of where the introduction and deeper engagement with the material occurs. Traditionally, the introduction is given in class through a lecture, and the deeper engagement occurs outside
of class through homework. In the above description, however, the introduction occurs outside of class and the engagement occurs inside the classroom. Researchers have come to dub this flipping of what is traditionally done inside and outside the classroom the “classroom flip” (Baker, 2000) or the “inverted classroom” (Lage & Platt, 2000; Lage, Platt, & Treglia, 2000).

**Figure 1.1.** The classroom flip (Baker & Mentch, 2000, n.p.) (Used with permission.)

**Investigations with the Classroom Flip**

I want to take a few moments to trace my involvement with technology in the classroom and how I came to be interested in the classroom flip. In 1998, I began using PowerPoint and web pages as instructional aids in my introduction to statistics courses. This marked the beginning of my everyday computer use in the classroom. In the spring semester of 2001, I replaced the paper textbook in my precalculus course with a CD-ROM video lecture “textbook” called Thinkwell (see http://www.thinkwell.com for more information). Outside of class, students watched precalculus lectures and completed
online multiple-choice exercises for homework. When students came to class, we worked on more difficult precalculus problems in small groups. Without giving it a name, I was following the format of the classroom flip: introduction of material outside class using computer technology, and active participation inside class. Later, in a 2002 newsletter, Thinkwell made reference to how their product can be used in an “inverted classroom” setting (Thinkwell, 2002).

In June of 2001, I participated in a summer training institute where I learned how to use a courseware management system (CMS) (see Appendix A for a complete list of acronyms used in this document) called Blackboard. Blackboard (and other CMS) is a computer system designed to help professors develop an interactive web page for use in the classroom. Professors and students can exchange computer files (text, video, and audio), and professors can set up electronic discussion boards, give students on-line quizzes, and manage their grade books online (among a host of other things). I first heard of the classroom flip during this training institute, and the administration at the university where I taught encouraged me to try it using Blackboard.

The following spring semester (2002), I explored the classroom flip idea further by videotaping myself teaching a lecture that covered a chapter in my Introduction to Statistics course. Students viewed this lecture for homework and completed a project during class for that chapter. I collected small amounts of data in both the Thinkwell Precalculus class and the Introduction to Statistics class with videotaped lecture. The results of these pilot studies guided my thinking at the beginning of my dissertation research. They are summarized below.
The Thinkwell Pilot Study

In the spring semester of 2001, I used the Thinkwell video lecture series and web-based homework system (rather than a paper textbook) as the primary learning resource in my precalculus class. The class was made up of 15 students: 7 female and 8 male. The class met 3 times per week and students were required to watch an hour of video lecture and complete multiple choice homework assignments on the web before coming to each class session. When students answered each homework question, the system immediately told students if their response was correct. If the student had responded incorrectly, the system gave an explanation as to the probable mistake they made and provided the correct answer along with a brief justification for that answer.

At the beginning of each class meeting, I would conduct a short question and answer session over the assignment that was due that day. Then, I would hand out challenging problems (similar to the more complex problems they did for homework) for students to complete in pairs. I would float around the room to answer questions and provide hints to help students solve these more difficult problems.

I had a three-fold motivation for structuring class this way. First, I had difficulty in previous courses getting students to read their mathematics textbooks before coming to class, and I wanted to see if video lectures could sufficiently introduce students to concepts and get them ready to work with more involved mathematics in the classroom. Second, since this class was an 8:00 a.m. class, I wanted to give students control over when they were presented with new information. I had watched too many students struggle to stay awake through early morning lectures and hoped that giving students control over when they considered new ideas would prove productive. Finally, I hoped
the immediate feedback of the web-based homework would help students as they worked to understand the mathematical concepts in the course.

**Methods**

At the time I was teaching this precalculus course, I was also exploring research that dealt with technology and education. Themes of interest to me in this literature dealt with control over learning, student confidence with the computer, student enthusiasm, connections to people rather than machines, and the need for a physical classroom. I developed a questionnaire that addressed some of these themes (see Appendix B), and at midterm I administered this questionnaire to get feedback from students about their experience in this unique classroom setting. All of the questions on the questionnaire were categorical in nature, so I used the chi-square test statistic as a tool to look for significant relationships among these themes.

**Results**

In the Thinkwell precalculus class, students were evenly split (7 to 7) in their opinion of whether the technology gave them more or less control over their learning in the course. There was also a split (i.e. there was no significant statistical difference) among the students as to whether technology gave them a worse (9 students) or better (5 students) opportunity to master precalculus. Since Thinkwell gave students: (1) the freedom to manipulate the video lectures (to replay or skip over sections), (2) the freedom to choose the time when they viewed the video lectures, and (3) immediate feedback on homework questions, I was initially surprised by these survey results. However, as I reflected on conversations I had with students throughout the semester and analyzed written comments on the surveys, I began to see potential explanations for these
results. On the written portion of the questionnaire, half of the students stated they loved having control over the video lectures and freedom to choose when they would view lectures and complete homework. However, many students recounted problems with technology that hurt them in the learning process. A few students had access only to older computers, and this caused the video lectures to periodically hang up and then jump ahead. These difficulties made viewing the lecture a frustrating experience for these students. A couple of students complained of needing to constantly troubleshoot technology issues (one student wrote, “it takes more time to fix technology problems than to actually do the homework”), while others actually experienced headaches from spending long periods of time watching the computer screen. Many students mentioned how frustrating it was to not be able to ask the professor on the video a simple question, and almost all students at one point or another in the semester stressed how inconvenient it was to have to be connected to the Internet to complete their multiple choice homework assignments.

Taken together, these problems present a mountain of technical difficulties students must climb to be successful in the course. These difficulties explain students’ responses to the question that asked whether they were enthusiastic or hesitant about using technology in this course at the beginning of the semester versus at midterm. Twelve students reported being enthusiastic about technology use at the beginning of the term while only 4 reported being enthusiastic about technology use at midterm. These results show a significant shift in the students’ opinions of technology use from the beginning of the semester to midterm ($p < 0.01$). The frustration with technology is apparent in this student’s comment from the written portion of the questionnaire:
Technology makes things go faster and is much easier, but there are more drawbacks from technology than positive things. In this course, I feel technology is a drawback. I am not learning… there is no benefit in using technology in this course. Plus, it is more of a hassle [than] just getting out the textbook and doing the homework.

In the questions that measured relationship development in the class, none of the students responded that they felt more connected in their relationships with the professor or other students in this class than they do in their other classes. In an even split, 7 students said they felt the same level of connectedness to other students in this class as compared to their other classes and 8 students said they felt less connected. However, students reported 11 to 4 that they felt less connected with the professor in this class than in their other classes. This result was moderately significant ($p < 0.10$) when compared to an expected response of the class being split evenly between the same and less connected.

One student felt so strongly about the importance of being connected to the professor that all he wrote on the written portion of the survey was, “Everything is 3.” The third question on the survey was the question that asked about connectedness to the professor.

Finally, the issue of the need for a physical classroom was raised in 3 of the students’ written responses and in conversations with students throughout the semester. Students commented that class was redundant, boring, or even a waste of time. As one student wrote, “Class can get a little boring since we already learn the stuff on the computer.”

Conclusions

Two conclusions from this pilot study informed my dissertation research. First, if a professor is going to use technology as the main tool to introduce students to new content, then the technology must work smoothly and not burden students with its form.
Students are willing to work with technology to a point before calling for support, but if there are too many technical difficulties and students must spend more time troubleshooting than doing homework, then the positives technology brings to the table (freedom and control over learning) will be over-run by the negatives.

Second, it appears that using technology to introduce students to new content may cause students to feel less connected to the professor in the classroom. Using technology for the introduction may also negatively influence students’ ability to transfer their learning to contexts different from those in the initial introduction. When students feel class is a waste of time, this is an indication that the professor must offer something beyond more difficult practice problems in class. Perhaps the professor should focus classroom activity on helping students transfer their learning to new situations. Whatever the case, professors must offer something in the classroom that students cannot get elsewhere. They must create an environment where the classroom becomes a dynamic learning community.

_The Flip Pilot Study_

During three days in February of 2002, I again investigated the classroom flip, this time in two of my Introduction to Statistics classrooms. I structured one class as a lecture and homework out of a book class and the other as a classroom flip class. I wanted to investigate how the change in communication in a classroom flip setting would influence students’ learning, confidence, and attitudes toward learning.

_Method_

I used a random number generator to choose the 8:00 a.m. section of Introduction to Statistics to be the classroom flip class and the 9:10 a.m. section to be the lecture and
homework class. Both sections had been structured as a lecture and homework class when we learned the information in chapter 1 of the textbook. For chapter 2 (the descriptive statistics chapter), however, I had the flip class go to the library to check out and watch a 55-minute video of me lecturing over the information from the chapter for their homework. When students came to class, they completed a group project for three class periods. This project gave them an opportunity to apply descriptive statistical techniques to a real-world context. Students then wrote a report to a fictional character who asked them to put their mathematical findings in everyday language. (For a description of the project, see Appendix C). The lecture and homework class continued in the normal way for the three days that we discussed chapter 2. When this three-day investigation was complete, both sections returned to the lecture and homework class format for the remainder of the semester.

In an effort to gather data that would shed light on this pilot study’s research objectives, I recorded grades on the first exam (chapters 1–3), developed and distributed a survey to measure students’ confidence in their abilities to complete problems over the information in chapter 2 (see Appendix D), videotaped class sessions, and interviewed 3 students from the flip classroom. I analyzed the quantitative data using a t-test to look for significant differences between the two sections. I analyzed the qualitative data by performing a theme analysis to look for patterns that could provide descriptions and explanations of what was happening in the two classrooms.

Results

An analysis of the confidence surveys showed that students from the lecture and homework class were more confident in their abilities to successfully complete a quiz
over information from chapter 2 than students from the flip class ($p < 0.001$). Students in the lecture and homework class also had a higher average score on the first exam than students in the flip class ($p < 0.05$).

Analysis of the classroom flip interviews revealed that students seemed to struggle with where they fit into this new way of doing class. As one student described,

The thing I have with [the classroom flip] really is that it didn’t fit my study habits. I’m used to doing my homework later at night with either a movie on or music playing. And with all of those people talking, especially some certain groups in the class that – it was just really distracting and it was just a big change and really out of my comfort zone. … I think with it being at 8:00 in the morning I’d rather hear a lecture than wake up and try and do my homework, because I’m not a morning person at all. And I can sit and write things on PowerPoint notes but especially math, because it’s like my weakest subject, I think I’d rather get a lecture in the morning.

Students were forced to adjust personal learning strategies they had relied on for years to fit this new classroom structure, and it appeared this adjustment was something students had difficulty doing in a short period of time.

One student mentioned needing to be in control of the environment when doing homework (rather than having to go to the library to view a video). “I’d rather be able to control my environment and make it more relaxing, then sit in a class and listen to a lecture. I’ve done it for how many years?” This control issue arose in a different context when another student said, “I mean it wouldn’t bother me too much to have to get my work done in class, but it would take me less time to do my homework outside of class than to watch the video.”

Another theme found in the interviews dealt with the in-class working environment for students. One student mentioned not being a “work-in-groups kind of person” and said, “Our group pretty much just faced each other and then did our own
work. So that’s what we did, so that was fine for me.” I went to the classroom videotapes to see how prevalent this approach was and found that about two-thirds of the students sat silently in their groups working on their papers while one-third of the students discussed their courses of action with others. This lack of robust group discussion perhaps explains why so many of the students’ reports read more like a play-by-play account of the steps involved in finding the mean, median, quartiles, stem-and-leaf display, etc. rather than a creative report explaining what these statistics tell the reporter (the fictional character to whom they addressed their report) about the data under investigation.

This mental separation from the group is possibly the way many students best coped with the radical change they were experiencing in their working environment. They withdrew and then did their individual best even when they technically were required to work collaboratively. Here is how one student explained the withdrawal from the group:

Well, when I’m in class, I have the tendency to listen to the other people. If they are talking about something I don’t know, then I just feel like I’m not doing something right. But if I’m doing [my work] myself, then I’ll do it my way and I’ll be more confident in the work that I’ve done.

Since the classroom flip structure was not going to extend beyond three days, students may not have seen the benefit of exerting the time and energy it takes to make a good group discussion work.

Conclusions

The results of this study reveal how profoundly the classroom flip structure changes the learning environment for students. Students need time to adjust to such a radical departure from what they are accustomed to in class. With just three days to
adjust, the classroom flip students received a substantial blow to their performance and confidence as evidenced by the lower test scores and the confidence survey results.

The data revealed an interesting link between learning in groups and confidence. When some students worked in groups and heard other people in the class explaining things in a different way, they began to feel like their thinking was wrong and doubted their abilities. Instead of engaging other students in conversation, they preferred to work alone and feel more confident in their work (even if the final product was not necessarily as good).

Three findings from this pilot study informed my dissertation. Students must have time to adjust to the changes the classroom flip brings, there must be flexibility so that students can become comfortable with the things they do and do not have control over in the learning process, and students must come to see that group learning activities can benefit their personal learning.

Problem Statement

With the increase in availability and quality of computer based instructional aids, college and university faculty are “flipping” or “inverting” their classrooms by using technology to introduce students to content outside of class and actively engaging concepts inside class. In most instances where the classroom flip is used, the professors explicitly state that they chose to use this format in order to give students a chance to actively engage course material without losing the coverage of course content (Baker, 2000; Bowers, 2002; Collins, Glenn, Violanti, & McKinney, 2002; Lage et al., 2000; OCTET, 2003; Phillips, 2002; Roane State Community College, 2003; Schauf, 2002; Thinkwell, 2002; Turoff, 1999; Ursuline College, 2002). While the classroom flip may be
useful in helping professors address this *practical need* in their classrooms, it may present *theoretical problems* for classroom learning.

The idea that course content can be “delivered” is founded on behaviorist theories of learning where knowledge is viewed as an objective entity that can be transferred from one person to another (as learned skills or strategies of thinking). However, active learning techniques have been used over the past few decades by educators who espouse constructivist theories of learning which view knowledge as something that must be built up by the learner through reflective abstraction. Thus, a classroom flip environment could end up being a place where the outside class activity is driven by one learning theory, and inside class pursuits are driven by a different (competing/conflicting) theory. It seems this situation could pose a significant problem for professors and students alike. As a result, I was interested in studying how the complexities inherent in the classroom flip method of structuring a course influences the *learning environment* for students as they progress through the course.

Learning environments can be conceived of as being made up of three domains: relationship, personal growth, and system maintenance and change (Moos, 1979, 2003). Relationship dimensions involve student attentiveness in the classroom, the extent to which students are involved with each other and come to know each other in the class, how the students work with others in the class, and the professor’s interest and attitude toward the students. Personal growth dimensions involve how students work to complete academic tasks and how they are motivated to learn. System maintenance and change deals with how orderly the class structure is, how clear expectations are, how the environment is controlled, and how responsive the classroom is to change.
This study sought to investigate how the structure of the classroom flip affects the learning environment for students. In one classroom, I used a user-friendly intelligent tutoring system (ITS) called ALEKS to introduce students to course content outside the classroom, while we completed projects together inside the classroom. Students in this flip environment and students in a lecture-homework environment took surveys, were interviewed, and were observed in class. I analyzed the data from these two learning environments to better understand the implications of this practical push for technology use in college and university classrooms.

Guiding Questions

The following questions guided the data collection and analysis in this study.

1. How does the learning environment of a classroom flip classroom that used an ITS compare to the learning environment of a lecture-homework classroom?

2. How does the activity in a classroom flip classroom that used an ITS compare with that of a lecture-homework classroom, and what is the influence on learning?
CHAPTER 2

CONCEPTUAL FRAMEWORK

This chapter develops a conceptual framework (arranged according to Figure 2.1) for investigating learning activity in a classroom that is structured using the classroom flip. Extensive use of educational technology to deliver course content outside of class is central to the classroom flip idea (the arrow going to the left and downward in Figure 2.1). Active learning during class time is the other necessary feature of the classroom flip (the arrow going to the right and downward). These two foci influence student learning environments in fundamental ways (the two arrows coming together at the bottom of the diagram). These core ideas drive the conceptual framework for this research, and the chapter is sectioned to correspond with this structure.
The history of computer technology has been filled with high expectations and deep disappointments for those who care about education. Since 1959, when Donald Bitier began the first extensive computer project in education (dubbed PLATO), educators have expected computers to help solve various problems (Molnar, 1997). Despite studies that have shown computers can effectively help students learn, some have called for their removal from classrooms until the evidence more clearly shows schools can implement computer technology within the curriculum in a way that is helpful to education (Stoll, 2000).

The computer chip is clearly transforming our society, so it is no wonder educators are struggling with how best to use this tool in the classroom. Fletcher (2001)
claims that we are in the midst of the third technological revolution in education. The first came with the development of written language. This development allowed ideas and teaching to *transcend time and place*. The second revolution was ushered in by the printing press. The mass production of high quality inexpensive texts made the content of learning *widely available*, anytime and anyplace. The third revolution involves the use of computers in education. Now, learners not only have access to the content of education, they have access to *high-quality instruction* through relatively inexpensive computerized technology, anytime and anyplace.

From this historical perspective, advances in technology have provided opportunities to transition classrooms from one-way transmission of knowledge environments (from teacher to learner) to more interactive learning environments (Bransford, Brophy, & Williams, 2000). Consider, for example, when textbooks were not plentiful in classrooms. Over the course of the school year, teachers would write course content on the chalkboard while the students, in effect, transcribed their own texts. The introduction of class textbooks in this setting allowed educators to change their pedagogy and interactively engage students with discussion during lectures on various sections of the textbook. Since technological revolutions inevitably bring cultural and structural change (Kaput, 1992), it is not surprising that educators are changing pedagogical practice in fundamental ways as a result of this third revolution.

A recent pedagogical change involves the use of web-based courseware management systems (CMS) to help faculty members create online learning environments for students using PowerPoint slides of lecture notes, video lectures, threaded discussion groups, online quizzes, live chat rooms, interactive computer
learning environments, course related video clips, sound files (audio interviews with experts, etc.), and online tutors. After the successful implementation of these systems in distance learning programs, researchers began calling on faculty members to use CMS in traditional classrooms face-to-face with students (Turoff, 1999). As university and college faculty were introduced to CMS on a large scale in the late 1990’s and early 2000’s, many professors began changing the way they plan learning in the classroom (Collins, de Boer, & van der Veen, 2001; Collins et al., 2002; Hopkins, 2002; Lage et al., 2000; Phillips, 2002; Schauf, 2002).

As faculty explored how CMS could be used to encourage collaborative learning, group projects, and increased communication within the class, Wes Baker and Maureen Lage, Glenn Platt, and Michael Treglia independently saw the possibility of using CMS to completely invert the traditional structure of the classroom, moving the lecture outside the classroom and active learning opportunities into the classroom. Baker (2000) called his move the “classroom flip.” Lage, Platt, and Treglia (2000) called it the “inverted classroom,” stating, “Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa” (p.32). The classroom restructuring these educators envisioned seeks to exploit the strengths of computer technology so that course content can be conveyed in interactive and even entertaining ways. Using technology in this way allows students to interact with the material on their own time and at their own pace.

Considering these developments in context shows that the classroom flip idea has been driven more by praxis than theory, and it appears this trend will continue. Workshops are offered that encourage and equip university and college faculty to employ
the classroom flip (Baker & Mentch, 2000; Bowers, 2002; OCTET, 2003; Ursuline College, 2002). In their 2003 strategic plan, Roane State Community College encouraged faculty to try inverting their classrooms (Roane State Community College, 2003), and a textbook company is solely in the business of selling (paperless) video lecture textbooks (Thinkwell, 2002). Obviously, the practical push for increased use of the classroom flip is strong. It is this practical push that sparked this investigation.

*Intelligent Tutoring Systems*

While professors employing the classroom flip have usually relied on web-based course management systems to help students learn course content outside the classroom, I will use an intelligent tutoring system (ITS) to fulfill this purpose. This section describes the development and use of ITS over its short history. Early computer use in education resulted in what has been termed Computer Assisted Instruction (CAI). As cognitive psychologists, educators, and computer programmers (particularly those in the Artificial Intelligence [AI] field) looked more closely at what a computer can (and should) do to help students learn, ITS emerged with the goal that one day computers will tutor students with the same skill that human tutors do (Lesh & Kelly, 1996).

*Early ITS*

From the 1950’s through the 1970’s, many workers in the AI field were full of optimism that a computer could be designed to think like a human (Urban-Lurain, 1996). Scientists such as Alan Turing felt the limitations were mainly with computer power and that within the next 10 years, technology would be developed which was powerful enough to build a “thinking” computer. Unfortunately, the goal always seemed to be 10
years away; despite growing computational power, certain entrenched problems kept the goal out of reach.

During this same period, the first CAI programs were developed. These early programs presented information to learners in a linear fashion, essentially making themselves computerized flash card systems that kept track of correct and incorrect student responses (Urban-Lurain, 1996). Although these programs helped students perform basic skills and provided personalized instruction at the student’s own pace, they were plagued with serious limitations. Because of the linear sequence of instruction, these programs tended to promote a passive approach to learning. Students were not able to use natural language to solve problems and were forced to learn in a multiple-choice environment. This caused students to see the learning program as rigid, which in turn stifled motivation, initiative, and creativity (Jamieson, 1991).

Eventually, programmers developed CAI programs that responded differently to the learner depending on how they answered different questions. For example, if a student answered a question incorrectly, the program would give a response specific to that incorrect answer and then offer a remediation problem to try and correct the learner’s mistake. The program would be designed to go in a different direction depending on which incorrect answer was chosen. These programs were termed “adaptive CAI” or “frame-oriented CAI” and were the precursors to ITS. Although adaptive CAI were the first programs to begin to model student behavior, they still could not escape the limitations of earlier CAI programs. When using an adaptive CAI program students should always, perhaps after a number of programmed detours because of incorrect responses, reach the point were they were supposed to have mastered the material. If
students did not master the material, however, at some point they were bound to circle back to a set of questions they had previously seen and did not understand (Lelouche, 1998). In essence, adaptive CAI suffered from the same linear limitations as their predecessors, albeit after a number of possible detours.

What makes ITS different from adaptive CAI is that ITS actually conducts experiments with the student to help the system decide the content and teaching strategies needed for a specific learning session. To accomplish this, the system must have its own diagnostic capabilities and problem solving expertise, making it possible for the ITS to give effective instructional advice to the learner (Sleeman & Brown, 1982). It is not easy to describe all that is involved in building a system with these diagnostic capabilities, but most ITS developers agree an ITS consists of four components: the expert module, the student model, the tutorial module, and the evaluation module (or user interface) (Albert & Schrepp, 1999; CoMPIO, 2001; Cruces & de Arriaga, 2000; Duchastel & Imbeau, 1998).

*Expert Module*

While educators formerly dreamed of offering entire courses through CAI programs, ITSs were developed with the idea they would be used to teach a modularized curriculum. Because the system must operate like an expert human tutor, it must contain (and know how to use) all the knowledge of the topic at hand (or the *domain*). This principle exerts tremendous pressure on ITS developers to stick to specific (even specialized) domains lest the system grow to unmanageable proportions.

If computer programmers were going to be successful in writing programs that could tutor students the way human tutors do, they would need to develop computer
systems that (1) contain “expert” knowledge and (2) know how to use that knowledge to solve problems. These types of computer systems began to appear, but in AI rather than in education. As AI researchers came to terms with the idea that they would never develop a thinking computer, they began to explore what became known as “expert systems” (i.e. computer systems that can solve problems the way human experts do). The first applications of expert systems were found in business. Another example includes systems that were developed to predict weather patterns for weather forecasters. These expert systems were able to take all relevant information into account and make decisions just as competently if not better than human experts (Mueller, 2001).

**Student Model**

To be intelligent, an ITS must have some understanding of the student it is tutoring. Therefore, ITSs incorporate a module that gathers information on the student with regard to the student’s understanding of the domain, learning patterns, and personal preferences/learning styles. Most early ITSs tended to focus on modeling the student’s knowledge but gave very little attention to the student’s personal learning style.

There are three different ways ITSs model student knowledge. First is the overlay model. This model views student knowledge as a subset of the expert knowledge within the system (Goldstein, 1982). The second model, called the differential model, focuses on the difference between the expert and student’s knowledge (Burton & Brown, 1982). The third model is the perturbation model, which characterizes incorrect student responses as misconceptions of expert knowledge (Burton, 1982).

However an ITS models student knowledge, an important challenge for developers is that of taking student knowledge, learning patterns, and preferences into
consideration and adjusting the pedagogical style of the system to fit the individual student (Okamoto, Cristea, & Kayama, 2001). While this remains an ideal to strive for, there is much room for improvement. Wenger (1987) addressed these issues when he asserted that student models must gather information about the student, create a representation of the student’s knowledge and learning preferences, use this representation to predict the student’s action, and compare the student’s actual action to the prediction and refine the model of the student. An effective student model will have some way to assess student knowledge either by continual interaction or by a specific “test-like” situation. It is difficult to make reliable assessments, however, because students do not always respond consistently, even when they understand certain concepts. Good ITSs will account for this kind of “noisy” data.

**Evaluation Module**

Since ITSs are integrated systems for learning, it is sometimes difficult to speak only of one aspect (or module) of an ITS. The evaluation module overlaps considerably with the student model (and the tutorial module), and it is the part of the ITS that evaluates (or assesses) student knowledge and preferences. What this evaluation looks like will depend considerably on how the ITS models the student. Evaluations can include traditional tests and surveys or continual evaluation of students based on their overall interaction with the ITS.

**Tutorial Module**

The tutorial module of an ITS is the part that interacts with the student in order to teach new material. According to a report put out by the Consequence Management Program Integration Office (CoMPIO) of Carnegie Mellon University’s Learning
Systems Architecture Lab (LSAL), the approach to the tutorial module is where we find the largest source of variation among different ITSs (CoMPIO, 2001). Even within one ITS there may be many different learning theories at work. Some ITSs use sophisticated dialogical interaction with the student, while others are problem driven. Whatever the case, the tutorial module will be largely influenced by the subject matter and the educational philosophy (whether implicit or explicit) of the developers.

*Examples of Early ITSs*

Carbonell developed the ITS called SCHOLAR in the early 1970’s to teach the geography of America (Duchastel, Doublait, & Imbeau, 1988). This system used Socratic dialogue as the pedagogical tool. SCHOLAR not only asks questions of the students, but it also allows students to ask it questions. A sample dialogue between SCHOLAR and a student appears below (student input appears after the double asterisks).

```
What is the capital of Ontario?
** Toronto
What is its population?
** Where is Kingston
I don’t know. What is Kingston?
** A city
O.K. In what province is Kingston?
** Ontario
O.K. Do you know about its size?
** No. Let’s talk about Alberta.
Fine. What are its major cities?
** Calgary
Yes, and another one?
** -
Edmonton. Which one is the capital?
```
(Duchastel, Doublait, & Imbeau, 1988, p.164)

Notice that SCHOLAR is instructible in the sense that someone other than the ITS developer can add to the knowledge base of the system. This is a positive characteristic in
that the system can change as the world changes, but it is a negative characteristic because students (or teachers) could enter incorrect information, causing the system to lose accuracy (Duchastel et al., 1988).

Dialogical pedagogy was extensively explored in a medical ITS called GUIDON (Clancey, 1982). GUIDON’s goal was to build a tutorial system on top of the medical knowledge base/expert system on infectious disease called MYCIN. GUIDON is considered a “case method tutorial program” because it interacts with students by presenting them with case studies on different patients and then enters into dialogue with the student to help them make the proper diagnosis. The rules GUIDON uses to guide the dialogue are very complex and are meant to closely mimic the dialogue of a human tutor. For example, GUIDON gives students help based on previous student questions and relevant information that the student does not yet seem to understand. GUIDON can also use creative techniques like “entrapment” to force students to make a decision that will reveal their understanding of the material, as well as possible misconceptions they may have. This is a technique human tutors often employ.

Another important ITS, called SOPHIE, was developed by Brown, Burton, and de Kleer in 1975 to help The U.S. Air Force train advanced electronics engineers about complex circuits (Brown, Burton, & de Kleer, 1982). SOPHIE went through three major revisions, and in the process contributed invaluable information to the ITS field regarding pedagogical techniques, natural language engineering, and knowledge engineering techniques. Although SOPHIE has been highly criticized for not constructing human-oriented explanations, it provided a “jumping off point” for future ITS projects.
Richard Burton developed another oft cited ITS called DEBUGGY which helped identify student misconceptions (i.e. “bugs” or “mal-rules”) regarding the rules of subtraction (Burton, 1982). The DEBUGGY diagnostics followed a perturbation student model, and provided the framework for many other ITSs that used similar student models.

The development of LISPITS was extremely important because it was the first ITS to be carefully developed with one specific learning theory as its foundation. John Anderson built the LISP tutor to teach the programming language LISP using his ACT* learning theory. LISPITS used “model tracing” to analyze where students’ knowledge diverges from the expert model and then provides hints to help get students back on track (CoMPIO, 2001; Merrill, Reiser, Ranney, & Trafton, 1992).

Criticisms

Early criticism of ITSs came from Rosenberg (1987) who charged that the systems were grounded more on the opinions of system developers than on substantial learning theory. Winne (1989) agreed that learning theory needs to guide designs for ITS. Specifically, he suggested extending Sternberg’s theory of intelligence to ITS by having ITS (1) adapt to the student, (2) select different interfaces for instruction, and (3) give opportunity for the student to shape the instruction.

From a mathematics education perspective, Thompson (1989) and Lesh and Kelly (1996) offer serious criticism of the development of traditional ITS. Thompson hypothetically states that if he were interviewing a potential teacher and she tutored students the way many ITS do (with heavy-handedness and lack of perspective), he
Lesh and Kelly provide further criticism by comparing ITS and successful human tutors. They describe ITS-like behavior as:

- determining the exact nature of student knowledge
- comparing novice and expert knowledge states
- asking sequences of small questions to move students toward a pre-specified goal
- giving students immediate feedback regarding the correctness of their responses
- providing hints and helps if a student fails to learn. (Lesh & Kelly, 1996, p.151)

Lesh and Kelly’s research established that successful human tutors:

- spent relatively little time diagnosing students’ procedural bugs
- emphasized multiple linked representations as powerful instructional devices
- encouraged students’ representational fluency
- offered “fuzzy” questions to students that were self-adjusting in difficulty
- encouraged students to use technology to move past procedural details
- focused on following the students’ thought processes rather than students following the tutor’s
- often ignored student errors or purposefully induced them to confront student misconceptions
- modeled knowledge as deep understanding of an elementary topic area rather than as expert and novice knowledge states. (Lesh & Kelly, 1996, p.152)

Contrasting these two lists suggests that human tutors are least effective when exhibiting ITS-like behavior and most effective when exhibiting non-ITS-like behavior.

Thompson’s strongest criticism of ITS is that there seems to be no teacher in the picture. In his view, software should be developed to support classroom teachers with the assumption that teachers will use the software to help students learn. Thompson also gives a convincing argument against a rule-based ITS like the DEBUGGY system. These types of systems encourage students to imitate some observed behavior (like how to subtract with abstract symbols) only to analyze errors made by those students who are merely marking on paper and, in effect, reasoning without meaning. Rather than defining competence as possession of correct rules, Thompson contends that computer systems
should encourage proper conceptualizations of mathematics through teaching relationships among quantities.

Lesh and Kelly (1996) call into question any ITS that models student knowledge by measuring the difference between student knowledge and expert knowledge because (1) there are no canonical novice and expert states, as such, when dealing with humans and (2) the development from a novice to an expert is not continuous. Beyond this, experts and novices may share the same knowledge, but they understand it very differently, and this difference is not additive. These conflicts present fundamental problems to the way ITS traditionally model the expert domain and students as well. They conclude, “we believe it is preferable for students to tell computers what to do and to evaluate the computer-generated results, rather than for the computer to tell students what to do and to evaluate the student-generated results” (Lesh & Kelly, 1996, p. 139).

Current and Future ITS

The ITS field is currently growing, and the limitations of pedagogical approaches are loosening in creative ways. Following Winne’s (1989) recommendations, ITSs are beginning to adapt their instructional interactions differently for specific students. The most significant development has been the introduction of multiple agents (or characters) within the ITS. There has always been a human student and a computerized tutor interacting within an ITS, but now one or more computerized students are being introduced into the picture (Chou, Chan, & Lin, 2003). These students can take on competitive, collaborative, or troublemaker roles within the ITS. Some human students may prefer the challenge of working in an environment where they compete with another (computerized) student to see who knows the material more thoroughly. Other students
may prefer to work collaboratively with another student who needs their help. In these situations, a student can work to complete a task and then learn the material at a deeper level by teaching the computerized student parts of the content. In other situations, the computerized student may take on the role of a troublemaker who sometimes injects erroneous information that the human student needs to filter out in the process of completing a task (Aïmeur, Frasson, & Dufort, 2000). By introducing the human student to different types of (computerized) learning companions within the ITS, developers can provide a richer pedagogical environment for the student that more closely matches the student’s learning style.

Other breakthroughs in ITS are occurring with respect to accounting for the unpredictable behavior of students. It is important for a truly intelligent ITS to be able to deal with students’ careless errors and inconsistency while learning. By using the results of a knowledge assessment to refine the model of student knowledge, researchers can allow students to act unreliably while working in an ITS and still recover an accurate model of students’ knowledge (Cosyn, 2002; Cosyn & Thiery, 2000). This important development has come from recent work in the field of knowledge space theory.

**ITS, Knowledge Spaces, and the Classroom Flip**

Knowledge space theory is built on the premise that the domain for a given topic can be described using a formal mathematical structure without any reference to its interpretation in human minds (Lukas & Albert, 1999). I loosely relate the domain in knowledge space theory to cultural meaning as described by van Oers (1996). This will be developed in the next section. Each bit of knowledge in the domain is called an item. The theory contends that each student has mastered a certain number of items, and these
items are called the student’s knowledge state. Based on the student’s knowledge state, she will be ready to learn new items in the domain. These ready-to-learn items are called the outer-fringe (see Figure 2.2). Similarly, there may be items that the student understands but has not quite mastered; these items are called the inner fringe. According to knowledge space theory, as students strengthen their understanding of inner-fringe items, those items become part of their knowledge state, and as students work to learn new content, outer-fringe items move to the inner fringe. Working in this way, students will be able to progress through a learning path of ever growing knowledge states that eventually ends in mastery of the domain (Albert & Schrepp, 1999; Doignon, 1994; Doignon & Falmagne, 1999; Falmagne, 1993).

![Figure 2.2. Example of a knowledge state (ALEKS, 2001, n.p.) (Used with permission.)](image)

As part of the student and assessment modules, ALEKS determines all possible knowledge states within the domain by considering the prerequisite relationships between items in the domain. For example, it would be impossible for a student’s knowledge state
in basic arithmetic to only consist of multiplying two single digit numbers since a prerequisite for understanding multiplication is understanding addition. ALEKS then uses a sophisticated assessment tool to determine a student’s knowledge state. Based on the student’s knowledge state, ALEKS goes into a learning mode and presents the student with a new problem on his outer-fringe. The student can view different explanations of how to solve the new problem, or he can try to solve the problem right away. Then, ALEKS gives the student an opportunity to practice the problem until the item is mastered. ALEKS continues offering problems to students in this way until the entire domain is mastered. Periodically ALEKS will give the student subsequent assessments to determine which of the new items have actually made it into the student’s knowledge state. All through the learning and assessment modes, ALEKS does not use multiple-choice questions but provides students with the means to enter answers using standard notation. Students are also able to view their recent progress, see a graphical representation of their knowledge state, and print out personalized review worksheets.

In a flip classroom, teachers can use an ITS like ALEKS to introduce students to course content outside the classroom. ALEKS gives a full explanation of course content and provides examples of the concepts when students are ready to learn them. Well developed ITSs tend to have minimal technical difficulties and are designed to have a comprehensive knowledge base that should satisfy teachers’ requirements for content coverage. Because the ALEKS ITS meets both of these criteria, it was chosen as the technology system used in the classroom flip course for this study.
The classroom flip is usually motivated by a desire to give students an opportunity to learn through active participation in the classroom. This motivation, however, needs clarification. What exactly is meant by active participation? Is not all learning active, whether learning from a book, a lecture, or a small group activity? Piaget says that learning occurs not when a person merely copies an idea, but when a person acts on it. When people really learn something it will be because they have developed a system of ways to (actively) transform the object of their thought (Piaget, 1971). Perhaps what we should be saying, then, is that the classroom flip provides opportunities for students to learn through a variety of different kinds of activity in the classroom. It is important, then, to have a framework for analyzing learning through activity.

Comments on Learning Theory

A good place to start in building a framework for learning through activity is with a concept Bruner (1990) terms rebus, or understanding by doing something rather than just talking or thinking. The word rebus (Latin for “by things”) refers to how things rather than words can control our activity. Note that students can know how to do something using a tool long before they understand conceptually all that is involved. This happens frequently in the mathematics classroom. For example, students can know how to use a calculator to take a square root when they do not conceptually understand what a square root is. When asked, these students sometimes are not able to describe the difference between squaring a number and taking the square root of it. This example fits well with one of Bruner’s related assertions that instruments and aids often define work before it is completed.
Developing deep understanding, then, can involve using aids and instruments to complete an activity and later deciphering why it was necessary to complete the activity in that particular way. So, a barrier to learning occurs when students ask, “Now, why am I doing this?” only to continue their activity without finding an adequate answer to that question. Of course, students cannot be expected to completely understand the full scope of their activity up front, and learning theorists do agree that imitation is an important aspect of learning. However, Vygotsky contends that the focus of learning should be the development of higher psychological function, not just imitation. Through the use of language and signs (symbols that refer to thoughts and concepts), the learner is able to mediate their activity and move from a life where action dominates meaning (i.e. rebus) to one where meaning dominates action (Vygotsky, 1978). This movement, however, is a process. Students must be given a space where they can reflect on their own thinking and actions in the learning process to fully develop their understanding of classroom content.

In this manner, Dewey (1990) argues in his classic text *The School and Society*, that practical activity and reflection should guide learning:

> Here is the organic relation of theory and practice: the child not simply doing things, but getting also the idea of what he does; getting from the start some intellectual conception that enters into his practice and enriches it; while every idea finds, directly or indirectly, some application in experience and has some effect upon life. This, I need hardly say, fixes the position of the ‘book’ or reading in education. Harmful as a substitute for experience, it is all-important in interpreting and expanding experience. (Dewey, 1990, p.85)

Dewey’s comments hold Bruner’s rebus and Vygotsky’s higher functioning in healthy tension. It is not enough for students to do the activity; they must also get “the idea” of the activity. Getting the idea will necessarily involve guiding students to reflect on and assign meaning to their activity. It is important to note here that understanding does not
occur only at the end of activity; rather, students should form some kind of intellectual conception of the task at hand “from the start.”

Along these lines, van Oers (1996) has devised a theory of learning that informs the “give and take” between doing the activity and getting the idea of the activity (i.e., doing the mathematics and getting the idea of the mathematics). His theory assumes two types of meaning in the learning process: cultural and personal. Cultural meaning can be thought of as generalized knowledge. It refers to the concepts, norms, methods, and skills that have been built up within the mathematical community over the centuries. Because of its generalized state, cultural meaning can be converted into curriculum content, and taught. Personal meaning (or sense) is based on the value that learners attach to activity in relation to the task at hand. This personal sense develops as learners ascribe significance to the actions and goals of activity with regards to their motives, ambitions, and position in society. Undesirable rote learning is often the result of instruction that denies students opportunities to attach personal meaning to the instructional communication of cultural meaning.

Meaningful learning occurs in van Oers’ system as students develop both cultural and personal meaning in their educational setting. When students are able to master technical mathematical procedures as historically developed while also attaching personal meaning to the methods and results, they have achieved meaningful learning. How then can instruction be designed to foster this type of interaction between cultural and personal meaning? Van Oers argues that the link between both types of meaning can be reinforced through student reflection on the execution of their actions. He officially defines an action as “an attempt to change some (material or mental) object from its initial form into
another form” (van Oers, 1996, p.97). Therefore, as students act in the learning process, it is essential for them to reflect on their actions; van Oers calls this reflection orientation.

Through orientation, students are able to use cultural knowledge, rules, methods, and concepts in a personally meaningful way to complete the task at hand. Drawing from the classic Piagetian notion of reflective abstraction (Piaget, 1971), the orientation process results in students relating their actions to signs and symbols and eventually interiorizing them (transforming them to a mental level). Once interiorized, actions can be performed by either referring to their signs or just thinking about them. This is a very important step in the development of mathematical thinking. In fact, van Oers contends that the orientation (reflection) part of activity should be the fundamental focus of the teaching and learning process. From this perspective, mathematics instruction should primarily be concerned with guiding students’ orientational actions so they can explore and solve problems using culturally accepted methods.

One way to encourage reflective abstraction is by asking students to think of a mathematical concept using different representations of that same concept. Representations occur internally as constructs and schema in the student’s mind, and externally as words, symbols, graphs, charts, and pictures (Pape & Tchoshanov, 2001). Students often show that they have developed deep understanding of mathematical concepts when they are able to represent concepts using multiple representations and can freely move between those representations while thinking about a problem (Meyer, 2001). It is therefore crucial for the teacher to encourage students to use various representations when doing mathematical work, and then to have patience while analyzing student representations. Students sometimes use non-standard representations
to correctly represent mathematical concepts, and although their representations may appear incorrect to the accepted mathematical culture, a careful interpretation may provide valuable insight that can be used to guide students’ learning toward a deeper understanding of the mathematics involved. Teachers therefore act as negotiator/mediator between cultural meaning and personal meaning for the students by analyzing their representations. Because of this, mathematics teachers and researchers alike should primarily be interested in students’ evolving personal representations (Golden & Shteingold, 2001). Instructors assist students by offering suggestions, giving hints, openly scrutinizing, voicing objections, and encouraging alternate forms of representation. In other words, teachers enter into many different types of conversations with individual students and groups of students, and it is through these conversations that representations are used to negotiate, refine, and explain mathematical concepts (Pape & Tchoshanov, 2001). Without question, the key benefit of focusing on representations is that educators can see student knowledge construction as it unfolds, be involved in the learning process, and give feedback and guidance to students along the way.

**Activity Theory**

All learning occurs within some system of activity, and activity theory’s primary focus is the analysis of these systems. Activity theory is a dynamic way of conceptualizing and analyzing human action through a socio-cultural lens; it is not a static analytical structure or a strict methodology (Jonassen & Rohrer-Murphy, 1999). Due to the adaptability of this theory, it has become a useful tool for analyzing human activity in a number of different fields including education, health care, work environments, and human-computer interaction (Engeström, 2001; Jonassen, 2002;
Scanlon & Issroff, 2005). Here, I will describe the basic tenets of activity theory. For a full treatment of the genesis of this theory, see Engeström (1987).

I will begin with Vygotsky’s dissatisfaction with the dominant behaviorist stimulus-response model of explaining human action (S → R) in early 20th century psychology. He argued that *signs* (something as simple as tying a knot on your finger to remember to do something) change human psychological function and, as a result, render the stimulus-response model inadequate for describing most human behavior. The presence of signs in human psychological function allows humans to “*control their behavior from the outside*” and raises psychological operation to a qualitatively higher level where signs permit humans to mediate their behavior (responses). Vygotsky explains,

> The use of signs leads humans to a specific structure of behavior that breaks away from biological development and creates new forms of a culturally-based psychological process. (Vygotsky, 1978, p.40)

Figure 2.3 shows Vygotsky’s modification of the well known S → R model where X represents signs that mediate human behavior.
The first generation of activity theorists adapted Vygotsky’s model to conceptualize a subject’s action upon some object (mental or physical) in order to achieve an outcome. They describe a subject’s action as being mediated internally by signs and externally by tools. Tools are more complex than signs and are aimed at controlling behavioral processes. Examples of tools include: language, number systems, works of art, literature, maps, and mechanical designs (Engeström, 1987). In the study of mathematics, we can view representations of mathematical concepts (graphs, equations, and linguistic explanations) as the tools and signs students use to mediate their learning activity. Recent research has shown how dynamic technological tools (like the Cabri geometry system) are not just used by learners to act on an object, but that these tools can actually change the ways learners construct and process knowledge (Rivera, 2005). I have adapted a common reformulation of Vygotsky’s model in Figure 2.4 (Engeström, 2001; Scanlon & Issroff, 2005).
This new way of thinking about activity allowed psychologists to move beyond the stimulus-response model toward a more contextualized understanding of human action; however, the first generation of activity theory’s focus on the individual as subject limited the scope of its influence. The subject’s community has a profound impact on his action, and thus needs a place in the model. The second generation of activity theory made room for community and conceived of the collective activity system depicted in Figure 2.5 using the work of Leont’ev as their foundation.

Figure 2.4. Modern reformulation of Vygotsky’s model (Engeström, 2003, n.p.) (Used with permission.)
While the subject’s action on an object using signs and tools to achieve a certain outcome is still the primary focus of the activity system, the above conceptualization takes into account the richness of the community’s influence on the subject, object, and signs and tools (which are always culturally defined anyway). The subject will act within the community according to certain explicit and implicit rules influenced by cultural norms. These rules will impact how the subject acts on and engages the object of the action to produce the desired outcome. Further, the community also defines how its members act on objects according to some division of labor. Some actions on certain objects will be expected by members of the community, and other actions may be forbidden by the established division of labor.

Let’s consider how a mathematics classroom operates as an activity system. One desired outcome is learning the material. If we consider the student as the subject and the
material to be learned the object, the tools and signs a student uses to act on the material will involve language, symbolic algebra systems, books, computers, heuristics, and study plans. The community where this activity takes place is the class itself, but it could also include tutors, apartment-mates, and anyone else with whom the student engages the material. Within this community, there will be rules that govern when certain mathematical techniques are preferred over others, how time should be used in the classroom, when students should come to class, and how students should complete their work. The division of labor in the community is distributed in different ways as the student acts on the material to be learned. The professor is expected to provide lectures or activities in the classroom that guide the student as she acts on the material. If the student is working in a small group, other members of the group may be expected to perform certain tasks while the student does something else. All of these elements in the activity system work together to help or hinder the student as she learns the material in the course.

Due to their interactive and dynamic nature, activity systems are continually driven to change by contradictions that arise between the elements within the system. For example, a student may see the object as “material I want to learn” or as “material I must get right on a test.” The same student may hold each of these views at different times throughout the semester, and balancing these competing/contradictory views will change the tools the student uses in the learning process as well as the rules used to engage the material. If a student wants to learn material because of some intrinsic motivation, he may use a heuristic that promotes long-term learning as a tool when acting on the material. However, if the student views the material as stuff that must be learned for a
test, he may use a heuristic similar to “cramming” that is more likely to produce short-
term learning. Rules that govern time allocation for learning will also most likely be
different depending on which of these two views the subject has of the object.

Activity systems are also in a state of flux due to the movement between the elements of the system. Something that begins as an object in the system may later become a tool that needs a new set of rules to govern its use. For example, when a student first encounters a histogram in a statistics course, it is an object to be studied and acted upon. Once the student knows how to make a histogram, it moves from being an object to being a tool. The system then needs to adjust, and rules must be developed that tell the student when it is and is not appropriate to use a histogram as a tool when acting on other mathematical objects. The potential for movement between the elements of the activity system in this way are endless. An object may become an outcome, then a tool, and may eventually become a rule (Engeström, 2003). Rules may also be challenged, reconsidered, and changed. This sometimes causes them to become new tools and objects themselves along the way.

Activity theorists have conceptualized the messiness of activity systems by separately defining activity, action, and operation. Activity, when viewed from this perspective, becomes a (muddled) collection of actions carried out in the context of community. Actions themselves, taken one at a time, tend to be more direct. Relatively clearly defined goals guide actions, and they can be carried out by individuals or groups of people. Actions, in turn, are made up of lower level operations that began as actions, but have been interiorized and routinized to the extent that they can be performed almost as an automatic response to an observed condition. People or even machines can perform
operations. A graphic of this hierarchical nature of activity, action, and operation is displayed in Figure 2.6.

<table>
<thead>
<tr>
<th>Level</th>
<th>Oriented Towards</th>
<th>Carried out by</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITY</td>
<td>OBJECT / MOTIVE</td>
<td>COMMUNITY</td>
</tr>
<tr>
<td>ACTION</td>
<td>GOAL</td>
<td>INDIVIDUAL OR GROUP</td>
</tr>
<tr>
<td>OPERATION</td>
<td>CONDITIONS</td>
<td>ROUTINIZED HUMAN OR MACHINE</td>
</tr>
</tbody>
</table>

Figure 2.6. Hierarchy of activity
(Engeström, 2003, n.p.) (Used with permission.)

The bi-directional arrows in the figure show that activities, once worked out, can be compressed into actions. And actions, if repeated enough, can be automated to the point of becoming an operation. Conversely, if an operation is disrupted, it can be raised again to the level of an action, and an action may be raised to the activity level (Jonassen & Rohrer-Murphy, 1999). For example, learning how to create a histogram to display a numerical variable’s distribution may be an activity carried out as an entire class. The nuances of the meaning behind histograms are explored and students think deeply about each part of the display. Once the idea of a histogram has been internalized, students can begin to make histograms as only one action in the larger activity of solving a more complex problem. This pushes the creation of a histogram down to the level of an activity. Eventually, students may use a computer or other technology to create a
histogram. At that point, making a histogram becomes an operation. However, if there is a problem with the technology, or if students wish to compare two different variables using histograms, they may need to again engage the histogram creation as an action (adjust class widths, etc.) or even an activity (to consider how they should work with the histogram to decide if there is a significant difference between populations, for example).

The question that has driven the development of the third generation of activity theory is, “What happens when activity systems from different cultures and communities interact?” Since the second generation’s conceptualization of activity did not allow contributions from multiple communities, the third generation of activity theory has worked to develop ways to conceptualize the dialogue and interaction between different communities and traditions. Researchers are envisioning how networks of activity systems may operate and how people cross borders between systems to act on shared objects that may have different meaning in different systems. Gutiérrez and her colleagues (Gutiérrez, Baquedano-López, & Tejeda, 1999) describe how a “third space” is created when two activity systems interact, and that this third space may allow for the development of new meanings that go beyond the limitations of the two original systems.
Figure 2.7 shows that the same object may be engaged by two different activity systems. At the first level, the object is engaged at face value by both systems (Object₁), but as the systems interact, they each work from their situated perspective to reveal a collective meaning for the object (Object₂). This interaction allows for a potential third level of meaning (Object₃) constructed collectively by the systems (Engeström, 2001).

As students participate and learn in a classroom that is focused on helping them use different representations of mathematical concepts to make personal sense of culturally defined mathematical symbols and techniques, their learning environment is affected, and activity systems provide a nice framework for analyzing the activity within that learning environment.
The environment in which learning takes place will be profoundly affected if a professor uses technology to introduce course content and then proposes a variety of learning activities in the classroom. Further, students will most likely not be accustomed to initiating their own introduction to content, and different students will receive this task in various ways. Having a framework for conceptualizing the classroom environment will be helpful when investigating how the changes inherent in the classroom flip influence classroom dynamics.

Learning environments research has its roots in a sociological study of human environments in general (Moos, 1973). Moos and Walberg independently applied human environments research to learning environments in the 1960s and 1970s in the USA. Since then, others have built on Moos and Walberg’s work, but the most extensive work has been done by Fraser and his colleagues in Australia (Dorman, 2002). Eventually the Learning Environments Research special interest group of the American Educational Research Association was formed and this group launched the *Learning Environments Research* journal in 1998. Operating from a solid theoretical base, learning environments research has been committed to the improvement of educational policy and classroom learning.

Perhaps the most important and enduring theoretical development in learning environments literature is Moos’ three domains of social-environmental variables. Moos (1979) asserts that vastly different social environments can be conceptualized using variables that fit into three broad categories: 1) relationship, 2) personal growth, and 3)
system maintenance and change. These three categories must be described and examined (at a minimum) if researchers wish to gain understanding of the social environment under investigation (Moos, 2003).

The relationship domain has to do with the extent to which students are involved in the classroom. The variables in this domain are closely tied to the sense of community students feel with one another and the teacher. They include the extent to which students help and support one another, the level of morale in the class, how freely students share ideas, how students share in work responsibilities, the level of participation in classroom discussions, how attentive students are to the course content and the class activities, and the depth of student relationships with other students and the teacher.

Personal growth dimensions involve how the goals of the classroom encourage student development and learning. Student independence is key in this domain since true learning and development occur when students are free to succeed or fail. The ways the environment encourages students to be aware of significant course concepts is also an important feature of this domain. If a classroom places a great deal of importance on academic, intellectual, and scholarly activities, the students’ desire to grow and learn will be affected. Other factors that influence personal growth and learning in a classroom setting include the level of competition in the class and how the grading policies in the course are structured.

The system maintenance and change domain is concerned with the formal structure of the classroom and how this plays out in the day-to-day operation of the classroom. The clarity of classroom expectations, the ways communication occurs in the classroom, the rules and policies that govern normal operation in the classroom, the
practicality of the classroom (how orderly it is supervised), classroom propriety (how considerate and polite the environment is), and the ways the classroom adapts to change all relate to the system maintenance and change domain. These dimensions set the stage for how the classroom is run and how students interact within its structure.

Along with the three social-environmental domains, influential early conceptualizations of human environments dealt with the interplay between the needs of the individual and the press of objects in the environment (Dorman, 2002). Needs are defined as factors in the individual that influence behavior, and the press of an object involves the ways the object can influence (positively or negatively) the attitudes, actions, and motivations of a person. It is often difficult to determine the press of an object because of the subjectivity involved. For instance, if a student believes failing a classroom quiz will cause her to fail the course, then the quiz has a certain press on the student even if, in reality, the quiz is only worth 1% of the overall grade. This way of thinking about learning environments has led researchers to see the importance of the distinction between students’ preferred learning environment and their actual learning environment, and instruments to measure learning environments were developed with this in mind.

As individual students interact with their learning environments, the social-environmental domains of the classroom come into contact with the personal system each student brings with them to the class (see Figure 2.8). As a student learns, the interaction between her social environment and personal system instigates a series of struggles and adaptations as she strives to learn in that environment. A student’s personal system includes age, gender, ability level, interests, values, attitudes, expectations, and coping
preferences. When a student is confronted with a learning experience, she will experience a need to change. Her personal system and social environment will influence how she appraises the situation cognitively as well as the actions she decides to make within that environment (activation). Once the student acts in the environment, she will go through cycles of adaptation and coping until equilibrium is re-established and change (learning) has occurred.

Figure 2.8. A model of the relationship between environmental and personal variables and student stability and change (Adapted from Moos, 1979, p. 5; used with permission.)

Using the Framework

The conceptual framework for this study describes how the classroom flip uses technology and ITS, how mathematical representations relate to learning theory, how activity theory is used to analyze various types of learning activity, and how students adapt to classroom learning environments as conceptualized by Moos’ (1979) three domains. While this framework fills in practical and theoretical background for this
study, I used the framework in two specific ways. First, the framework helped me separate the related research literature in Chapter 3 into two main sections: mathematical representations and learning environments. Second, the conceptualization of activity theory and learning environments as set forth in this chapter provided a lens through which I fit together and analyzed the data collected in this study. The framework was at work implicitly as I coded and categorized the qualitative data. However, it is important for research to show how the conceptual framework was at work explicitly in the analysis of the data. Therefore, in the Student’s Take sections of Chapter 5, I explicitly show how activity theory and learning environments theory shaped my analysis in this report.
In this chapter, I use the activity theory triangle to conceptualize the relevant literature (as shown in Figure 3.1) in the following way. Students (subjects) use mathematical representations (as tools and signs) to mediate their actions on problems (objects) and produce some outcome in their learning environment (rules, community, and division of labor). The teacher is present to help students mediate personal sense and culturally developed mathematical norms and ways of thinking (van Oers, 1996) using various mathematical representations. This chapter reviews research-based studies that investigate (1) the role mathematical representations play in student learning and (2) the learning environment of technology-rich classrooms that use different types of activity to support learning.
Mathematical Representations

The term mathematical representation refers to a person’s manifestation of a mathematical concept (Pape & Tchoshanov, 2001). These manifestations can exist externally as pictures, symbols, charts, signs, objects, graphs, etc. Often, researchers think of external representations as fitting into one of four categories: pictures and verbal descriptions, tables, graphs, and formulas (Janvier, Girardon, & Morand, 1993). Representations also exist internally as constructs and schema in a student’s mind. Many researchers believe students’ evolving internal representations should be of primary interest to teachers and researchers alike (Golden & Shteingold, 2001). Foundational to this research project is the belief that student representations of mathematical concepts are a primary tool used in the negotiation of cultural and personal meaning.
Representations: Flexibility, Translations, and Connections

There is evidence in the literature to suggest that the ability to flexibly switch between representations of a mathematical concept enhances mathematical thinking and helps students successfully solve problems (Brenner, 1999; Knuth, 2000; Stonewater, 2002; van Streun, 2000). Stonewater (2002) examined samples of student writing in a university calculus course to more clearly describe the difference between “successful” and “unsuccessful” writers in mathematics. Forty students wrote an essay where they defined the idea of limit and described how it is central to the concepts of derivative, function continuity, and area under a curve. In his findings, Stonewater showed that the highest scoring students used clear, specific language in their essays and that they used “both a greater number of algebraic, numeric, and graphic representations (Rule of Three) and a greater variety of these representations to augment their written work than do the lowest scoring writers” (Stonewater, 2002, p.330-331). Results also showed that the highest scoring writers did not hesitate to use mathematical symbols and formal notation in their essays, while the lowest scoring writers avoided using these. These results suggest that students who have a deeper understanding of mathematical concepts are able to use a variety of representations when discussing and explaining those concepts.

In a study by van Streun (2000) in the Netherlands, 420 tenth-grade students participated in a study that compared traditional classrooms and heuristic classrooms. The heuristic classrooms were taught how to use translations between different representations as a problem solving technique. At the end of the school year, when students in the traditional classrooms were presented with a problem to solve, they
showed a lack of flexibility in the representations they used in their solutions. This lack of flexibility proved to be a hindrance in their problem solving activity. Students in the heuristic classrooms, however, could take the given problem and translate it into analytical representations. From there, they easily applied an algorithm to finish the solutions. These results are somewhat surprising since students in the traditional classrooms spent considerably more time studying analytical representations and algorithms than students in the heuristic classrooms. Thus, it seems the heuristic students were able to build up their analytical representations from their ability to connect multiple types of representations.

This idea of connecting representations and translating between them is a common theme in the literature. Brenner, Herman, Ho, and Zimmer (1999) investigated translating between mathematical representations in a multi-national study involving 895 sixth-grade students: 223 from China, 224 from Taiwan, 177 from Japan, and 271 from the United States. Students in that study were presented with a mathematical problem that required them to think about rational numbers using two different types of written representation (e.g. fraction notation and decimal notation) and one visual representation (e.g. a pie graph). Researchers asked students questions that required students to: 1) find a solution and 2) recognize equivalent alternate representations of the given problem. Results showed how difficult it is for all students to translate between different representational systems. American students tended to do well with visual representations. However, good visual representational skills alone produced limited benefits if not supported by other types of representational skill, as evidenced by the American students scoring last overall on most items. Evidence in this study suggests that
by the sixth-grade, Asian students have surpassed their American counterparts in their ability to flexibly move between different representations of mathematical concepts in their knowledge-base.

In a very specific investigation of students’ ability to translate between representations, Knuth (2000) studied 178 students in a large American suburban high school to see how well they understood the “Cartesian Connection” defined as the connection between a point being on the graph of a line if and only if the x and y values for the point are a solution to the algebraic formula that represents the graphed line (2000). Results showed that not only did most students not make an efficient connection between the points on the graph and solutions to the algebraic equation, but that many students viewed graphical solution methods as unnecessary and unconnected from their algebraic representations.

Unfortunately, educators sometimes overlook the importance of stressing connections between representations. Perhaps educators assume students can make these connections without direct instruction. A textbook comparison between American and Japanese seventh-grade textbooks shows that the Japanese textbooks spend considerably more space explaining the connections between representations in their solutions (Mayer, Simms, & Tajika, 1995). If mathematics instructors want students to possess a more robust and flexible understanding of mathematics, they must intentionally work to help students move freely and flexibly between representations while solving problems. Students must explicitly work on translating between representations in both directions (e.g. from table to graph and from graph to table) (Janvier et al., 1993) if they are to move past simple procedural competence toward a more dynamic conceptual understanding.
Representations as Mediating Tools

It is important to make the distinction that representations of a concept and the concept itself are different things. Representations mean nothing without a person to interpret them. In this regard, representations are viewed as tools for understanding and acting on mathematical ideas. Just as a hammer has many uses, so representational tools have many uses and they should be used as vehicles for exploration and communication within the classroom (Pape & Tchoshanov, 2001). Recent research has gone a step further to show how dynamic technological representational tools (like the Cabri geometry system) are not just used by learners to act on an object, but how these tools can actually change the fundamental ways learners construct and process knowledge (Rivera, 2005).

In a study by Sedlmeier (2000), 46 students at a German university investigated statistical thinking by manipulating external representations of mathematical concepts. Students learned about probability conjunctions using a computer program that encouraged them to represent probabilities using either Venn diagrams or frequency grids. After completing a training session with the software and completing a number of problems in the program, students were given a test over the concepts using items that had already been used in other studies where students learned by reading and listening to lectures. Students in the Sedlmeier study scored three times higher than students in the previous study. The evidence in this study suggests that when students are able to engage mathematical concepts using different representations (words, symbols, and graphics), and when they actively manipulate graphical representations in the learning process, they are better able to develop conceptual understanding of the material.
In light of the research by Sedlmeier (2000), is the active manipulation of representations the key to productive learning, or is the type of activity the student engages in distinguishably important? DelMas, Garfield, and Chance (1998) conducted a study that investigated the types of activity that encourage sound development of statistical reasoning among their students. They began the investigation with an activity that guided students to discover the major concepts of sampling distributions. This activity used a well-designed computer program that showed a graphical representation of a population and a graphical representation of sampling distributions that students drew from that population. With this program, students were able to change: 1) the shape of the population and 2) the size of samples drawn from the population. Then, students drew large numbers of samples from the different populations and observed the results. Eighty-nine introductory statistics students participated in this activity, taking a pre-test and post-test that measured their understanding of the implications of the Central Limit Theorem (a direct extension of sampling distributions). While there was evidence that students improved in their understanding from pre-test to post-test, a significant number of students still did not appear to understand the implications of the Central Limit Theorem.

In response to students difficulties with the Central Limit Theorem, delMas, Garfield, and Chance designed a new type of classroom activity that asked students to predict what would happen in a scenario before they used technology to draw samples from the population and observe the results. This was done from a conceptual change theory perspective in the hopes that students’ misconceptions (if they existed) could be revealed and confronted. Students generally tend to hold to an incorrect assumption until
they experience evidence that directly contradicts it. Once the contradiction occurs, students are forced to reassess and change their incorrect conception. Using this new activity, a second pre-test and post-test study was conducted with 141 students. These students outperformed the post-test scores of students in the first study on 4 out of the 5 items. These results suggest that activities designed to reveal student beliefs and assumptions are preferable to activities that provide a straightforward presentation of knowledge in a field (delMas, Garfield, & Chance, 1998). When students’ beliefs and assumptions about mathematical concepts are revealed and students are encouraged to evaluate these in light of empirical results, students are better able to negotiate personal and cultural meaning (orientation).

A study conducted by diSessa, Hammer, Sherin, and Kolpakowski (1991) investigated 8 sixth-grade students’ “invented” graphs of the motion of a car that comes to a stop and then starts moving again. The teacher asked each student to represent the motion of this car with a graph that was as expressive as possible but as simple and easy to interpret as possible. Students worked collaboratively to come up with a series of graphs that represented different important aspects of the motion. Over a period of 5 days, the teacher probed the class to explain the positives and negatives of each graph, to reflect on what each graph showed (speed, time, etc.), and to explain with words how each graph represented the car’s motion. A careful analysis of the conversations that took place over this 5-day period showed the importance of asking students to create representations that seemed natural to them as the starting point for the activity. This gave students an opportunity to explain what their creations meant using their own words. Eventually, these natural representations helped the class critically consider what the
overall purpose of the graphical representation was, and determine which elements needed to be present for the graph to fulfill its purpose. In this classroom, graphical representations were truly tools that helped students better understand how to study motion with mathematics. The original “invented” graphs led students to develop personal meaning in the final formal graphical representation the class came up with at the end of the activity.

“Natural” Representations

Evidence has shown that activities which require students to develop their own approaches to representing and solving a mathematical problem provide a rich environment for learning to take place (diSessa et al., 1991; Doerr & English, 2003; Lehrer & Schauble, 2000). In one such study, Doerr and English (2003) investigated 1 Australian and 32 U.S. middle school mathematics classrooms to better understand the process students go through when solving problems that use a system of mathematical relationships which, at the end of the activity, can be transferred to other problem situations. Students were given problems designed to elicit the development of a mathematical model as a byproduct of their solution. Results of this study showed that realistic modeling activities provide an environment where students can create natural and inventive ways of representing and communicating mathematical ideas to others in the classroom. This increase in mathematical communication enabled students to use representations to verbalize and refine their implicit understandings of deep mathematical concepts. Instead of focusing on one pre-determined right answer, students understood there can be multiple approaches to the solution of realistic mathematical problems. It was concluded that instead of guiding students toward one specific way of representing
and solving a problem, students benefited from exploring a variety of representations to
revise, refine, and extend their own ways of thinking (Doerr & English, 2003).

The ways we represent mathematical problems was also investigated by
Sedlmeier (2000). Students are able to use sophisticated cognitive algorithms to solve
even complicated Bayesian inference tasks. Sedlmeier suggests students learn these
algorithms best when problems are presented in ways that they would experience in
every-day life. Thus, mathematical understanding and problem solving ability is
enhanced when students use external representations that were developed to fit naturally
with the problem’s embedded real-life context. This “natural” fit of representations was
the focus of the second part of Sedlmeier’s (2000) study. (The first part of the study was
reported above.) In his study, 46 students used either Venn diagrams or frequency grids
to study probability problems. The findings in the study reveal that students who used the
more natural “frequency grid” representations seemed to be more resistant to forgetting
how to complete Bayesian inference tasks than students who used (the less natural) Venn
diagrams in their statistical reasoning. This evidence leads to important questions such as:
What other kinds of “natural” representations are there in statistics? Can exploring with
certain representations help students develop their own “natural” representations? Will
students’ invented representations be somewhat of a bridge for them to understand
standard representations? Answers to these questions could shed important light on the
orientation process students go through when negotiating between personal sense and
cultural meaning.

Taking these studies on mathematical representations as a whole, we see that
students who explore mathematical ideas using various forms of representation are often
successful in developing deep conceptual knowledge. However, attaining this knowledge is due to more than just good software and clear instructions. Successful learning opportunities must give students a chance to correct faulty thinking. Students who have misconceptions (faulty or not fully developed internal representations of mathematical concepts) must have an opportunity to make these misconceptions explicit and experience evidence that contradicts their misconceptions before they will change them. Reflecting on representations of mathematical concepts can be an effective way to bring about this change. Just understanding the solution to the problem when it is explained is not enough; rather, students must use mathematical representations to actively engage a problem and build conceptually rich mathematical knowledge.

Technology-Rich Learning Environments

There have been few research studies that specifically investigate flipped, or inverted, classrooms as strictly defined. I will review these studies first. There are many studies that investigate environments where technologies are used as a tool to increase student involvement in classrooms, and I will review these studies in the second part of this section.

*Flipped and Inverted*

In a study using the classroom flip, Baker (2000) provided lecture notes on a web page, extended classroom discussions through online threaded discussion, and used online quizzes in two of his courses (Graphic Design for Interactive Multimedia and Communication in the Information Age). His aim was to achieve the following goals: reduce time spent on lecturing, focus on understanding and application, provide students with more control over their own learning, give students a sense of responsibility for their
learning, and give students an opportunity to learn from their peers. Baker’s action research project evidenced increased interactivity and collaboration in both courses when compared with other courses the students have taken. Students noted an increase in collaboration both in the classroom and out of the classroom (using technology). Students felt they received more personal attention due to the structure of the class, had more control over their learning, and were able to engage in critical thinking that explored the implications of their learning (Baker, 2000).

In a study by Lage, Platt, and Treglia (2000), Introduction to Microeconomics courses were modified by asking students to read assigned sections of the textbook and view either videotaped lectures or PowerPoint lectures with sound before coming to class. The first part of each class session involved answering questions, which usually lead to a mini-lecture lasting no more than 10 minutes. If there were no questions, there would be no lecture. The rest of the class time was spent in an experiment, lab, or group work that investigated the topic at hand. Lage’s and Platt’s goal for inverting the classroom was to give students opportunities to learn economics according to their individual learning style. Students could learn course content by choosing between reading the textbook, watching a traditional lecture, or viewing PowerPoint with sound. They could also combine or repeat these content delivery methods according to their individual preferences. Hands-on activities inside the classroom added further diversity to the available teaching and learning styles. This study of 80 introductory economics students showed positive student attitudes toward the inverted classroom. In fact, the evidence showed that students would prefer to have an inverted classroom rather than a traditional lecture class. The study also evidenced increased faculty-student interactions.
and the development of student communication skills. Since the material in the course is presented in a number of different formats, it was shown that students’ learning preferences were better matched to course pedagogy (Lage & Platt, 2000).

Although the classroom flip terminology was not specifically stated, this instructional method was used in a study involving 16 graduate level research methods and statistics students to compare lecture-based versus computer-based methods for presenting students with course content (Frederickson, Reed, & Clifford, 2005). These researchers were interested in seeing if there were differences in the level of learning and student opinions of the learning environment between the two groups. The 16 students were randomly assigned to two different groups: one group spent an hour in a computer lab going through a web-page based presentation of the material while the other students spent the hour in a classroom listening to a lecture over the same material with overheads and handouts. The random assignment in this study is a very important and unusual aspect when compared to other current studies. Most studies that compare different pedagogical approaches allow students to choose which group (lecture-based or technology-based) they will be in for obvious ethical reasons. However, in this study, all 16 students agreed to be randomly assigned to a group. It is also important to note that the information in the web-page presentation and the lectures were developed by the same instructor and were virtually identical.

Frederickson et al (2005) gave both groups of students pretests and posttests to detect changes in their statistical knowledge and levels of math anxiety. Results showed that both the lecture-based and the web-based groups increased their understanding of statistical knowledge from pretest to posttest. However, there was no significant
difference between the two groups on either the pretest or posttest. There were no other significant effects between the two groups in terms of their pre-anxiety and post-anxiety levels. The researchers also solicited written feedback and they performed a cursory qualitative theme analysis on those responses.

Frederickson et al.’s (2005) important study provides evidence that similar gains in knowledge will occur for students whether the material is presented in a web-based or lecture-based format, and math anxiety does not appear to be influenced by one method or the other. Qualitative data were also collected through open-ended questions on a survey given to all students. The analysis of this data suggested students were more critical of the web-based format. Students in this environment wanted their learning goals to be more clearly defined so they could check to see if they were “on the right track” along the way. They wanted more explanations and examples on the websites and a more interactive experience. Although the lecture-based students received the same stated learning goals, explanations, and examples, they made no mention of the need for more feedback and reinforcement as the web-based students did.

Analyzing these results (Frederickson et al., 2005) from an activity theory perspective suggests that the introduction of a new tool (the web-page driven learning modules) caused a disruption in the students’ activity system. Now, new rules were needed to define how learning was to occur in this environment. Further, the division of labor changed since the teacher was less involved in the presentation of material and the student had more responsibility. Students responded to these disruptions by taking more responsibility for deepening and monitoring their learning (the demand for more examples and clarity in learning goals). From a learning environments perspective, what
at first appears as student dissatisfaction with the system maintenance and change domain of the learning environment (unclear goals) may have actually had a positive effect on the personal growth domain since the environment now encouraged students to be more aware of the content and their own learning process.

One study has been conducted that investigated the learning environment of students who used the ALEKS intelligent tutoring system (Canfield, 2001). Three classes of 10 students each participated in a Basic Mathematics course that used ALEKS at a U.S. university and completed a questionnaire at the end of the term. Results showed that students liked the detailed explanations and feedback, the tailored review problems, and the self-paced nature of the work. Students also reported lower stress levels as compared to traditional lecture style mathematics courses they had taken. Eighty percent of the students in these courses reported that they learned as much or more in the ALEKS course as compared to other courses, they would take another mathematics course that used ALEKS, and they would recommend ALEKS to another student. Canfield contends that since ALEKS teaches the standard factual knowledge usually found in traditional lectures, teachers have an opportunity to make their classrooms a place where inventing, abstracting, conjecturing, proving, and applying mathematics in realistic situations is the norm. This is the essence of the classroom flip.

Technology-Rich Active Learning Environments

Broad, Matthews, and McDonald conducted a study to investigate the effect a virtual learning environment had on students’ learning preferences (Broad, Matthews, & McDonald, 2004). These researchers took content from an accounting course and packaged it in a hypermedia environment on a CD (similar to a courseware management
system like Blackboard, but self-contained). The content on the CD took many different forms (static text, hypertext, quizzes, PowerPoint presentations, practice exercises, and online links) so that a variety of learning styles could be accommodated. Students began working through this material at the beginning of the term and attended 2 lecture sessions a week as the term progressed. The lectures were meant to add value to the virtual learning environment through personal interaction and the ability to target the lectures at trouble spots for students. As students worked in this environment, researchers collected data on their learning preferences.

The significant findings of the Broad et al. (2004) study show that students using the integrated virtual learning environment became progressively less pragmatic in their approach to learning. Pragmatic learners tend to focus on doing what is necessary to complete assignments and are not as concerned with engaging in theoretical discussions or exploring the implications of the concepts they are learning. This suggests students have adjusted their approach to learning and as a result of the change in learning environment. This evidence is in accordance with the Frederickson et al. (2005) study suggesting that as students use courseware learning systems to learn content, they tend to adjust their activity systems in a way that strengthens their awareness of the learning process and course content (the personal growth domain).

A study involving computer science students at the university level studied learner preferences and students’ choice of learning environment (face-to-face or on-line) (Buerck, Malmstrom, & Peppers, 2003). Twenty-nine students at a U.S. university participated; all were working at least 40 hours per week and all were at least 22 years old. Results showed that there was no significant difference in the academic performance
of the two groups. There was evidence, however, that computer science students who chose the on-line format were converging learners and students who chose face-to-face were assimilating learners. Convergers tend to be good problem solvers and decision makers. They more easily see practical applications for theories, and therefore prefer to work on technical tasks more than interpersonal ones. Convergers like to experiment with new ideas and therefore prefer laboratory assignments and practical applications. Assimilators, on the other hand, are good at transforming information in a logical manner to create theoretical models. Therefore, assimilators prefer to read, hear explanations, and explore analytic models. Having time to think through things is very important for assimilators.

While Buerck et al. (2003) looked only at computer science majors, their study speaks to all fields because it highlights an aspect of the personal system that students bring with them into the learning environment, learning preference. Students with different learning preferences will adjust differently to a technologically rich learning environment, some needing more time and help than others. If possible, the technological learning environment should be developed so that learners of all different styles can find ways to learn that are comfortable for them (see Lage et al., 2000).

In a study that investigated the influence computers had on middle school social studies classrooms, Mucherah (2003) noted the important ways in which the learning environment was affected. Three hundred and six students from 14 classrooms in 3 urban middle schools on the east coast of the U.S. participated in this study. Data were collected in this study through student questionnaires that measured perceptions of the classroom environment, graduate student observations of classrooms, and interviews with
participating teachers. Evidence from this study suggested that while students’ perception of the classroom environment explains a significant amount of variation in student learning, there is often a disparity between how students perceive the classroom and how teachers perceive it. Teachers in this study believed that when students learned with computers they tended to stay on task better, work more cooperatively, and be more motivated to learn. These teacher beliefs contributed to the perception that students interacted in the classroom and were involved in class activities while the teachers provided support for learning.

Student perceptions of the environment painted a different picture, however. Students tended to see the classroom as a rule oriented place, highly controlled by the teacher with activities structured by the teacher. This result demonstrates how the classroom activity system can look very different depending on who the subject is. The dynamic dependence of activity systems on the subject is supported by previous research showing that people in positions of authority with more responsibility for the learning environment tend to view the environment more positively (Mucherah, 2003).

Beliefs about learning was the focus of another learning environments study that concentrated on changes in students’ instructional and epistemological beliefs as they participated in a problem-based, collaborative, and technology-rich project (Elen & Clarebout, 2001). This study measured the instructional and epistemological beliefs of 139 secondary level students from 3 different European countries. After the initial survey, these students worked for 4 hours a week for 8 weeks collaboratively to prepare a position paper for a member of the European Parliament on the increasing international mobility of the labor market. Students from each school were matched with students from
the other participating schools and required to solve the problem as a group. Students had
email, videoconferencing, telephone, fax, Internet, and a dedicated database at their
disposal as they worked on the task. After the task was completed, students’ instructional
and epistemological beliefs were again measured.

Elen and Clarebout (2001) defined instructional beliefs as the beliefs students
hold regarding the optimal conditions for learning. For instance, if students think an
activity is easy, they tend to put less effort into their work, which in turn influences their
ability to engage the material and learn effectively. The second type of belief,
epistemological beliefs, is the belief students hold about the nature knowledge. Examples
include the view that knowledge as fixed and innate, or that knowledge as something
built up over time (both in society and the individual). Evidence in this study showed that
as students worked in this learning environment over 8 weeks, they significantly shifted
both their instructional and epistemological beliefs.

The surprising result is that student beliefs about the benefits of learning through
collaboration while using a variety of technological tools decreased. This result led the
researchers to evaluate the learning environment as planned and the learning environment
as it was implemented. They found that the implementation did not mirror the planned
learning environment, and students’ changes in beliefs reflected their ability to adapt to
their learning environment as it was implemented. This evidence further supports claims
that the introduction of tools (assorted technologies) and objects (an open-ended
collaborative assignment) into the learning environment can cause profound
disequilibrium in the activity system. This disequilibrium will result in a need for a re-
adjustment in the rules, division of labor, and the community itself. Without a concerted
focus on helping students through this re-adjustment, they can become disillusioned and withdraw from the learning process.

A study involving 406 students in a traditional *assignment-based* learning environment and 312 students in a redesigned *problem-based* learning environment investigated the influence of the environment on student level of learning (Nijhuis, Segers, & Gijselaers, 2005). The level of learning was characterized as being either deep learning or surface learning. Deep learning occurred when students showed interest in and searched for meaning in the learning task as they worked to integrate the individual parts of the task into a meaningful whole. Surface learning occurred when students only engaged the content enough to get the questions on the task correct. Students who only develop surface learning spend more time memorizing and reproducing information. They do not seek out further connections, meanings, or implications of the information learned.

Nijhuis (2005) used the Course Experiences Questionnaire and the Study Process Questionnaire to assess the level of learning for students in the two different learning environments. The researchers expected the *problem-based* learning students to adopt more of a deep learning approach than those in the traditional assignments based learning environment. However, the evidence showed that the *problem-based* learning students showed significantly more surface learning and significantly less deep learning than the *assignments based* students. An analysis of the factors that contributed to these results led the researchers to conclude that communication in the problem-based environment needed to increase. Teachers needed to communicate the ideas behind problem-based learning and give students more feedback as they process the learning tasks. Researchers
also concluded that students needed training to help them deal with the changes that the problem-based environment would bring to the classroom. These conclusions agree with Elen and Clarebout’s (2001) assessment of the complexity that changes in the learning environment bring to the community of students and their teacher. Again, these results are in agreement with an activity theory assessment of the fluid movement of the elements in a changing activity system.

Summary

Research has shown the power of using multiple linked representations to develop deep mathematical understanding. It is especially helpful when (1) students use mathematical representations that are a natural conceptual fit, (2) students are specifically encouraged to translate between representations, and (3) students are encouraged to make their latent conceptions visible before an activity so that misconceptions can be confronted and a deeper understanding of the underlying concepts can be developed.

Other studies have shown the potential of the classroom flip course design. When given more freedom to act in the classroom, students are often willing to step up if the instructor provides structural support within the activity system. However, if the classroom environment is not managed to handle the environmental changes, students’ learning may suffer. This is why it is so important for teachers to be aware of the domains of the learning environment and to provide a balance between them so that a healthy learning environment results (Moos, 2003).
CHAPTER 4
RESEARCH METHODS

Sound research methodology requires that data collection methods and analysis techniques be driven by the guiding questions of the overall study, the setting in which the study occurs, and the practical considerations of what is feasible for the researcher in that setting (Denzin & Lincoln, 1998; Strauss & Corbin, 1998a). Due to the nature of the questions guiding this research and the context in which it occurred, it was necessary to investigate the learning environments of classroom flip and traditional lecture-homework structured classrooms using both quantitative and qualitative research methods.

A number of validated quantitative instruments have been developed to study learning environments. Since these instruments have driven most of the research on learning environments, it was important to use one of these to investigate students’ perceptions of their learning environments in this research study (Fraser, 1998; Fraser, Treagust, & Dennis, 1986). However, the complexities that make up the learning environment cannot be sufficiently accounted for by giving students a survey on one particular day towards the end of the semester. For this reason, many learning environments studies are incorporating multiple methods to investigate the intricacies of this research domain (Fraser, 1998).
A search for deeper understanding in participants’ lived experiences and an exploration of the complexities of context and setting will require a research strategy that draws on qualitative methods (Marshall & Rossman, 1999). In an effort to collect data that would provide insight into the underlying complexities of the classroom learning environments in this study, I collected and analyzed data from student interviews and focus groups, in-class observations, audiotaped classroom sessions, student assignments, student written reflections, and researcher reflections.

Participants and Setting

This research took place at a Midwestern Christian liberal arts university. The data collection occurred between September and December 2004. Of the just over 1000 students enrolled in the traditional undergraduate program at this university in fall 2004, 58% were female, 90% were from Ohio, and 96% were white. Undergraduate tuition at this school was around $14,500, and the average amount of financial aid for the 94% of students who received it was $12,000 per student. It should be noted that 46% of the financial aid received was in the form of government loans. Taking all of this information into account, it is safe to describe the majority of students at this university as being middle-class White Americans from the Midwest. I collected data in two different Introduction to Statistics classrooms taught by me at this university.

One statistics class was structured according to the classroom flip method and met in a computer lab. Outside of class, students were introduced to new content by working with the Assessment and LEarning in Knowledge Spaces (ALEKS) intelligent tutoring system (for an explanation of all acronyms, see Appendix A). When students came to class, they completed activities that were designed to help them engage the content they
were learning in ALEKS in a different context. Students could interact with each other and the professor in class as they worked to strengthen their understanding of the more formal mathematical material presented in ALEKS. Often, these activities required students to use the Microsoft Excel spreadsheet program as a tool.

The other statistics class was structured according to a traditional lecture-homework format where students came every day to a classroom with tables and chairs and heard a lecture over statistics content. These lectures were heavily content driven. I would introduce statistical concepts and then work through examples that used those concepts. During the lectures, students had opportunities to ask questions or answer my questions related to the examples discussed. In this way, I made an effort to make the lectures as interactive as possible. After 2 or 3 class periods, students were assigned a set of problems from the book to complete as homework.

Students’ grades in both of these statistics classes were determined by their performance on identical midterm and final exams, completeness of assignments (homework from book or ALEKS as well as in-class work or short quizzes), and one major project at the end of the semester. I chose to give students identical midterm and final exams as a way to maintain consistency in assessments between the two sections. The exams presented students with open ended tasks to complete that they were familiar with (find the mean, perform a hypothesis test, find a confidence interval, etc.). Students were given sample exams with answers to study from the week before the exam so that there would be no procedural surprises on exam day. The thrust of the major projects between the two sections was similar in that students were presented with a situation where they needed to perform hypothesis tests and write up their results to complete a
task. The data collection methods for the major project between the two sections were slightly different due to the differences in the way the sections were structured. The flip section used data from a contrived problem they had worked on throughout the semester, and the lecture-homework section collected their own data for their major project.

*The Participants*

Most students in both sections agreed to participate in this research. Twenty-seven of the 28 students in the lecture-homework classroom and 23 of the 27 students in the flip classroom agreed to participate. One lecture-homework participant dropped the class a few weeks into the semester for scheduling reasons, so there were 26 participants who finished the study in that class. Participants from both classes were evenly split by gender (13-F, 13-M and 12-F, 11-M). The majority of students in both sections were underclassmen: 21 in the lecture-homework class, and 14 in the flip class. Also, the academic interests of students in both classes were quite diverse. Fifteen different majors were represented in the lecture-homework class, including Business, Psychology, English, Mathematics Education, Biology, Spanish, and Theological Studies. The flip classroom had 14 different majors, including Accounting, Chemistry, History, Sociology, Sports Management, and Youth Ministries.

*The Data Collection Team*

Since I taught both classes where this investigation occurred, it would have been difficult for me to collect good qualitative data from observations, student interviews, and focus groups. I enlisted other people to join my research efforts to help me collect data. A social work professor at the university where I was teaching observed my classroom, conducted 2 interviews, and conducted 2 focus groups. This professor has her M.S.W.
and was in the dissertation writing portion of her social work Ph.D. program at OSU at the time. She is very skilled at taking field notes and conducting interviews as she had spent 6 months doing fieldwork in Romania 1 year prior. A professor of psychology at the university with his Ph.D. in clinical psychology also observed a class session in this research.

Two senior social work majors also participated in collecting data for this research. These two students had both taken introduction to statistics and an upper level undergraduate research methods course the year before they assisted with this research. The social work professor and I met with these two students multiple times to discuss graduate level articles on taking field notes and conducting interviews. With these experiences serving as a foundation, these students observed class sessions, conducted interviews, and observed the focus groups for this research. Members of the data collection team had a protocol for asking questions in interviews and focus groups (see Appendix E). When the team was observing and taking field notes, there was no formal written protocol defined. However, since the data collection team was familiar with the guiding questions of the study, they all focused their observations mainly on how students were engaged with the professor, each other, and the learning content while in the classroom.

I also was a part of the data collection team. I audiotaped class sessions, kept a reflective journal, took observations after class sessions using a course log, and conducted member checking interviews. In the paragraphs below, I describe my activities as an educator and researcher over the past 10 years or so.
My involvement with educational technology at the professional level dates back to 1995 when I was hired as a graduate assistant whose job was to support faculty as they worked to integrate technology into their teaching. Over a span of 4 years, I held training sessions, researched new programs and technologies, and maintained staff, faculty, and lab computers (both Mac and PC).

In 1999, I began to teach full time at the university and, from the start, I was interested in ways to include technology in my teaching. I have mostly taught mathematics courses, but have also taught an Educational Technology course and an Internet for Business course. Looking back, I see that in those first 2 years I was unreflective and a bit naïve with regards to the benefits of technology in the classroom. Perhaps my deepest thinking on the subject at the time was that technology could hold students’ attention and make content interesting.

As I progressed in my teaching experiences and reflected on my students’ technology use in classroom flip settings (as described in the pilot study summaries in the introduction of this document), I was confronted with situations where technology was used as a tool that students used to help them learn. This sometimes meant the technology made the content interesting and held their attention, but it also sometimes meant students were frustrated. This led to frustration on my part, and was probably the circumstance that set the sequence of events in motion for my interest in this current research. So, rather than trying to show evidence for some pre-conceived notions I had about the benefits of technology use in education, I wanted this research to provide insight into how technology use and the classroom flip structure influence the learning environment for students and the instructor.
For the classroom flip environment, I needed a way to deliver content to students outside of the classroom. One option was to videotape a semester’s worth of lectures or PowerPoint slides with audio for students to view outside of class. This was not feasible as I did not have the expertise, equipment, or the other resources that would have been necessary to make this possible. I also felt that this type of videos and PowerPoint slides would not sufficiently engage students’ attention for an entire semester. I needed to find a technology that would satisfactorily introduce students to material in an engaging way. After reviewing all of the capabilities of the ALEKS intelligent tutoring system, I decided that it could accomplish this important part of the classroom flip for my students.

In order to minimize technical difficulties during the data collection for this research, I chose to teach a section of introductory statistics using the ALEKS program the semester before this research was conducted. During that time, I used ALEKS as the “textbook” for the course, but the format of the course was the more traditional lecture-homework format. I did not use the classroom flip structure at that time. Students came to class, we went through a lecture with examples, and students completed homework on ALEKS. I collected no data during this time. My sole reason for teaching a semester of statistics with ALEKS at that time was to work out any technical difficulties so that would not be a factor when I collected data for this present study.

Data Collection

Data were collected for this research using both quantitative and qualitative methods. The guiding questions of this study warranted data that measured opinions and preferences of students as well as data that provided a rich description of the context of the study. The specific methods used for collecting data are outlined below.
Quantitative Data

With two weeks left in the semester, students had experienced the flip environment and the lecture-homework environment for many weeks. This is the time I chose to administer the College and University Classroom Environment Inventory (CUCEI) questionnaire (Fraser et al., 1986). The CUCEI questionnaire provided insight into: (1) students’ perceptions of their actual learning environment and (2) students’ opinions of what their ideal (preferred) learning environment would look like. The CUCEI was developed to measure student and teacher perceptions of classroom psychosocial environment in college and university classrooms. The instrument is grounded in Moos’ theory that all human environments contain, at minimum, relationship dimensions, personal development dimensions, and system maintenance and system change dimensions (Moos, 1974). Pertaining to the relationship dimension, the CUCEI focuses on identifying the nature and intensity of personal relationships, assessing the extent to which students are invested in their environment and support and help each other. The CUCEI also seeks to assess the extent to which the environment pushes students toward personal growth and self-enhancement (the personal development dimension). Finally, the CUCEI strives to measure the overall orderliness of the environment, its responsiveness to change, and the clarity of expectations (the system maintenance and system change dimension). These dimensions of the environment, then, are measured on the CUCEI using the following seven scales: personalization, innovation, student cohesion, task orientation, cooperation, individualization, and equity. The development of this instrument was guided by findings of studies that used similar validated instruments to measure learning environments in elementary and secondary
schools. Further, the CUCEI’s internal consistency for the seven subscales has been measured in multiple studies and has been shown to be quite acceptable with Cronbach’s alpha coefficients ranging from 0.70 to 0.90 (Fraser, 1998; Fraser et al., 1986).

**Qualitative Data**

Qualitative researchers seek to study phenomena in their natural setting by regularly (if not daily) immersing themselves in that setting, using participants’ words and actions as the chief data source, and recognizing that authentic interaction with the participants is crucial to establishing credible findings. The qualitative researcher analyzes this data using a descriptive and analytic approach in order to better understand their participants’ perspectives on the setting under study (Marshall & Rossman, 1995). There are countless approaches to research within the qualitative paradigm. This study was positioned so that the teacher in the classroom acted as a researcher who was focused on doing theoretically-based research that informed better practice.

In this project, I employed an educational anthropology methodology for collecting data. Anthropologists approach research by analyzing human total ways of life (i.e. culture) holistically, relativistically, and comparatively (Zaharlick, 1992). Human interactions in anthropology are considered in their natural contexts (the holistic approach). In this context, many different ways of acting, thinking, and feeling are equally valid, and the researcher is responsible for finding sensibility in observed behaviors and beliefs, even when they at first seem puzzling (the relativistic approach). Anthropological research is further strengthened by its commitment to comparison between cultures. No one setting or type of setting can fully answer questions about
humanity, so researchers must compare research cross-culturally in order to acquire useful explanations and generalizations (the comparative approach).

Anthropologists have developed varied methods to conduct research. The methods I employed in this inquiry are termed ethnographic. Ethnographies analyze descriptive sociocultural data from a single social group (or several closely related groups) in order to give an engaging portrayal of the society or societies under study by placing specific events into a fuller, more meaningful context and having the insight to make the implicit and tacit explicit (Spindler, 1982; Tedlock, 2000; Zaharlick, 1992). Ethnographers are able to accomplish this by making prolonged contextualized observations, allowing the hypotheses and questions that guide the study to emerge and change as the inquiry progresses, constantly reflecting on the research process and the biases they and their participants bring to that process, and constantly moving between the participant’s (or insider’s) view (the emic) and the outsider’s view (the etic) of the society under study (Pelto & Pelto, 1978; Spindler, 1982). The ethnographic approach fit well with my research since the participant group under study (an Introduction to Statistics class) can clearly be viewed as a specific social group.

My research methodology placed me as both an insider (course instructor) and an outsider (educational researcher). These dual roles placed me as a participant observer throughout the research process. With this in mind, I needed to use data collection techniques that helped garner appropriate information. It was important for me to gather data that documented my thoughts and actions as instructor in order to get a fuller understanding of the context and movement of the course throughout the semester.

Consistent with methods that include the researcher as a participant in the study (Ellis &
Bochner, 2000), I collected data by writing in a reflective teacher journal after specified class sessions. In this journal, I focused more on myself as teacher in the classroom. I documented my thoughts on how I thought class was going in general, my struggles and successes, the emotions I felt, how well I thought students were learning, and how I changed course instruction throughout the semester. This movement of looking inward and then outward between then the personal and the cultural is typical of this type of research.

While I may be an insider in this research, I am also clearly an outsider. As I sought to understand student perspectives, how students adjusted to change in environment, and how deeply students understood statistical concepts, I was looking from the outside in. To collect observational data on these topics, I kept a “field notes log” that focused on student behavior in the classroom. I also wore a microphone to audiotape selected class sessions (at the beginning, middle, and end of the semester). After class was over, I listened to these tapes and wrote my observations of the class. I also had members of my data collection team come into the classroom and observe the classroom settings during the middle of the semester and then again towards the end of the semester.

From a classic ethnographic perspective, the data collected from participant observation field notes should be taken in a way that strives to minimize observer bias and find agreement between the observed and the observer in terms of what is happening in a given situation. The act of recording the observation, then, becomes a major focus of fieldwork. Pelto and Pelto (1978) argue that recorded observations should be kept at as
low a level of abstraction as possible and that ethnographers should avoid making assumptions and generalizations when observing an event.

Other traditional ethnographers have argued that observation should be conducted in a systematic way. First, the ethnographer should observe and record everything, taking a child-like approach to the observed scene and taking nothing for granted. As the researcher begins to understand the event at a deeper level, she is able to separate the relevant from the irrelevant (as it relates to her study). At this point the ethnographer focuses on what she feels is relevant. Finally, the ethnographer is able to give focused attention to the relevant observations in order to lift out the underlying salient attributes of the observed scene (or event). This way of observing has traditionally helped ethnographers gain a deep understanding of the context under study (Angrosino & Mays de Perez, 2000).

While observation has long been considered the foundation upon which all social science research rests, it is important to point out the well supported critique that no observation can be completely objective (Angrosino & Mays de Perez, 2000). It has also been argued that “unbiased” description alone does not represent the ethnographic observation process. On the contrary, observation can be viewed as being rhetorical constructions (even co-constructions) of the observer (with the observed) (Clifford, 1990). From this perspective, objectivity should not (indeed cannot) be the goal of observation. In fact, Tedlock (2000) contends calling an ethnographer a “participant observer” is a misnomer since the researcher cannot be both emotionally engaged as a participant and objectively detached as an observer. Instead, she argues that ethnographers must be “observant participants” who see meaning emerging from the
human context of which they are a part. Contemporary ethnographers, in contrast to traditional ones, believe it may not be possible, or even desirable, to bring the observer and the observed into agreement with regards to what happened in a certain situation. In addition to focusing on the method of observation, contemporary ethnographers have highlighted interest in the many possible ways in which the observer enters into relationships with participants in the group under study (Angrosino & Mays de Perez, 2000).

For this research, members of the data collection team focused on both the traditional and contemporary approaches to observation as we made observations. There are, however, limitations to the kinds of insight to be gleaned from observation alone. As participant observers, we passively received information from the setting we observed, and many questions were raised in our minds. Often we wanted to probe for answers to these questions. Wolcott (1995) points out that in “the simple act of asking, the fieldworker makes a 180-degree shift from observer to interlocutor, intruding into the scene by imposing onto the agenda what he or she wants to know” (p.102). Thus, any interaction the ethnographer has where he is asking questions of the participants in a study would be considered a shift from observation to interview (whether formal or informal).

Some researchers view the reason for an ethnographer to change from observer to interviewer is to get participants to tell you their story (Seidman, 1998). In telling their stories, participants reflect on their experiences, give order to those experiences, and then tell a story about those experiences in order to communicate the meaning they have made out of the event or series of events under study. In light of the powerfully informative
details interviews make available, they often serve to focus the research, as well as make it more “efficient” (Wolcott, 1995). Three members from the data collection team (the social work professor and the two senior students) conducted one-on-one and focus group interviews at the end of the semester in order to collect this important type of data. Hoping that students would be more candid, I did not participate in these interview sessions. I promised students that I would not view the interview transcripts or listen to the tapes until after the semester was over so that there was no potential for their grades to be affected by what they said in these sessions.

Questions for these interviews were short and to the point. They were developed by the social work professor and me and focused on a few big issues that arose from earlier field observations. These questions were worded in such a way as to illicit stories from the participants and get them to talk (Seidman, 1998). In addition, the interviewers intentionally worked to be active and creative listeners in order to help the interviewees be more effective speakers (Wolcott, 1995). For a complete list of questions, see Appendix E.

Although I did not conduct formal interviews during the semester, I did conduct informal interviews after class or as students came to my office in order to gain deeper understanding as an outsider looking in. These casual interviews never involved a tape recorder, but I recorded (in written form) conversations that took place as quickly as possible to preserve as much accuracy as possible. Later, after the analysis began, I returned to students who were still at the university and conducted follow-up interviews as member checks.
In addition to observations and interviews, I looked to a variety of documents for information in this inquiry. I included documents created by students in the class such as reflective papers, projects, and exams as part of my data corpus. Wolcott (1995) argues that these varied types of data sources can often be critical to gaining deeper understanding of the phenomenon under study.

Data Analysis

The purpose of this research was to study learning environments in a way that informed teaching practice and suggested classroom implications. With this goal in mind, I employed mixed methods data analysis techniques from both the multiple analysis of variance and the grounded theory data analysis traditions. I started coding the qualitative data, moved into the quantitative analysis, and then finished the qualitative analysis. I chose this approach to mixed methods analysis in an effort to let the data speak for themselves and to minimize any initial bias that the quantitative survey could bring into the study. After establishing a strong base of qualitative analysis, I felt an analysis of the quantitative data would help focus the further analysis in ways that were productive and consistent with current developments in the field of classroom environment studies.

Quantitative Analysis

I began analyzing my body of data by first open coding the qualitative data. After writing a number of exploratory memos on the unfolding analysis and coding a little over half of my qualitative documents (including student reflections, focus group observations, interview observations, exploratory memos, classroom observations, and transcripts of class sessions), I analyzed the College and University Classroom Environment Inventory (CUCEI) results using a number of quantitative methods.
The quantitative analysis began with finding means and standard deviations for the preferred and actual versions of the CUCEI for all students involved in the study. Recall that in the preferred version, students were expressing their opinions of their ideal learning environment, and in the actual version they were expressing their opinions of their actual class experiences. Next, the means and standard deviations were found for each class (traditional and flip) individually. I then grouped the results into the 7 subscales of the classroom environment (personalization, innovation, task orientation, student cohesion, cooperation, individualization, and equity) and ran a repeated measures multivariate analysis of variance test to see if there were significant effects between which class the student was in and the student’s scores on the actual and preferred versions of the CUCEI.

**Qualitative Analysis**

Grounded theory is one of the most developed qualitative analysis methods, and it focuses on building middle-range theory that explains data collected in an inquiry (Charmaz, 2000). What makes grounded theory unique is its built-in resolve to ensure that the resulting theory in a research study *emerges from* and is *grounded in* the collected data. Some researchers argue that researchers must not force their theory upon the data (Glaser, 1995). To guard against this “forcing,” Glaser claims it is essential for grounded theory studies to not begin with *any* preconceived research questions or problems whatsoever. Instead, as the researcher constantly compares collected data, problems and concepts will emerge as the inquiry unfolds. Other researchers, however, approve of studies that begin with guiding research questions and trust in grounded theory data analysis techniques to make certain the theory remains grounded in the data.
(Strauss & Corbin, 1998b). Both approaches, though, assume that questions will emerge during a study, and that these questions will remain in a constant state of development as the participants identify (explicitly and implicitly) new problems and concepts for exploration.

My research began with the stated initial questions and then followed data analysis techniques consistent with grounded theory in order to explore learning in a classroom flip environment. Data analysis with qualitative data usually involves multiple phases that can occur simultaneously. These phases include organizing the data, generating categories and themes (through open coding, axial coding and memo writing), testing hypotheses (through axial coding, selective coding and memo writing), searching for alternative explanations (through axial and selective coding), and writing the report (Marshall & Rossman, 1999; Strauss & Corbin, 1990).

**Open Coding**

As my research team and I began collecting data, I immediately started the process of open coding. At this early stage in the project, open coding involved simply identifying categories, themes, and patterns in classroom observations and transcripts of class sessions. After the semester was over, I open coded my log entries, focus group transcripts, focus group notes, interview transcripts, and student reflections.

The aim of open coding is to make quality comparisons and ask appropriate questions that will help the researcher recognize cogent themes in the data (Strauss & Corbin, 1990). This process often began by looking at a document and asking: What is this?, Does this behavior appear elsewhere in the data?, What does this represent?, etc. By asking these types of questions and comparing the document with itself and other
documents, I developed concepts that described (in an abstract sense) what was going on in the data. The names I gave to these concepts are called codes and they took the form of a single word, a line, a paragraph, or even an entire document (Strauss & Corbin, 1990). When I began coding a document, I often included theoretical notes for each instance of a code in order to give a deeper explanation of why I chose to code that part of the document the way I did. These notes proved to be very helpful later in the analysis when memo writing and categorizing the data (Corbin, 1986).

Once I generated a number of codes for the data (80 to 90 codes), I looked for codes that were similar so I could begin grouping them together into larger categories. I wanted to identify these larger categories so I could see more clearly the larger themes that were operating in the data. I wanted to go through this process analytically, so I first revisited the portions of original documents and recoded them. This recoding may at first appear to be redundant, but researchers have often found that going back and revisiting documents after coding a number of other documents provides fresh insight, often produces more succinct codes, and may even aid in the development of new concepts. Recoding is also a useful tool in the process of “constant comparison” necessary for developing quality grounded theory (Corbin, 1986). This process of looking for larger categories overlapped considerably with another analysis technique called memo writing.

**Memo Writing**

The writing of analytic memos is a powerful tool in the process of category development. Memos are written by the researcher, for the researcher (Corbin, 1986), and they helped me organize my thoughts and make my understanding of the data visible. Going through this process helped me compare, verify, change, and modify my ideas as
new data were analyzed. The initial memos helped me investigate connections between concepts (codes) and group them together into categories in ways that were consistent with the data. Through memo writing, I was able to track my thought process and see where the analysis had been and where it needed to go. The thoughts and analyses in these memos helped build categories (and subcategories) of similar concepts and hypothesize connections between different concepts in the study.

Memo writing was also helpful in identifying important properties of each concept. Each property of the concept varies over a range of dimensions. Identifying these properties and dimensions became a crucial piece in the later development of the grounded theory. To illustrate the connection between properties and dimension, consider the concept of color. One property of color could be “shade.” This property of shade can then vary in dimension over a range of possible values from light to dark. When I wrote memos, I made a concerted effort to focus on the possible properties and dimensions of the concepts found in the data.

As I went through the process of open coding and memo writing, I made an effort to use techniques that helped maintain what Glaser terms theoretical sensitivity (Glaser, 1978). Theoretical sensitivity refers to the ability of the researcher to understand (with deep insight) the patterns and meaning in the data. In the analysis process, I was constantly tempted to think that I was seeing all there was to see in the data, but in reality we often miss far more than we see. To analyze the data well, I needed to be able to “see” with analytic depth. I used a number of techniques to help enhance my theoretical sensitivity in this study.
The first technique to enhance theoretical sensitivity is “constant questioning.” Constantly asking questions such as Who? When? Where? What? How? How much? and Why? in the analysis process often uncovers hidden connections to explore in subsequent observations or interviews (Strauss & Corbin, 1990). I also tried to remain sensitive to interesting phrases or sentences that struck me as important, and to develop questions (for later interviews) or sensitivity to the ideas involved when making subsequent observations. Further, I was constantly on the lookout for “red flag” phrases like: never, always, everyone knows that…, it’s never done like..., it couldn’t possibly be that …, etc. Probing the possible meanings behind statements like these often brings hidden concepts to light.

Finally, theoretical sensitivity was heightened by using strategies of comparison. When I hit a lull in the analysis process, it was helpful to compare dimensions of the concept under study with a concept that was its opposite. This flip-flop comparison sometimes generated properties of categories that would not have been brought to light otherwise. I also used comparison techniques that involved simultaneously and systematically asking extremely detailed questions about every aspect of two or more phenomena under study. Sometimes it was helpful to think up hypothetical scenarios where different phenomena may simultaneously occur helped me consider (in minute detail) the types of interactions that may come about in those settings. Another helpful comparison technique used involved thinking of a concept seemingly totally unrelated to the concept under study and then reflecting on comparisons that could be made between the two. Comparisons made in this way helped me to think in creative ways that eventually led to promising areas for future analysis (Strauss & Corbin, 1990).
**Axial and Selective Coding**

With open coding and memo writing, my analysis focused on conceptualizing the data into small pieces (concepts, or codes) and then grouping related concepts together into categories (and even subcategories). The next phase of analysis helped me begin to link categories and subcategories together through the paradigm model of axial coding (Strauss & Corbin, 1990). This process sought to link the small pieces of data together in order to see connections that would shed light on the larger phenomenon under study.

The paradigm model of axial coding is a systematic approach to analysis where the researcher considers the causal conditions that led to the phenomenon under study, the context of the phenomenon (by investigating the properties and dimensions of the concepts involved), the intervening conditions (or the broader context that may influence the actions people take in the phenomenon under study), the actual strategies for a person’s action / interaction during the phenomenon, and the consequences of the actions taken during the phenomenon. It is important to note that these consequences may later become a set of causal or intervening conditions for other subsequent actions; this is referred to in the literature as process (Strauss & Corbin, 1990). A quality research study will clearly account for process in the final analysis.

Once I noticed connections between categories and concepts, I then returned to the data to look for further evidence to support or refute these connections. The perceived relationships had to be confirmed repeatedly in the data to be valid. Often, there was variation in the data where some of the data supported the connections, and some of the data refuted them. Noting this variation in the data and adjusting the possible connections between categories in light of this variation strengthened the developing analysis.
During the axial coding process I began to note and develop full models of relationships and linkages between categories and subcategories. In the selective coding phase, I made significant progress toward developing a rich analysis by taking the initial (and often rough) linkages and systematically developing them into a conceptual and comprehensive picture of the learning environment. This was accomplished by developing a narrative story around the core category found in the data. Choosing a core category that encompassed all the main features of the data proved to be difficult. It was important that the core category be chosen analytically in such a way that all of the concepts in the data meshed well with it.

After choosing the core category, I began to develop the storyline of my data by first noting the properties and dimensions of this category in depth. Next, I used memo writing and concept maps to explore the relationships between the core category and other categories in light of the paradigm model mentioned above (conditions → phenomenon → context → strategies for action → consequences). Some of the categories were viewed as initial conditions for the core category (paradigm) while others were categories that delineated strategies for action. This “arrangement” step took a lot of work and required multiple revisions before the arrangement of the categories fit the story of the data well. Once the categories were ordered (in terms of the paradigm) around the core category, I returned to the data to validate the arrangement and make sure that it held (in a broad sense) in case after case throughout the data.

Once the arrangement of the categories in relation to the core category was validated in the data at the broad conceptual level, I was ready to systematize and solidify the connections between them on a more detailed level. This was done by considering the
dimensional ranges of all the properties of the categories and then relating these categories at their dimensional levels. This step was extremely difficult due to the subtleties of the categories’ dimensions as well as the complex relations themselves.

After the more detailed connections between categories were identified, I focused on writing memos that explored these connections in story form. I also used diagrams and concept maps to help make the analysis clearer. In light of the main storyline, I strove to make clear statements of the main relationships in the story. These statements took the form of: when (this context is present), then students will tend to (use this strategy) or when students (take this action), then (this consequence occurs). At this point, I returned to the data once again to validate the story and the statements of relationship. I checked to make sure the data fit in a general sense since specific cases always have their idiosyncrasies. In this way, I looked to develop a theory that best fit the data. This constant back and forth movement from the developing theory, to the data, and back again is a hallmark of grounded theory.

In moving between the theory and the data, I saw many cases that supported the specified theory and a few that did not. It was therefore important to identify these “negative cases” and analyze them in light of the theory. Often, cases that appear to not fit the theory do so because their initial conditions leading to the phenomenon under study are in a state of transition. Because of this transitional quality (perhaps due to lack of dimensional clarity for a property of some category), the case can fall somewhere between two different initial conditions rather than clearly located in one or the other. In situations like this, I tried to give a clear analytic explanation for why the case did not fit with the theory. Other negative case analyses revealed that the case had unique
intervening conditions that were not found in any of the other data. In this situation, the
case pointed to deeper variation in the concepts and categories involved in the study
rather than a negation of the theory.

Validity

In a broad sense, validity refers to the principles we use to determine whether or
not the research under question is of good quality (Trochim, 2002). Traditional scientific
standards for quality research such as generalizability, replicability, objectivity, internal
and external validity, etc., have long been issues with which social science researchers
have struggled (Lather, 1986, , 2001; Roberts, 1982, , 1996; Scheurich, 1996). Are these
the only standards we should use to measure the quality of research? If not, what other
standard(s) should be used?

While I do not attempt to provide a point-by-point analysis of the concepts that
underlie the traditional standards of validity and how qualitative research can meet these
standards (this has been done elsewhere (Corbin & Strauss, 1990; Guba & Lincoln, 1981;
Guba & Lincoln, 1985)), I draw on the literature to indicate how the grounded theory
approach as I have outlined it produces quality research. Roberts (1996) claims good
qualitative research must be more than just a nice story (or “case story”); it must have a
point and reach some conclusion about the phenomenon under study. If neither of these
two qualities are present, the study makes no contribution to knowledge. Using
Toulmin’s philosophy of the basic structure of knowledge-producing arguments, Roberts
(1982) argues any research (qualitative or quantitative) that seeks to build knowledge
must provide warrant and backing for the assertions that are made. He points out that
quantitative research already has clear standards for warrant (i.e. statistical significance),
and that warrant for qualitative studies is less familiar. Even so, if qualitative researchers can support their assertions with systematically developed conceptual frameworks, then sufficient warrant can be established. I argue that the grounded theory approach, as specified above, accomplishes both the telling of a story that has a point and a conclusion. Further, this approach provides sufficient warrant for the assertions that are made by grounding every aspect of the developed theory in an abundance of data.

Lather (1986) delineates ways in which researchers can seek to minimize their own distortions of the data. By triangulating data sources, methods, and perspectives on the data, the researcher is able to establish data trustworthiness. Data credibility in a study can be established by performing member checks, which involves recycling the data analysis and conclusions back to the participants in the study to get their feedback. By designing research that provides multiple interactions with the participants, researchers can also bolster construct validity (or the goodness of fit between conceptual labels and the data itself). Perhaps most importantly, Lather insists that research should be self-corrective. By fostering a “vigorously self-aware” (p.66) posture, researchers can minimize the distortions they bring to the data and allow the participants in the study tell their story.

The multiple data sources in this study (reflective journal, field notes, interviews, and document analysis) as well as multiple data types (qualitative and quantitative) encouraged data trustworthiness through triangulation. Toward the end of the study I elicited feedback from students regarding the results of the research using an individual interview member-checking strategy. Based on the preliminary analysis, I developed interview questions to ask some of the key participants of the study as determined by the
preliminary analysis. Through this member checking, I established data credibility.

Interaction with the students and the data strengthens construct validity in the study.

Further, the constant movement between the coding/re-coding process and the data itself found in the grounded theory method also bolstered construct validity. Finally, self-awareness of the researcher in this study was fostered through the use of my reflective teacher journal.

While some scholars have argued that we must dispense with the idea of validity because it results in silencing voices, encouraging sameness rather than diversity, and is divisive in nature (dividing what is considered science from not-science) (Scheurich, 1996), I believe it is important for the researcher to make visible attempts at making sure the product of a study is quality (valid) research.

Limitations

This study was limited in design because I was both the teacher and the researcher. This made it difficult for me to write observational field notes in real time or to even observe many types of behavior that I would otherwise have observed if I were seated in the room intently observing instead of teaching. I attempted to address this limitation by audio taping class lectures throughout the semester. This allowed me to “step outside” the teacher role and observe what happened at a later date. While the microphone sometimes picked up student questions and comments, it did not always do so. Also, due to the limitations of the audiotape medium, I was unable to read very important non-verbal cues and gestures (mine and the students) from listening to the lectures. These difficulties made it a challenge to get a truly robust observation of the class session myself. Another tool built into the research design that addressed this
observation limitation was to have various members of the team come in and observe (take field notes) at different times in the semester. Three different team members made a total of 4 observations each. One member observed only one class session.

Other limitations involved the fact that many students were at times reluctant to be forthcoming with criticisms of the course throughout the semester since I had control over the grade they received. To address this limitation, I asked students to choose between participating in a focus group, an individual interview with a member of my research team, or writing a reflection paper. All three of these activities were aimed at allowing students to describe their learning journey over the course of the semester in a context where they would not feel threatened by repercussions. Two colleagues of mine kept the tapes and papers in their offices until the semester was over, and I promised not to listen to the focus group or interview tapes, or to read the papers until after I had submitted student grades for the semester.

Another important limitation to consider is that students were not randomly assigned to either the flip or lecture-based classroom. Because of the lack of random assignment, this research cannot make generalizations to some larger population group. However, the qualitative research design upon which this study is built does allow for a thorough and rich description of the participants and context. Designing research in this way can often lead to findings that can inform similar contexts and participants with a high degree of confidence of the quality of transferability (Marshall & Rossman, 1995).

Finally, the demographic make-up of my course participants could be seen as a limitation. Since the majority of the students at this university are middle-class, Christian, white, Midwestern young adults, this participant group appears to be quite homogenous.
While it is true that participants are alike in these categories, they were also quite diverse in terms of their academic abilities (high, middle, and low achieving), rural or urban background, home stability, support systems, and how comfortable they are working with computer technology. This was far from a homogenous group of students in these respects.
I report the findings of this research in two main sections. An analysis of the quantitative results outlines a picture of what happened in the classroom. The report of the qualitative findings that follows not only corroborates the quantitative results, but also colors in and brings into focus the picture that was sketched by the quantitative results. During the qualitative findings section, I present findings from both the professor’s and the students’ perspectives in order to give a more varied and thus a fuller account of what happened in the two learning environments.

Quantitative Results

The College and University Classroom Environment Inventory (CUCEI) measures students’ perceptions of: (1) their actual learning environments and (2) their preferred (hypothetical) classroom environment. Structuring the survey into these two parts helps make for a full and meaningful measure of what students say they actually experienced in the classroom in light of their personal preferences. Both the actual and preferred versions of the survey are broken up into seven subscales which loosely sit inside Moos’ (1973) three domains of social environments (relationship, personal growth, and system maintenance and change) discussed in Chapter 2. The seven CUCEI subscales are as follows (the corresponding Moos social environment domains are
included in parentheses: personalization (relationship and personal growth), innovation (personal growth and system maintenance and change), student cohesion (relationship), task orientation (personal growth and system maintenance and change), cooperation (relationship and personal growth), individualization (personal growth and system maintenance and change), and equity (personal growth and system maintenance and change).

Items in the CUCEI fall under one of the subscales and most are worded so that a high score (5) is positive. For instance the personalization subscale item A1 states “The instructor considers my feelings.” Students can answer from 1 to 5 on a Likert scale where 1 is almost never and 5 is almost always. To provide variety in the instrument, 14 items are worded in reverse direction so that a high score (5) is negative. For example, the first reverse scored item, A7, states “The instructor is unfriendly and inconsiderate towards me.” A high score of 5 (almost always) would be a negative rating. I wanted to meaningfully compare means and standard deviations for all items together on the CUCEI, so I before I analyzed the data, I adjusted these reverse scored items so that a 5 became a 1, a 4 became a 2, and a 3 stays a 3.

The item means and standard deviations for the actual version of the CUCEI for both the traditional and the flip classes show that the means of each item range from 1.34 to 4.75. Also, the item means and standard deviations for the preferred version of the CUCEI range from 1.63 to 4.9. For a list of each item and their corresponding means and standard deviations, see Appendix H. In considering the variability of these sample means and observing that the standard deviations of most items are close to 1, it is
reasonable to conclude that the CUCEI was sensitive to the varying opinions of students in this study yet still allowed for a consensus of opinion on most items.

One question of interest regards how students think of their actual learning environment compared to their preferred learning environment. In Table 5.1, the means and standard deviations for each of the subscales of the CUCEI are presented for the actual and preferred versions. When we consider the difference between each subscale mean for the actual and preferred versions, the results indicate that students as a whole feel their actual learning environment is not measuring up to their preferred environment. This is a common occurrence in studies where the CUCEI is used. Every mean for the actual version is statistically significantly lower than the preferred version.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Actual Mean</th>
<th>Actual SD</th>
<th>Preferred Mean</th>
<th>Preferred SD</th>
<th>Difference Actual - Preferred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personalization</td>
<td>3.93</td>
<td>.802</td>
<td>4.44</td>
<td>.533</td>
<td>-0.51**</td>
</tr>
<tr>
<td>Innovation</td>
<td>2.91</td>
<td>.543</td>
<td>3.45</td>
<td>.678</td>
<td>-0.54**</td>
</tr>
<tr>
<td>Student Cohesion</td>
<td>2.84</td>
<td>.674</td>
<td>3.57</td>
<td>.673</td>
<td>-0.73**</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>3.75</td>
<td>.612</td>
<td>4.46</td>
<td>.517</td>
<td>-0.71**</td>
</tr>
<tr>
<td>Cooperation</td>
<td>3.44</td>
<td>.892</td>
<td>3.89</td>
<td>1.001</td>
<td>-0.45**</td>
</tr>
<tr>
<td>Individualization</td>
<td>2.48</td>
<td>.594</td>
<td>3.21</td>
<td>.574</td>
<td>-0.73**</td>
</tr>
<tr>
<td>Equity</td>
<td>4.41</td>
<td>.995</td>
<td>4.83</td>
<td>.408</td>
<td>-0.42 *</td>
</tr>
</tbody>
</table>

* Paired *t*-test significant at the 0.01 level (2-tailed)
** Paired *t*-test significant at the 0.001 level (2-tailed)

Table 5.1. Means, standard deviations, and difference scores for actual and preferred versions of CUCEI

Another question of interest is whether students’ scores on the subscales differ between the traditional and the flip classrooms. Table 5.2 shows the means and standard deviations for each subscale of the actual version of the CUCEI for the traditional and the
flipped classrooms. These measures were analyzed using an independent samples \( t \)-test, and the results suggest that there are significant differences on the actual version of the survey for the Innovation, Task Orientation, and Cooperation subscales.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Traditional Mean</th>
<th>Traditional SD</th>
<th>Flipped Mean</th>
<th>Flipped SD</th>
<th>( t )-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personalization</td>
<td>3.74</td>
<td>.819</td>
<td>4.13</td>
<td>.752</td>
<td>-1.71</td>
</tr>
<tr>
<td>Innovation</td>
<td>2.74</td>
<td>.444</td>
<td>3.08</td>
<td>.589</td>
<td>-2.22*</td>
</tr>
<tr>
<td>Student Cohesion</td>
<td>2.69</td>
<td>.607</td>
<td>3.00</td>
<td>.714</td>
<td>-1.61</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>4.00</td>
<td>.403</td>
<td>3.51</td>
<td>.691</td>
<td>3.00**</td>
</tr>
<tr>
<td>Cooperation</td>
<td>2.97</td>
<td>.905</td>
<td>3.90</td>
<td>.591</td>
<td>-4.24***</td>
</tr>
<tr>
<td>Individualization</td>
<td>2.38</td>
<td>.622</td>
<td>2.58</td>
<td>.563</td>
<td>-1.15</td>
</tr>
<tr>
<td>Equity</td>
<td>4.63</td>
<td>.800</td>
<td>4.19</td>
<td>1.13</td>
<td>1.52</td>
</tr>
</tbody>
</table>

* Independent \( t \)-test significant at the 0.05 level (2-tailed)
** Independent \( t \)-test significant at the 0.01 level (2-tailed)
*** Independent \( t \)-test significant at the 0.001 level (2-tailed)

Table 5.2. Means and standard deviations for the actual version of CUCEI

We next perform the same subscale analysis between the two classes for their preferred version scores. Table 5.3 shows the means and standard deviations for each subscale of the preferred version of the CUCEI for the traditional and flipped classrooms. The means and standard deviations were again analyzed using an independent samples \( t \)-test. These results indicate students in the flip class prefer an environment with greater innovation and cooperation when compared to the traditional class. There is no evidence of a difference in preference for the other subscales. Comparing these results with the actual version shows that students felt their preference for the innovation and cooperation were met in the actual experience of class. Further, lack of a difference in preference for task orientation the traditional and flip classrooms combined with a significant difference
in their actual experience shows that the flip classroom likely felt the task orientation aspect of the learning environment was sub par. It will be important to use this result as one of the lenses through which we view the qualitative results.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Traditional Mean</th>
<th>Traditional SD</th>
<th>Flipped Mean</th>
<th>Flipped SD</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personalization</td>
<td>4.32</td>
<td>.557</td>
<td>4.56</td>
<td>.489</td>
<td>-1.58</td>
</tr>
<tr>
<td>Innovation</td>
<td>3.14</td>
<td>.576</td>
<td>3.76</td>
<td>.639</td>
<td>-3.52***</td>
</tr>
<tr>
<td>Student Cohesion</td>
<td>3.65</td>
<td>.640</td>
<td>3.50</td>
<td>.709</td>
<td>0.79</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>4.48</td>
<td>.640</td>
<td>4.43</td>
<td>.366</td>
<td>0.37†</td>
</tr>
<tr>
<td>Cooperation</td>
<td>3.60</td>
<td>.976</td>
<td>4.18</td>
<td>.958</td>
<td>-2.09*</td>
</tr>
<tr>
<td>Individualization</td>
<td>3.08</td>
<td>.561</td>
<td>3.35</td>
<td>.567</td>
<td>-1.67</td>
</tr>
<tr>
<td>Equity</td>
<td>4.84</td>
<td>.500</td>
<td>4.82</td>
<td>.301</td>
<td>0.16</td>
</tr>
</tbody>
</table>

* Independent t-test significant at the 0.05 level (2-tailed)
*** Independent t-test significant at the 0.001 level (2-tailed)
† Significant on Actual Version, but not on Preferred

Table 5.3. Means and standard deviations for the preferred version of CUCEI

The above exploratory data analysis begins to lift out significant patterns in the CUCEI data. However, due to the multivariate nature of this data, it is possible that some of these results are due to interactions between the variables rather than the patterns we observed above. Therefore it is essential that we perform multivariate analysis to look for interaction effects between the many variables in the data. Since each student took the preferred and actual version of the CUCEI, the samples for these two versions were paired. Further, since the initial analysis suggested that at least some of the subscale scores were correlated, it was appropriate to examine the data using repeated measures MANOVA. For each student, I paired their actual and preferred answers for each of the
sub-scale measures and used these as the *within-subjects* factors. I used type of class (traditional or flipped) as the *between-subjects* factor for the analysis.

Results from the MANOVA are shown in Table 5.4. We can see from these results that when studying the mean scores for each of the sub-scales of the CUCEI, the version of the CUCEI the students took (the first main effect) explains 64.2% of the overall variation in the data. The class that the student was in (the second main effect) explains 44.5% of the overall variation in the data. Both of these effect sizes are statistically significant, as might be expected. Further, just considering the interaction effect between version of the scale and class explains 35.5% of the overall variation in the data. These results show that the significant differences observed in the *t*-tests above were, in fact, significantly explained by the version of the scale and which class the students were in and not by some other interaction in the variables.

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>F</th>
<th>P</th>
<th>Effect Size (Wilks’)</th>
<th>Effect Size (multiple $\eta^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version of Scale</td>
<td>7, 40</td>
<td>10.25</td>
<td>&lt;0.001</td>
<td>0.358</td>
<td>0.642</td>
</tr>
<tr>
<td>Class</td>
<td>7, 40</td>
<td>4.58</td>
<td>0.001</td>
<td>0.555</td>
<td>0.445</td>
</tr>
<tr>
<td>Version x Class</td>
<td>7, 40</td>
<td>2.75</td>
<td>0.02</td>
<td>0.675</td>
<td>0.325</td>
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</tbody>
</table>

*Table 5.4.* Repeated measures multivariate analysis of variance results for the CUCEI

As part of the repeated measures MANOVA analysis, I ran tests of within subjects contrasts to see which subscale means are significantly different when pairing the actual with the preferred version. The within subjects contrasts test showed significant differences for all of the subscales. The Equity subscale was significant at $p <$
0.01 and all other subscales were significant at $p < 0.001$. These results confirm earlier observations that students’ actual environment scores are consistently lower than their preferred environment scores.

To investigate which of the subscales had significant effects on CUCEI scores while taking into account the between subjects factor of which class the students were in, I performed a test of between-subjects effects for the final quantitative analysis. Table 5.5 presents these results and shows significant effects for the Innovation, Cooperation, and Task Orientation subscales. It also appears that the Personalization and Individualization subscales may potentially show a trend toward significant effects. Again, this multivariate analysis confirms results we saw in the earlier exploratory analysis.

<table>
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<tr>
<td>Class</td>
<td>Personalization</td>
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<td>3.62</td>
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<tr>
<td></td>
<td>Innovation</td>
<td>1</td>
<td>13.91</td>
<td>0.001***</td>
</tr>
<tr>
<td></td>
<td>Student Cohesion</td>
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<td></td>
<td>Task Orientation</td>
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<tr>
<td></td>
<td>Cooperation</td>
<td>1</td>
<td>10.92</td>
<td>0.002**</td>
</tr>
<tr>
<td></td>
<td>Individualization</td>
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<td></td>
<td>Equity</td>
<td>1</td>
<td>1.79</td>
<td>0.188</td>
</tr>
</tbody>
</table>

* Significant at the 0.05 level
** Significant at the 0.01 level
*** Significant at the 0.001 level

Table 5.5. Tests of between-subjects effects for the CUCEI

Summary

A careful analysis of the quantitative data in this study shows that students in the flip environment preferred and experienced a higher level of innovation and cooperation.
in their classroom. It is unclear how much the semester long experience in the flip environment itself influenced students’ preferences since their learning environment preference was not measured at the beginning of the semester to compare with their end-of-semester responses. However, at some level, it is safe to say that students came to be contented with an innovative teaching approach in the classroom that required working with others when completing learning tasks. The analysis also revealed that students in the flip environment preferred the same level of task orientation as students in the lecture-homework environment; however, students in the flip environment report that they experienced lower levels of task orientation throughout the semester than students in the lecture-homework environment. These results present a dynamic flip environment where students prefer collaboration and innovative teaching strategies, but they are less satisfied with how the environment orients them toward course content. As the analysis moves to the qualitative findings, it is important to draw on the qualitative data to compare how the differences in innovation and cooperation influenced the learning environments in the two different sections. It is also important to draw on the qualitative data to see how students dealt with the learning challenges in the flip environment due to the deficient task orientation dimensions in the structure of the classroom. I use activity theory to help set the framework for this aspect of the analysis.

I note here that while I’ve drawn on grounded theory methods for the specifics of the qualitative data analysis, I am not strictly following the guidelines set by Glasser (1978, 1995). By allowing the quantitative analysis and activity theory to frame the qualitative findings, some could argue that I’m not allowing the data to speak for itself. However, I argue that by conducting the majority of the open coding before beginning
the quantitative analysis, I am triangulating methods rather than compromising grounded theory methodology. Also, using an activity theory framework to analyze student learning provides a reliable structure within which to use grounded theory methods to analyze learning in the two environments.

Qualitative Findings

Qualitative data were collected over the course of the semester in many forms. Field observations, researcher reflections, student reflections, interviews, focus groups, and course documents make up the body of data for this study. An analysis of these data revealed that the two different statistics classes (flipped and traditional) developed two distinct classroom cultures. In this section, I will attempt to describe (allowing the data to speak for itself) the culture of these two classrooms. After the descriptions of the classroom cultures are presented, I will focus the findings of the study on how students approached learning activity in these two environments.

The instructor’s reconstructions that follow were pieced together based on transcripts of the class sessions, log entries, reflective journals, and researcher memos. I wrote these reconstructions in the first person because I wanted to convey that this really is my take on the semester. While I made efforts to faithfully describe how the semester truly went, the account is mine, and therefore suffused with all of my personal experiences, goals, and even (unintentional) biases as the instructor in the course.

The reconstructions from the students’ perspectives were built based on the focus groups, interviews, and student reflection papers on their learning in the course. I wanted the students to tell their own story, so I decided to use direct quotes from the focus groups as the primary text of these sections. While the text for these sections does come from the
focus groups, I carefully chose the quotes and pieced them together to try to faithfully capture the broad views of the class as a whole which came to light after my analysis of ALL the student data (interviews and student reflection papers included). Throughout “The Students’ Take” sections, I included my own running commentary (using square brackets) to make connections between ideas and to fill out the narrative where necessary.

What Happened in the Flip Class

The Instructor’s Take

In an effort to establish a culture of mathematical investigation in the flip section of introduction to statistics, I began the semester with a three-week long investigation. I created a hypothetical problem where the owner of a computer store (Jack) has information on a sample of his customers, and Jack asks my class to help him determine what these data say about his customers as a whole (see Appendix F for a copy of the Jack problem). I purposely made this assignment open ended so that students could use a number of different approaches that would yield useful results. Students were encouraged to draw on their current mathematical understandings but to also create new strategies for analyzing data if what they currently knew about mathematics and statistics was not helping them progress.

For seven class sessions, I used the Jack problem as a tool to guide students as they investigated statistical concepts usually found in the first three chapters of a standard statistics text. These statistical concepts included: measures of central tendency, measures of variation, classifying different types of variables, and how to display both univariate and bivariate data. The assignment culminated with students writing a report (addressed
to Jack himself) that explained their findings using everyday language. In this report students gave Jack their recommendations for what he should do in his business, and students were encouraged to specifically support their recommendations using their statistical analysis.

An important dynamic developed during the Jack investigation that persisted throughout the entire semester. Some students would work for a little while on the assigned problem, and then if they got stuck or frustrated, they would begin playing games or doing other work on their computers. This presented a difficulty for me as the professor in the course as I did not want to constantly hound them about their computer use. I handled the problem by announcing at the beginning of class sessions that I wanted them to log out of all non-class related websites and programs. I also strongly encouraged students to struggle through problems when they got stuck, to try out creative guesses, and to help each other. This worked for some students, but others struggled with staying on task the entire semester, resulting in a negative effect on their learning in the course. Because of this negative effect, if we were not using the computers for a chunk of time during the class period, I would ask students to log out of their systems to the “login box.” Some students did not like this very much, but for the sake of other students’ learning I felt the positives outweighed the negatives.

While students were working on the Jack problem in class, I required students to register online with the intelligent tutoring system they would use to complete their homework throughout the semester (ALEKS). Students were also asked to take their first assessment on the system, which gave ALEKS a snapshot of the types of problems each student was already able to do on their own. Once students completed their first
assessment, I chose a set of ALEKS items that I wanted students to learn, and assigned that to them as an intermediate objective to complete as homework. The ALEKS items I chose to include in this first objective corresponded with the concepts they were learning in the Jack problem, specifically: measures of central tendency, measures of variation, classifying different types of variables, and how to display both univariate and bivariate data. I set a date on the ALEKS system for when every student in the class needed to have their intermediate objective set of items completed, and I strongly encouraged students to work on ALEKS a little bit each day so that their in-class investigations and their ALEKS homework would correspond.

After students completed the initial Jack assignment, I used the Jack data to guide discussions about probability. I felt the students’ familiarity with the Jack data would make it easier for them to see the subtleties between different types of probability questions such as “If I pick a customer at random from this list, what’s the probability that the customer is male and lives in an urban area?” and “If I pick a customer at random from this list, and I know he is a male, then what’s the probability he lives in an urban area?” I created activities for students that guided them to connect the solutions to these questions with different mathematical methods such as counting techniques, Venn diagrams, and formal equations. During this part of the semester, I gave students $\frac{1}{2}$-sheets of paper with exploratory questions to work through in groups of 2. After most of the class made it through these investigations, I would give a mini-lecture that summarized the main points they would need to take away from the investigation they had just completed. PowerPoint slides accompanied these lectures, and I printed out the
slides and gave them to students with room on the side of the page to take additional notes.

Ideally, I would have liked students to complete the ALEKS items related to these concepts before the classroom investigations. However, due to the nature of the intelligent tutoring system it was extremely difficult, if not impossible, to keep the entire class at the same point in the system for every class period. Here is how we worked in the ALEKS system: I assigned new objectives every two weeks that covered the material we were also working on in class, and I encouraged students to work on ALEKS a little bit everyday. Next, I assigned follow-up assessments after every two objectives. These assessments started at the foundation and asked students a series of questions to see how well they had learned both old and new items. If students answered questions incorrectly during the assessment, even though they had completed the item in a past objective, then after the assessment was over, students were required to complete these items again before they could move on to the new material for the next objective. Because of this caveat, I tried to structure the in-class investigations so that students could either (a) initially investigate these concepts and successfully work through them or (b) if they had already solved these types of problems in ALEKS, they could have an opportunity to successfully transfer that knowledge to this new context. Eventually, all students completed the same ALEKS items and in-class investigations.

After the class studied probability, we moved on to the $z$-distribution. I purposefully made the data for one of the numerical variables in the Jack problem normally distributed with a mean close to 0 and a standard deviation close to 1. I had students investigate this variable by creating a histogram of the data, finding the mean
and standard deviation, and finding the probability that the variable would have a value between one standard deviation below the mean to one standard deviation above the mean. Through this investigation, students were introduced to the idea of the standard normal distribution ($z$) and the empirical rule. Students were then introduced to the types of questions they can use the $z$-distribution as a tool for answering real-world problems. I gave students $\frac{1}{2}$-sheets of paper with problems for them to solve with a partner. I floated around the room to answer their questions and I encouraged students who understood how to do the problems to explain it to others. It is important to note here that students learned how to complete the technical parts of these $z$-distribution problems using both Microsoft Excel and the ALEKS calculator as tools. This was difficult for the class since Excel and ALEKS took the same approach on some tasks and different approaches on others. I gave special attention to explain the similarities and differences between the two different tools in my class handouts and in my lectures.

When students had a fair amount of practice with $z$-scores, I moved on to the concept of the central limit theorem. Students investigated the central limit theorem using an online Java Applet that took samples from a population of a penny collection (http://www.rossmanchance.com/applets/SampleData/SampleData.html). The applet automatically found the mean date of the pennies in a random sample drawn from the population. It tracked the shape of the distribution of all of the sample means using a histogram, kept track of the standard deviations of all the means, and allowed students to vary the size of the samples they drew from the population. I followed this investigation with problems that were designed to help students see the difference between the previous $z$-score problems and problems that use the central limit theorem to find
probabilities that the sample mean will fall in a certain range. There is a subtle difference between these two types of problems, and students often struggle with seeing what differentiates the two.

After students practiced in class with both types of z-score problems (population and central limit theorem), I moved students into the realm of inferential statistics by studying confidence intervals. Confidence interval problems are more involved than any type of problem we had dealt with so far in the course. These problems asked students to go through a 5-step process to identify the parameter of interest, come up with the confidence interval itself, and to finally write a concluding sentence stating what the confidence interval was in the context of the problem. In my explanations of these problems in class, I worked to help students see the progression from z-scores in general, to the central limit theorem, to confidence intervals. My teaching strategy in this phase of the semester usually involved working through an example problem together as a class and then giving students a problem to work together in pairs while I floated around answering questions. I would often wrap up these class sessions by going over the problem students were working on and highlighting concepts I felt were important for them to understand.

After students were introduced to confidence intervals for the mean using the z-distribution, they took the midterm exam. We continued learning different confidence interval techniques for means and proportions after the midterm exam using the teaching strategy mentioned above. In class we could complete a confidence interval from start to finish, but ALEKS split the process into smaller chunks. This made the process look very different in the two settings, and students commented to me that they were doing
something completely different in class than they were doing on ALEKS. To this, I
*strongly* encouraged the students to work to make connections between ALEKS and our
class. I assured them that we were learning the exact same mathematics, and that their
learning would be strengthened if they would consult our class notes when completing
their ALEKS objectives. Students usually resisted this encouragement, but I persistently
offered it as a useful way to learn in the class.

Once students had learned how to do confidence intervals for the population mean
and population proportion, they were ready to learn how to do hypothesis testing for a
mean and proportion. ALEKS also taught how to do these hypothesis tests, and our
classroom continued on in a similar path as with confidence intervals. I stepped students
through how to complete the 5 steps of hypothesis testing, gave them problems to
complete in pairs, and then walked through the solutions to their problems, highlighting
how the mathematics builds on and is connected to the central limit theorem, the $z$-
distribution, and confidence intervals. I also encouraged students to work often in
ALEKS and to make connections between how we are doing the problems in class and
how ALEKS does hypothesis testing.

Now, we come to a significant change in the way I structured this course. Up to
this point, students had plugged numbers directly into the formulas in all of their
analyses. At this point, however, we began studying hypothesis tests for comparing: two
population means, two population proportions, more than two population means, two
categorical variables, and two numerical variables. All of these tests’ formulas are more
involved, and ALEKS required students to work with these more complicated formulas to
find the values of test statistics. I made the decision at this point to teach students how to
complete these tests by entering the raw data into Microsoft Excel and letting Excel do all of the number crunching. I showed students how to do these problems in class, and then gave them sheets full of practice problems for homework. This was a significant departure from the classroom flip model for structuring class, but I felt it was a necessary step. We would not have been able to learn all of the hypothesis tests students needed before the end of the semester if students had to learn how to complete all of the tests by hand using all of the formulas.

With all of the different hypothesis tests to choose from in any given problem, many students were overwhelmed and had difficulty choosing which hypothesis test to use when confronted with a problem. To help students, I made a flow chart (see Appendix G) that they could follow to determine which type of hypothesis test they should use in different scenarios. This flow chart was structured so that if students knew whether the main variables under investigation were categorical or numerical, then they could choose the correct hypothesis test. This chart was available for them to use for the rest of the semester as well as during the final exam.

Finally, after students had worked through all of the hypothesis tests mentioned above, I assigned a major project for them to complete during class and to continue to work on outside of class as homework. I asked students to return to the Jack problem we started the semester with and revise the advice they gave to Jack in light of all that we had learned this semester. Based on the inferential statistical methods they now knew, students should have been able to give sound advice to Jack regarding the population of all his customers based on the random sample of data they were given to work from. This assignment gave students the space to connect most of the things they had learned in
ALEKS and in-class investigations to a real life situation. Students were asked to apply mathematical methods to data and give real advice to a believable character in a way that explained the mathematical methods using non-technical terms.

I floated around the class during the last week of classes to answer students’ questions about the major project. Students were engaged in completing this project, as it was a large portion of their grade for the semester. After working for a week on this assignment, student handed it in and took their final exam. The final exam for the course focused on the information learned after midterm, but also included a few $z$-distribution probability problems and a few problems that asked students to identify of terms. Students were able to use Microsoft Excel to compute the technical aspects of the hypothesis tests, confidence intervals, and $z$-score problems.

*The Students’ Take*

In “The Students’ Take” sections of this report, I will let the students in the focus groups (conducted with three weeks left in the semester) explain their classroom experiences *in their own words*. An analysis of the qualitative data revealed that the focus group data in particular reflected many of the major themes found across the spectrum of all the data sources. The raw focus group data provides us with a window into the students’ thinking about the factors that shaped the learning environment of both classes. In this section, I present a piece of a focus group quote and then provide commentary on the quote regarding the themes students brought up. Within the focus group quotations, parenthetical statements are included to give context to student’s statements, words in *italics* indicate words that students emphasized, and the use of an ellipsis (…) indicates
moments where students paused in their speech and then continued or paused and were cut off.

The following set of exchanges took place in a focus group led by Brenita. Students freely signed up for the focus group (they had a choice between writing a reflection paper, doing a one-on-one interview, and participating in a focus group). It turned out that the members of this focus group all sat in the very front row of the class. The first row was the most responsive to my questioning in lectures throughout the semester, so having them all together in a focus group made for a lively exchange. The students included Jim, Charles, Bill, David, Jenny, and Amy (to protect students’ identities, all student names in this document are pseudonyms). Let me introduce them.

Jim’s Criminal Justice major requires that he take introduction to statistics. He often expressed his frustration with mathematics in general, and stated that he was not looking forward to taking this course for that reason. Charles, a business major, sat beside Jim and they often worked as partners on group work. Charles also expressed that the only reason he was in the class is because it was required by his major. Bill is a business major. He often put his energies into making those around him laugh at his jokes or funny things that were on his computer screen. Bill rarely engaged learning activities in the classroom and often let his partner, David, do all the work. David got excellent grades in all of his classes, and was a youth ministries and psychology double major. David showed the ability to comprehend material and was articulate enough to complete assignments fairly quickly. David and Bill were friends and sat beside each other, so they worked together on group work. When Bill clowned around in class, David often encouraged him with a sheepish laugh “heh, heh, heh.” Jenny was a chemistry major who
got top grades in all of her classes. She also was often able to successfully complete assignments quickly, and she complained if she felt like her time and energies were being wasted. Amy was a sociology major. Amy took longer to complete assignments than others in the class, but she was always very careful with the details of her work and took extra time to make sure everything was just the way she wanted it. She was determined to do what it takes to be successful and she liked to work with others in the learning process.

I will start at the beginning and present this group’s interchange about the class in general.

Brenita Let's pretend I'm a friend from high school who will be taking a class from Prof. Strayer next semester. What would you tell me to expect from his statistics class in general?

Amy A lot of work on ALEKS - Take a lot of time with it.
Brenita Okay

David As long as you pay attention and do the homework, it's pretty much a cake class I think.

Jenny I would agree with that. It's very much a cake class. It's very much an easy A.

Jim For math classes, like for me, I'm used to getting an example in class and like going over it, and then getting a homework assignment, and it's usually in a book. You know, and I don't want to bash the fact that we didn't have to buy a book, but...

Jenny Yeah, that was nice.

Amy Uh huh.

Jim Um, yeah, but I'm used to going over a certain number of problems, doing them in different ways, and then through that you gain an understanding. But, in here, it's like with ALEKS, you can figure out, and I've told Strayer this, you can figure out where to plug in numbers and not know how to do the problem.

Charles Yeah,

Jenny Oh yeah!

Jim Like if I don't understand part of ALEKS, say I've been there for like two and a half, three hours, I'll just write down basically what the sample problem is and then the formula that they use, and then I can see where they took these numbers from in the problem and put them in the formula. And then, I just do that for the rest of the problems. I don't actually learn why they do that, it's just after four hours, um … I'm ready to get out of there. So, you can get through ALEKS and then sit down with that exact problem you just did and have no idea how to do it. Because when you're spending hours on this, really, time management is a little more important than “getting it.” So...
Amy  I don't know. I totally disagree because if you know what formulas you're using, you would know where to plug everything in anyways. So, it's not really like way too time consuming, and it really helps you out for a test, if you pay attention to what formulas you are using.

Brenita  Pay attention to the formulas *while* you're doing ALEKS...

Amy  Yeah, you know...(Charles interrupts)

Charles  Another complaint about ALEKS too is - we learn how to do this thing on Monday, and we might not do ALEKS for another two weeks in that thing, and so it's like completely time... I mean two weeks is so long before you actually do something on ALEKS, and you ... they need to be somehow closer together.

Notice how three of the strongest students in the group jump right in from the start and say the class is a cake class, an easy A. Amy adds that it is very important to stay on top of ALEKS. The ALEKS discussion that follows illuminates the clear tension that exists in the class regarding ALEKS. Amy’s strong work ethic comes through clearly as she basically says, “Do what Prof. Strayer has suggested. Use your notes to know what formulas you’re using as you complete ALEKS, and you’ll learn.” At the same time, Jim and Charles’s frustrations with ALEKS surface, including a perceived time commitment that forces students to “give up” and circumvent the system. Viewed from an activity theory perspective, Jim’s comments are made with regard to the change of classroom rules and division of labor from what he is used to in a more conventional class. The change in the bottom portion of the activity theory triangle (community, rules, and division of labor (see Figure 2.5)) caused a disruption in the system maintenance and change dimensions of the learning environment (Moos, 1979) as Jim was experiencing it. It seems he was working the ALEKS system by just figuring out which numbers in the example went where in the formula without understanding how the underlying statistical concepts fit into the problem. Rather than working at the *action* level and orienting his action toward a goal, as conceptualized in activity theory’s hierarchy of activity (see
Figure 2.6), Jim was routinizing the task and orienting his attention so that when he sees “these” conditions (a specific problem type), he plugs “those” numbers into the formula in these blanks. Thus, Jim was working at the most basic activity level of operation from the start, making it very difficult for him to think about his learning activity in more sophisticated ways. This process of circumventing ALEKS is further explored in the next section. Notice how Amy represents students who know how to circumvent the system in this way, but refuse to do it so they can learn the material.

Amy Sometimes you can always write down the different problems...
David ’cause they will repeat...
Amy And then some of them will repeat the problems. So if you write them down you get the answer - you can always just go through and just fill in the answer the next time they give that question to you.
Jenny The other thing a lot of times in ALEKS, is the order in which the numbers appear in the little paragraph with the question doesn't change. So you can just memorize that the first number goes in here in the formula and the second number goes in here in the formula...
Jim Exactly, yeah.
Jenny And that’s what you mean by not learning. You can just kind of, you know, register that, “Okay, whatever the first number is, it’s gonna go right there.”
Charles I figured out how to print off ALEKS - the whole thing. And so I'd just, when I went to a problem, ’cause I had only done the first homework assignment until a week ago.
(Laughter)
Charles So I had a lot to do, and I did ALEKS for 10 hours one day. I would just go straight and hit explain - I would print it and then I would go and I would just fill in the numbers in the problem and I did like 30 some sections.

The striking thing about the above interchange is how ALEKS is viewed as a system that can be worked around. The discussion resembles a discussion of students sharing video game secrets. When students view ALEKS this way, they can successfully complete the assignments (win the game) without learning the statistical concepts necessary for the course. Here we also see the issue of time management raised. This issue and other system maintenance and change difficulties become a major theme for
students as they progress through the flip section of the course. Students also have issues with personal responsibility and motivation, as the following interchange clearly shows.

David  I don't know, it's just math. It just kind of feels the same to me, just a higher level. So like back in high school we had homework every day. Like the amount of time spent doing homework basically equals what I do in this class. And it's just instead of doing it on paper and having to write it all out, I just type in the computer. So I think it's kind of similar [to other math classes].

Jim  I think you're probably right, I think that the amount of time we put into ALEKS probably does equal what we're used to doing, it's just when I was used to doing it - it was more spaced out. You know, you had one homework assignment every night. But like me, I'm a notorious procrastinator. So I don't do it until it's due, so I end up having to spend 6 straight hours on it. Whereas you probably spent 6 hours, you know, in high school doing homework, it's just...

Brenita  It's just not in all one big block of time…

Charles  The problem for me, and probably for some people, is that it's a required class. I'm a business major, it's a required class, but I'm thinking it's not really a business class … it's more of a math class to me and it's kind of annoying that I even have to take it, personally.

Jenny  uh huh

Jim  uh huh

Charles  And so in all of my business classes, I'm doing really good, you know. And 'cause they're my business classes, that's what I need to know. And I'm really … I worry about those and I do what I need to do. But in this I'm like - I just need to get the grade.

Jim  yeah

Clearly, students here are struggling with the classic “When am I ever going to use this?” and “Why do I need to learn this?” questions. In an effort to address these questions from the start, I began the semester with an applied investigation specifically tied to the field of business (the Jack problem). Students discuss this investigation later in the focus group, but I will say here that the applied investigation did not seem to help much with student motivation. When new community rules and division of labor are introduced into the equation, students have a big adjustment to make. We get a clear picture of students’ motivation struggles in the next interchange.
David  Um, I think students should be expected to do what Strayer says. If he says don't mess around with the computer, then don't mess with it. I think we're expected to be awake and attentive and taking notes in his course... everything that I don't do.

(Laughter)

David  We should be expected to do it. And I try to do it sometimes because I feel guilty, but I don't know, I don't feel *that* guilty to do it all the time.

Brenita  Ok, what do some of the rest of you think should be expected of students inside the classroom?

Jenny  Well, I think like what he said. To a large extent it's just acting like an adult and putting value in your own education to be motivated to care and like do it. And the sad thing is that we're not. I mean we don't care. I think for most of us, I mean we're in stats because we have to be. I mean none of us are statistics majors, we don't even offer that. So we're all in here kinda like, “This is retarded; it has nothing to do with my major. Why am I here? But I'm required to take it.” And that's just kind of our attitude, and I think that might be the biggest downfall of the class is just... that's kind of what we all think.

Brenita  Not necessarily ALEKS per se, or the style of the professor ...

Jenny  No.

Brenita  But the attitude...

Jenny  It's just why we're here.

Charles  Yeah.

The sense that students feel a need to be “guilted” into completing assignments (and this from one of the top students in the class) reveals the deep-seatedness of the motivation problem. Students feel like they *should* put effort into the course, but cannot see much of a pay-off for their individual learning in applying themselves in this course.

The next section shows how some students project this apathy onto me as the professor.

Jenny  And that's one of the other things, like I think Strayer does a really good job of being our friend, but I don't think he did a very good job of ever getting our respect. I mean like he says turn off the computers and we go, "Aw, Come on Strayer, you don't really mean it." And he never, I mean he never yells at us. He never gets mad about it. He doesn't care.

(Laughter)

David  He yells at me all the time.

Amy  Yeah he does.

Jenny  Yeah, but he just jokes around about it, he's not mean, I mean he's not...

Amy  I don't know, he can be.

David  This one time I started sleeping in his class, and I sit in the front row, and my feet were sticking out the desk and he kicked me! (Laughter)
Brenita Did it wake you up?
David Yeah, it freaked me out. I was like dreaming.

Jenny here comments that she thinks I should get upset, yell, do something to perhaps guilt them into caring about the course. David seems to think I am already doing that with him by waking him up when he would rather be dreaming, but Jenny continues in the next interchange to express her feelings that it is the professor’s responsibility to somehow make students care about the subject and the course. These exchanges shed interesting light on the ways students struggle with adjusting their rules and division of labor expectations within the community activity theory framework when they encounter an unfamiliar learning environment.

Brenita Let me ask you this. A lot of you guys mentioned personal responsibility oriented things. You know this is what you should do. You actually accentuated those words. What would get you to that point, do you think? … In a class that you are required to take that doesn't necessarily grab you?

Jenny I think if the professor made it really interesting. And like if he could somehow make us care. And like somehow, apply, (some members of the group are laughing), I mean do you know what I mean? I mean if he could apply it to something where we could be like, “Wow this is cool.” Or make us feel like we're really smart because we know how to do this, and so we'd be like, “Wooo hooo! We learned it!” I don't know.

Jim Sometimes I feel bad because like he gets excited about it.

Jenny Yeah.

(Many laugh)

Jim He's like, “Stats is awesome, you guys are gonna love this!” And he goes through it and we're like, "I could care less."

Brenita Yeah, doesn't do it for me.

Jenny Yeah if he could like pass that to us somehow, magically, then we'd be way more motivated.

Brenita Do you have professors that are able to do that?

Amy Uh huh.

Jenny Uh huh

Brenita What do they do? What’s their magic?

David I don't think it's so much, like, the teacher, because like Strayer, he does … he's like pretty funny.

Bill He's tight.
David: And I mean he's not ... when he lectures, he's not like most people where they just stand there in their boring monotone voices. He's walking around the classroom, you know ... I think it's just people just don't care. So, it's not a matter of what could Strayer do to make it more exciting. I think it's just our persons, like we have no like dignity in our work. You know it's just kind of like, “Well, I'll do my homework in the last second and I won't do it because ... I don't care.” It's just like...

Amy: He did warn us before our ... like our very first class he did warn us that if we played on the computer, there had been people who had failed the class because of their lack of being able to be responsible with the computer.

Jenny: Uh huh.

Brenita: So it could be that you've learned an important personal lesson so to speak about what you would need to do for yourselves to motivate...

Charles: I don't know, I take my laptop to classes and type my notes. I think my problem is that we get all the PowerPoints. And I can't do that in a class. Personally, if you give me all of the PowerPoints, then I go, “Oh, I've got all the notes.”

Brenita: So you check out.

Charles: I start counting the ceiling tiles.

Let's trace the progression through the above exchange. It begins with Jenny saying the professor should make the students care, that I should help students get excited about learning statistics and “...be like ‘Woo! Hoo!’” Then, Jim mentions that I do get excited about learning statistics, but fail to pass that excitement on. Jenny suggests that perhaps I should revert to magic to make the students care. When Brenita asks students to describe the professors who possess this magic, David suggests that there is just really not much more that I (as the professor) could do to make it more exciting. At this point, Brenita seems to want to help students see more clearly the part that they play in motivating themselves to learn, but Charles interrupts with another reason why he cannot learn in the class (that the PowerPoints make it too hard to learn). While the above interchange appears to be a list of student excuses for why they are not applying themselves in the class, the interchange below takes an opposite / confounding / seemingly contradicting stance.
Brenita: What do you think you should be expected to do outside [of class]?
David: You should be reviewing notes that you took inside of class. You should, I don't know, be doing the work everyday - even if it's not homework. You should at least sit down and do a couple of problems. Even if it's just like 15 minutes. It adds like so much more to your test grade.
Charles: Maybe if he could give, not as required problems, but give some homework problems to us.
Amy: We wouldn't do them
Jenny: We wouldn't do them
Charles: On the night ... we wouldn't do them, but we may...
Jenny: We wouldn't do it, be honest.
David: But we would be expected to - we should.
Amy: You've got the ALEKS to do and people don't even do that.
Jenny: Yeah.
Charles: Maybe if ALEKS was just synchronized with the day you did it ... something. I don't know how you'd do it.
Jim: You know, I think it would help. I don't doubt at all that it would help if I did extra, but I'm going to do what's assigned and not more. And that's what most people think. I mean I have classes where I do more because I'm interested in it. But that's where it all comes back to I'm just not very interested in stats.
Bill: Maybe if he could like split up ALEKS instead of having a huge chunk due every two weeks. And then you know how you like procrastinate the last couple of days. Maybe what he teaches in class, you do that chunk, that little chunk of maybe like three.
Charles: That's what I was saying
Jenny: Yeah
Jim: Yeah
Bill: Then you do another chunk for the next time that relates to that.
Charles: And also with that, if you don't do for this day, don't make it for this day, you've got to do this day and this day, and then if you don't do it on these two days, you've got to do these two and that one.
Brenita: Of course, if you don't do it the whole semester, you've got to do it all at once.
(Laughter)
Charles: Exactly.
Amy: But all at the same time, if you pay attention to Strayer's lectures, then you know which...
David: Yeah.
Amy: ... exactly what formulas to use. And you know which numbers to plug in where because Strayer pretty much explains it.
Jenny: He does, but I would say the ALEKS part of the course and what Strayer does with us are completely independent. And every once in a while, they kinda cross paths, but not often in a very useful manner. So I mean it's almost like you're taking two stats classes one online and one with Strayer.
Amy: It kind of did coincide with his lessons, though, if you did keep up with it.
Charles: But you didn't did you?
Jim I knew about three people who did that.
Charles (to Amy) Did you do it the night before it was due?
Amy No.
Charles I did.
Amy I didn't.
Jenny But see the other thing was sometimes I could do the ALEKS sometimes ahead of time, and then he'd go to do an example in class and I'd be like, hey I already did this in ALEKS, I already understand it. I don't really want to listen to you right now at all.
(David and Jim - laugh)
Jenny So that was the other problem. If you did work ahead and you were just like…
Brenita Wow! It's a very complicated issue. … Really!

The above interchange and the one that preceded it appear to be from two different groups of students. First, students are suggesting that it is the professor’s responsibility to make them excited about learning, and then they suggest they should be expected to do extra work (beyond the assigned homework) outside of the classroom to help themselves learn. While it may be tempting to attribute interchanges like this to student immaturity, it is important to analytically push through and try to make sense of what is going on under the surface of these seemingly contradictory exchanges. Placing these students’ struggles to adapt inside the activity theory model of community, rules, and division of labor, we are able to see the complexity of the adjustment that sometimes appears (and perhaps is) contradictory.

Notice how students want to do work … just not the work that is assigned. This is a division of labor issue. Students also have a desire to link ALEKS with the class material, but many fail to work on their assignments regularly, perhaps indicating a problem with the rules aspect of the activity system. This failure blinds them from seeing that ALEKS assignments actually did coincide with the in-class material (Amy seems to be the only one in the focus group to get this). I attribute these complexities in student
actions and beliefs primarily to their failure to adjust sufficiently to the change in how students complete tasks (division of labor in activity theory, or task orientation in learning environments research) within the classroom structure. We see here how profoundly a significant change to the task orientation dimension of the learning environment (Moos, 1979) can disrupt student learning. Brenita’s comment at the end ("It's a very complicated issue. … Really!") indicates how complicated students had made class, which also gives evidence that the learning environment did not have strong system maintenance and change dimensions that helped students adjust to change in the classroom structure. As students attempt to adjust, Amy tries to be the voice of reason, and most of the others appear to be all muddled up. Students seem to be suggesting that a general feel of negativity has developed in the course, and we shall see next that many of them attribute that feel to the initial three-week Jack problem investigation.

Jim I think the first week of class was important. Like the way we started out with wasn't great.
Charles Are you talking about Jack's problem?
Jenny Yeah.
Charles It went too long. I mean when I was doing the Jack problem, for me some of the stuff we're doing now is more complex, but for the Jack problem it was like, "Huh, I got the average. I got ..." and then you do these simple things. And so then I'd start ... I'd be done and there would be other people in the class that are still not getting it. And we'd be playing on the computer and doing stuff.
Jim And then I realized, hey I can play on the computer.
Jenny Yeah. We learned that real quick.
Charles I think that was maybe part of the problem is ... I think that maybe Jack's problem is ... it's all Jack's fault.
Brenita It's all Jack's fault.
Amy It really set the pace. He started the class out so boring, and we didn't have to have any paper, we didn't have to bring anything to class, we didn't have to bring any notes - we were pretty much typing it on the computer. It wasn't hard stuff to understand so it was like, "Blowoff."
Charles It was like the first three weeks almost wasn't it?
Amy Yeah, it was way too long.
(Laughter)
Charles My, my one complaint about Jack's problem was (David laughs sheepishly) is that you get in class and he hands it to you and he goes, "OK" and that's basically all he says. He says, “Figure it out.”

Amy Yeah.

Jenny Yeah.

David The first day.

Jim Uh huh.

Jenny He was like “Do it. You have three weeks to do it.”

Jim Yeah he asks us some pretty in-depth question and he was like, all right let's see how you figure that out, and we're like ...

Amy Like, “What?!’” Yeah.

Charles And I agree with her. It's that it did get me in that mindset of (pshuh). And whenever he was like, “Turn off the computers,” and you were like, (really high pitched) “What?”

(Everyone laughs really hard)

Charles I think what Strayer should do, if he uses Jack again, is at the end of the course to relieve some tension over Jack, is to make a scarecrow and then let all of the people burn him.

(Laughter)

Amy This is Jack.

Charles Just to relieve some tension.

Here we see course dynamics playing off of one another. First, students establish that the Jack problem went on for too long. They felt the Jack problem was too simple (“Huh, I got the average.”), and resorted to play games on the computer to entertain themselves while the slower students finished the assignment. But while students felt Jack was too simple, they also felt it was too complex (or at least confusing) on some level. Students resisted being told to “figure it out,” and even said the problem was “pretty in-depth.” Even though, as the instructor, I repeatedly encouraged students to push through and engage the more subtle and challenging parts of the Jack problem, many students chose to address the surface questions, get stuck, and play games on the computers. Within this open ended (or ill-structured) problem, students are having difficulty working at the activity level in activity theory’s hierarchy of activity where students’ actions are oriented towards a motive or object (the Jack problem as a whole)
and carry out the complex task successfully in community. Rather, students seem to be working at the **operation** level when they see certain conditions, they understand they need to find the mean, and then they are stuck. This is a very mechanized way of thinking about the task at hand, and it prevented many students from successfully learning with the Jack problem.

Earlier, Jenny mentioned that I did not care about their “game playing” on the computer, and that this was a problem. In the above section, we see Charles getting frustrated when I asked everyone to log out of the computers so we could have a classroom discussion uninterrupted by computer game playing. These conflicts further strengthen the analysis that student learning was significantly impacted by difficulties in adapting to changes in the activity system and learning environment.

After the Jack problem, class was a pretty steady back and forth between smaller lectures and group work with practice problems. Toward the second half of the semester, I began doing longer problems on the board (confidence intervals and hypothesis tests) in a lecture format. Students were still given opportunities to do practice problems together, but the lectures were much longer than they were the first half of the semester. In the next exchange, students discuss what the class was like under these different formats.

Jenny It's just, I mean I like when we do the sample problems. He passes out the little handouts and you have to work through it. And the first time we did one of those, like that's the first time it starts to make a lot of sense. Because when you're just up there doing it on the board, or he's just clicking through his PowerPoint and all of the solutions are just magically on the slide, I mean do you guys learn from those? I know I don't. I don't really follow the math that's magically on the board. I mean if he hands me a couple of formulas and says anytime you have this problem, you use this formula, I can memorize that. But if he hands me a problem and lets us struggle through it, and have to try to come up with the formulas on our own, I think we remember them better.

Amy Apply what you learned
Jenny Yeah
Amy Uh huh
Brenita Say that again
Amy Apply what you've learned.
Brenita Okay
Amy It's pretty much, I mean if you do take, I take extensive notes. Just because, very
detailed notes, because it is ... it seems pretty slow, so you have to know what
you've done, and then I'll go back and look at them. And then if he does give
like the handouts, I'll be able to apply what I've learned.
Brenita Do you ever have opportunities to apply what you've learned?
Amy Uh huh
Brenita In what context?
Jenny He'll hand us little half-sheets with a question on it, and then we work with the
person beside us in partners to answer the questions.
Amy Yeah
Brenita How does that go usually?
Amy Usually pretty well.
Jim (laughs) Sometimes you get (clears throat)
Charles Distracted
Jim (clears throat) Yeah, or neither of you know what you're doing. (David
sheepishly laughs) And then it becomes you just sit there for like 20 minutes.
And then he'll go up to the board and then go over it.
Jenny Although, when he does that though, he walks around the class and if there's a
group that has gotten it and the group beside them hasn't, he'll be like well, you
explain it to them. And he'll keep walking around, and so eventually he tries to
get some one on one attention with every group.
Charles Jenny usually explains it to me and Jim.
(Laughter)

It is surprising to hear at first that Jenny wants to be given problems that she has
to “struggle through” and try to come up with formulas on her own after the sound
thrashing the group gave to the Jack problem. After all, this is what the Jack problem was
all about. A close look at the above segment, however, appears to reveal that students
were able to function in class better with shorter, more well-defined problems to
complete. Even though there were still the usual computer “distractions” when students
got stuck, they seemed better able to help each other and work through these smaller
problems. From the above exchange, it is evident that students did have a desire to apply
what they were learning; they just seemed to have greater difficulty applying their
learning within a larger project (Jack) where their specific activity in the task was more
ill-defined.

While students did seem to prefer smaller investigations over larger ones, they
sometimes made statements that appeared to contradict this stance. In the next exchange,
students are referring to a part of the course where I was presenting example and practice
problems that built on each other and were just slightly different from each other. The
purpose was to help students build a solid conceptual grounding for problems that would
come later.

Brenita And what compels you do decide to [play on the computer]?
Jenny I get bored.
  Bill It's boring
  David It's boring (laugh)
Jenny He likes to, he goes over the same example in class a lot sometimes, like you do
the exact same type of problem and by the like third or fourth time, you just
don't care.
Brenita And so you...
Jenny Kinda zone out. And you're like, okay I've already finished the problem and you
are still explaining the first step and so I'm gonna go find something interesting
[on the computer].
Charles Well, like one time I made a screensaver, and …
(Jim laughs through nose, Jenny squeals)
Charles I went online and found professor (laughs) Strayer's picture and it was those
maze, you know the maze old in windows, and you'd go around the maze and it
was just him.
(Brenita laughs)
  Jenny It was pretty impressive, actually.
Brenita (reluctant) OK.
(Giggles, Brenita laughs out loud, David sniggers)
  Jenny Yeah we have fun goofing off, but we'll like follow along with the class
examples 'cause sometimes he'll go in excel and put it up on the projector and
you know he'll be making graphs and showing us how to do calculations and
stuff. And we'll make our graphs and then we'll have competitions to see who
can make the most colorful and elaborate graph, and so...
Brenita I actually saw that, I remember it... some of your graphs were pretty cool
Jenny Yeah, so we'll do stuff like that to savor the boredom.
Here, students resist doing the smaller example problems and choose to either “zone out” or “goof off.” I attribute the zoning out not so much to classroom structure (of doing many small problems) as to the difficulty introductory students have seeing the deeper meaning in the subtleties of similar problem types. Students feel that the course is repetitive, yet they fail to grasp the nuances in course material. Interpreting this data through a hierarchy of activity lens, it seems the students are functioning at the operation level (when we see this type of problem, we do this) when the task requires thinking at the action level (requiring students to recognize the goal in the problem and act on the material accordingly). If students never move upward in their activity level, the resulting disconnect in the hierarchy of activity may contribute to students’ failure to see the subtle, yet important, differences in course concepts. Jenny’s choice of words, “savor the boredom” indicates the profound way that the “hierarchy of activity disconnect” can influence how students engage course material. In this way, “savor the boredom” could perhaps be a fitting title for this focus group’s memoirs of the course.

Group work comprised a major part of the flip section’s classroom structure. Often, this resulted in a looser class structure while I floated around the room to answer questions, and students worked together by asking questions and explaining answers to each other. Students needed to adjust their learning approaches in various ways to learn in such an environment, and some students adjusted better than others. The next exchange highlights these adaptations, and it ends with a few comments that may even appear to contradict the students’ desire to burn Jack in effigy.
Brenita So what do you have to do, then, to adapt in order to maximize your learning?
Amy Learn how to ask questions, learn how to keep his attention right on you. If you don't understand, he'll move on real quick from one subject to the next, and if you don't understand that one, you have to like move him back. Which means wording it just right - and keeping his attention on that part strictly right there. So you have to like learn how to adapt on his thinking to get him to help you out the way you think.

Brenita Those of you who are in the business of helping others during class, how does that affect your learning in the classroom?
Jenny You learn more.
Brenita You learn more by helping?
Jenny Uh huh.
Charles I think that with me and Jim we're about on the same level,
Jim However high or low that may be. (laughs)
Charles But the thing is, is that sometimes Jim gets things that I don't get and I get things that he doesn't get and so we kinda help each other. You know I'll be like, no this is the way you do it, and he'll be like, no this is the way you do that.
Jim And sometimes it's just the blind leading the blind.
Brenita It's the hand in the air.
Charles Or Jenny.
Jenny Yeah, I'll help
David You retain a lot more knowledge if you teach it to somebody.
Amy Uh huh
Jenny Yeah, a lot more
Brenita OK (drawn out and raised inflection in voice. Brenita seems to be saying, "Do you guys get it?")
Charles That could be a good tool within the class is to have after you do something, say this partner teach this partner right now and then 5 minutes later this partner kind of explain it. You know, I don't know. Because for a lot of people, I know that to teach it is a good tool.
Jenny That was the one good thing. I don't think it was the Jack, it was the follow-up to Jack. Where we had to explain like what we did. We had to write up an explanation of what we'd done. I think that was really helpful
Jim Oh right, our report.
Charles So if we did that maybe more often, then that would have been…
Jenny Yeah, you really have to understand what you're doing to explain what you did. Not just show the math or show the work or whatever.
Bill I thought Jack's problem, I mean like even though he didn't teach us, it kinda showed us what we'd be learning and how it would be useful, like if we had our own business, you know it showed us how like…
Brenita Are you a business major?
Bill Yeah, I thought I was like, that kinda got me interested a little, I mean a REAL little
Students are adapting to class in various ways. Some have learned to adjust the way they ask the instructor questions since they only have a few seconds of one-on-one question and answer time as I floated around the classroom. Other students realized that they must adapt the way they talk with each other in the classroom. Sometimes students give help; other times they get help from others, which presents unique challenges when it feels like it is the “blind leading the blind.” But still students see the value of explaining their answers and thinking to others. Surprisingly, Charles (one of the students most critical of the classroom environment), suggests that I provide time in class for students to explain their understanding of the material to each other. Jenny piggy-backs off of Charles’ statement to comment on a positive aspect of the Jack problem. Bill even begins to see the value of applying statistics to a business situation using the Jack problem. However, the positive feelings for Jack fade as students claim a real business owner would “just pay a statistician.” Most of the group’s positive statements about working in pairs are focused on the idea of explaining their thinking to each other in small chunks (five minutes). Perhaps if students had regularly explained their thinking to each other in small groups, the community aspect of the activity system would have taken different shape and given stronger support to student learning.

It is interesting that students picked up on just paying a statistician to do the work since the Jack problem was (inadvertently) written in this context, separating the business owner from the statistician. Perhaps the problem needed to be written so that a business
employee rather than an “independent consultant” was the one actually doing the mathematical analysis. I am not sure if this would have helped, though, as the analysis shows students struggled more with the loose structure of such a large problem rather than with the idea of Jack per se.

As already noted, the second half of the semester focused on solving longer problems that often took the majority of a class period to complete. Students explain their experiences with these longer problems in the next exchange.

Brenita  What would I expect to experience in class (Jenny laughs, Brenita laughs as she asks the question) … and there are no computer games?
David  Strayer would just talk ["talk" is drawn out slowly] … the whole time... and work on some math problem that doesn't make any sense to you at first. And he would just figure the whole thing out. And then he would tell us to do it. And I have no clue what's going on (Bill whisper laughs) because he just talks and he just writes stuff on the board, and I don't know what's going on so I just zone out.
Brenita  Let me ask you this…
Charles  That's pretty much what it feels like.
Bill  Yeah
Brenita  Um, what do you think would help you track better? Like stay engaged?
David  If I was actively participating in the class.
Jim  Yeah.
David  Instead of him doing the math problem by himself up front …
Jenny  Uh huh.
(Charles whisper laughs)
David  If he just went step by step and explained while we were doing it instead of explaining it and then telling us to do it.
Jenny  Um huh
Amy  Mmm (thoughtful)
Jim  Uh huh
David  If he just went step by step and explained while we were doing it as well, it would help me a lot more.
Jim  Like, I agree. Like using a problem as an example is a good teaching tool, but if he were to break it down a little more because these are really long problems
Jenny  Uh huh.
Jim  And there's a lot of stuff involved. Um, and so like ok this is the first step and we're going to do this and talk about that - and then be like "do you guys understand that? Are there any questions?" Um, because there are times when I get out of class and I'm ready to like walk up here [to Prof. Strayer’s office area]
and just be like, "Alright, now what we did in class, um let's try that again - like basically the whole hour - because I was lost."

Jenny Uh huh (a couple of people laugh). Yeah, I think some problems he could give us A and then B and then C instead of doing the whole problem at once.

Amy Uh huh (raised tone)

Jenny Because, yeah, I think sometimes it confuses people to try to do it all at once. Because if you get frustrated with A and you give up, then you never even get to even trying to understand B or C.

Charles I think that would help to … uh, get rid of some of the boredom.

(group bursts out laughing)

Here again, students resist sticking with larger/longer problems and pushing through to make sense of them and learn. They specifically articulate a desire for me to give them smaller examples and problems to work on. As the professor, I believed I was doing exactly that when I gave them the 5-step method for solving both confidence intervals and hypothesis testing. The difficulty here, again, I see as a failure for students to move beyond the mechanized operation activity level (when I see conditions A, B, or C, the I do this) and begin to work at the action and activity levels. Another caveat to this issue is that the ALEKS system separated the 5-step method into distinct problem types. Perhaps students’ desire for me to split the method into smaller problems stems from an underlying desire (even if not articulated specifically in this discussion) for class and ALEKS to look more similar.

In the final exchange I include from this focus group, students explain what they do when they have difficulty in the course.

David I just assume we're all confused.

(Laughter)

Brenita You're in good company with your confusion.

Charles Don't worry, he's probably the most right person in there.

Jenny Yeah that's true.

Bill I think pretty much everybody is confused.

Jenny I think we all are now.

Charles Sometimes you just go like (mocking) hmmm, oohhh,
Amy Yeah, right.
Jenny Uh huh (drawn out)
David I'll just look at him for a few seconds and then go back to my computer.
Jenny Yeah, I don't think anyone knows what's going on right now.
Charles Right now, yeah.
Brenita No shining star, just got it all figured out kind of person?
   All No.
David Well maybe the kid that sits behind Bill.
   Bill Well he's like a math wiz.
   Jim Well, most of the people I know in that class, they kinda do the same thing.
      They'll just kinda wing it until test time, and then they learn what they need to.
Brenita So how do you do that? How do you learn what you need to?
   Jenny Well...
   Charles He gives us the practice test.
      (laughter)
   Jenny I figure we get the practice test, and I'll just go talk to him.
   David If he doesn't make a practice test, I'm obviously not going to get an A because I have no idea what's going on. One thing about Strayer is that he is kind of like standoffish in the classroom, but if you like go down to his office and you are like, "Hey man I don't understand this at all." He's willing to sit there as long as you want.
   Jim That's true, yeah.
   Jenny Yeah.
David I missed class one day and on Monday I went up and I talked to him. And I said "I don't understand my ALEKS thing 'cause I missed class," and he sat there for like an hour after class time and he was just explaining it to me until I got it. So like if you... I don't know, some people might think "Since he's not very ... like helpful in the classroom, he's not gonna help me outside of it." But he really is willing to take a lot of time and effort into you outside of class.
   Jim Yeah, he's spent a lot of time like going over stuff with me. Math is like really hard for me. Um, like this class was tough. And so if I don't get something, it's really easy to just turn the computer on and forget about it. It's just like I'm not really getting this right now, I'll get it later. So it makes it a little easier.
Brenita Are you able to get it later.
   Jim (pause) (high pitched voice) Maybe (laugh).
   (everyone laughs)
   Jim It depends. Like if I come down and talk to him, yeah. But then if I don't then no, not, not so much.

The picture here is of a class that is lost (except for the unnamed math whiz).

Students are putting their success in the promise of a sample test they can study from for the final. Also, many students mention that they come for one-on-one help in my office
outside of class. Many more students from the flip section would come to my office with questions throughout the semester (mainly about ALEKS) than students from the traditional section. This gives evidence that the flip class structure as implemented in this study caused such difficulty for students, as they tried to engage in learning activity in the classroom, that they were forced to come and learn from the instructor in a completely different setting (one-on-one help).

What Happened in the Traditional Class

The Instructor’s Take

A fixed and predictable pattern for conducting class was established early on for the traditional section of introduction to statistics. Students would enter class and I often began with a couple of jokes or comments with students about happenings outside of class. From there I would take questions on homework from the night before and either pick the homework up to grade or give a quiz over the information in the homework. If there was no homework due, I would go straight into the lecture for the day.

Lectures usually began with explanations of terms followed by example problems. During the lectures I constantly asked for feedback from the students (either verbal or nonverbal) by asking, “Does this make sense?” or “Is this ringing a bell?” or “Is this an intuitive thing to do?” I worked to create an environment where students felt comfortable asking questions at any point for clarification. If students were getting weary during a lecture, I would work to get their attention back by making a joke or doing something I felt was entertaining, something to break the monotony of the material.

Class sessions ended with a homework assignment every two or three sessions. Homework was assigned out of our textbook and looked differently at different points in
the semester. Early on, our work focused on terms, different types of variables, and statistical measures (some familiar like mean and median, some not so familiar like standard deviation and inter-quartile range). These early homework assignments were longer than later ones. Students were required to practice these methods outside of class with little or no practice with the concepts in class. As the semester progressed, the problems became more involved and took more time to complete; therefore, the homework assignments had fewer problems, but still took about the same amount of time to complete.

The structure of the course did not change much throughout the semester even as the course material changed. The course began with a discussion of terms and other statistics-specific vocabulary. We then studied various descriptive statistical measures (both measures of central tendency and measures of variation). We studied how to display univariate and bivariate data, and we also studied the basics of probability. At this point (almost four weeks into the semester), the students took an exam over this material.

After the first exam, I introduced students to the standard normal distribution (z). I explained the special properties of the distribution, relating it to what we had studied previously (the mean, standard deviation, and shape of the distribution). I showed students how to use the chart in the back of the book to compute the technical aspects of these problems, and students used this chart on their homework and subsequent exams. After practicing z-distribution techniques in their homework, we moved on to study the central limit theorem. I used an online Java Applet tool (http://www.rossmanchance.com/applets/SampleData/SampleData.html) to demonstrate to students the basic concepts of the central limit theorem. Students watched as I
manipulated the applet and commented on the effects of varying the sample size and number of samples. In class, I explained the subtle but important differences between the z-distribution problems we had been doing and problems that require the central limit for a solution. Again, students completed homework from the book to practice these techniques and get a feel for completing problems with these subtle differences themselves.

Once students were successfully completing central limit problems, I moved on to inferential statistical techniques. Students were introduced to the 5 steps of confidence intervals during lectures, and they completed problems for homework that required them to predict the value of an unknown population mean using these methods. At this point, midterm had arrived, and this class and the flip section both took the exact same midterm exam.

After midterm, class continued in the lecture/homework pattern as we learned how to compute confidence intervals for a population proportion. The course then moved on to learn the 5-step process of completing a hypothesis test, and students completed hypothesis tests for one population mean and one population proportion. In class, I made an effort to show how the concepts of the z-distribution, the central limit theorem, and confidence intervals all built upon each other to bring us to the tool of hypothesis testing. At this point in the course, I felt students needed another assessment of their learning, and so students took another exam just over what we had learned since midterm. This was their 3rd exam in the course.

After the exam, I led the class through how to complete hypothesis tests involving two population means, two population proportions, more than two population means, two
categorical variables, and two numerical variables. Like the flip section, I showed the traditional class how to do the more complex hypothesis testing by entering the raw data into Microsoft Excel and letting Excel “crunch the numbers” rather than calculating the test statistics by hand using more complex formulas. Also, like the flip section, I provided the flow chart (see Appendix G) to students to help them decide which hypothesis test to use for a given scenario. When I taught these hypothesis testing methods, I continued to follow the same lecture / homework format that we had established for the course up to this point. We remained in our traditional classroom setting, and I demonstrated in class what to click on in Excel to complete these problems. I then assigned students problems from the book for these types of tests, and they went to a computer on their own and completed the problems (using Excel as a tool) as homework outside of class.

Towards the end of the semester, I also assigned a major project for the traditional class. I wanted to give this class a similar experience of working with data from a sample in a real life context and then using inferential statistical techniques to make conclusions about the larger population based on the sample data. Therefore, I asked students to pick three numerical and three categorical variables they wanted to study about our university’s students and I showed them how to take a random sample of telephone numbers from our student body. I required students to take a sample of students, ask them their questions, conduct a hypothesis test using the data, and write a report of the study including conclusions they drew about the population based on their sample data.

After students completed their major project write-ups, they took the final exam. I gave the traditional section of statistics and the flip section the exact same final exam.
Both sections were able to use the flow chart on the final exam, and I provided handouts with all formulas, charts, and tables needed to complete the problems.

*The Students’ Take*

The quotes below are taken from a focus group Brenita led with students from the traditional class. Students who participated in this group sat in the last two rows (out of 4) of the room during most class sessions. Students in this group possessed a mix of natural abilities and presented a good representation of the abilities of class as a whole. Their names are Bob, Carrie, Adam, Nancy, and Greg.

Bob was a chemistry major and showed an ability to understand material well by his correct answers to questions in class. He often joked around with me and other students, and was willing to answer questions during class. Because he had a good sense of humor, he made class more enjoyable for many. While Bob showed an ability to learn material, he often failed to hand in homework and received a grade that was most likely lower than his abilities could have earned. Carrie was a social work major. She liked to ask detailed questions and give full and clear answers in class. Carrie’s attention to detail and ability to score highly on exams marked her as one of the top students in the class. Adam was a mathematics education major. He performed at the top of most of his classes, was an honors student, and was also one of my advisees. Nancy was a business major who stated that she struggles with mathematics. She has taken another mathematics class with me, and she admitted that she was struggling more with statistics than she did the other class. Greg was also a business major and was a quiet student in class. His grades placed him in the middle of the pack, but he attended class regularly, and handed in all assignments. I begin this presentation with the group’s opening discussion of the
course. I will continue the practice of commenting on sections of focus group interchanges throughout this section.

Brenita  Let's say I'm a friend of yours from high school and I'll take Prof. Strayer's stats class next semester. What would you tell me to expect from the course in general?

Bob    Expect to wake up early.

Adam   Expect, I think he knew his stuff. And it was conveyed well - I always felt that way. I think it helped that he always talked about *Napoleon Dynamite* - this B movie.

Bob    Yes!

(Laughter)

Adam   I think that helped, like, loosen people up a little bit. I know it helped me. So, I'd say expect funny little things once in a while.

Bob    You always do have to kinda pay attention to his little wit and Seinfeld humor.

(Everyone laughs. Someone says "yeah.")

Adam   Yeah, that's a good call. That's nice mixed in.

Nancy  That makes it interesting.

(Group agrees, “Uh huh.”)

Brenita What else would you expect to experience during class time?

Carrie Fatigue.

Brenita Anything else?

Bob    Long pauses where nobody says *anything*.

(Big laughter from everyone)

Carrie He just sits there and stares at us. And I'm thinking, “*any* time...”

Bob    That *kills* me.

Brenita Tell me more about the long pause and the stare.

Bob    Well, I mean like it's obvious he's waiting for the answer, you know for someone to say the answer. And it's just the classic, "Nobody wants to be the one to say it." So usually it's like there are 3 people in the class that are just like, “Alright, let's get this thing moving. *Fine*, it's Standard Deviation.”

Brenita So you know the answer and just don't want to be the one to say?

Bob    Yeah - nobody wants to be that guy ... or girl?

Brenita What would it mean if you were that guy or girl?

Nancy  You'd be a geek.

Adam   *Oh!* He knows the answer! He's a loser. That's probably what the general thought is, I don't know.

Brenita Is there anything else you would expect to experience?

Carrie A very interesting sense of humor. He's very, just, I don't know - kind of off the wall stuff. I think he knows that stats isn't the funnest class in the world. So he just tries to make it a little more fun and stuff like that. But it's not the most interesting material I would say.

Nancy  (whispering) *Yeah.*
Here, students establish that waking up early for statistics class is definitely a negative and that the course does not contain the most interesting or “funnest” material in the world. There is also evidence of a real reluctance to enter into classroom discussions on specific statistics issues. This reluctance persists even though students seem to appreciate the use of humor in the classroom as an attempt to make up for the deficiencies in the subject matter (as they see it). Students appear to be suggesting that it took a good deal of adjustment for them to get used to how the community, rules, and division of labor part of the activity system (see Figure 2.5) was different in this class than in other classes. In the next interchange students continue to discuss the “loose” atmosphere in the classroom, and its effects on their learning.

Brenita  So, what do you expect from a professor in general inside the classroom?
Bob  Yeah, I think Strayer likes to keep a lot more looser atmosphere …
(Whole group says "yeah" "uh huh")
Bob  … than you would typically think of like a college classroom. He likes people to speak up, even if it's something funny.
Adam  Yeah.
Bob  He doesn't mind, you get a good laugh out of it and then you move on.
Adam  Uh huh.
Bob  But um, I don't know. I think in a lot of other classes, it's like I'm here to lecture you, and you take notes.
(group yeah)
Adam  Yeah, that's true. I don't know if it's expected, but it's nice when there's a little extra, to make jokes with the students or whatever, it just makes it more conducive to learning I think. And I really respect that because you don't feel like it's just a book that can talk. You know, he actually has a personality and cares about what he's doing and that's really important.
Brenita  Is it hard to adjust or adapt from a format where you're not expected to talk into a format where there is some expectation that you're going to be speaking?
Adam  I think it makes it a little easier because you just get loosened up and you feel like you can be yourself a little bit more. I mean if you say something stupid, you know he says stuff stupid too.
(Groups laughs someone says "there's no pressure")
Adam  Someone's gonna laugh, and it doesn't really matter and I like that about the class a lot.
Bob I definitely think it took a while to get used to. You know. Especially him a little bit just kind of like getting used to like, "Oh, yeah, he is joking."

(Laughter)

Brenita At first, you're not sure you should laugh because it might not be a joke?

Bob Yeah because there's definitely some professors you just, you know, they're funny but you don't laugh at them.

(BIG laughter)

Brenita How do you think the environment affects how you learn? You were talking about this informal environment that is more informal and laid back. How do you think that affects your ability to learn stats?

Bob I think it holds our attention a lot better.

Greg To see him mess up on the smart board or something like that.

(Laughter people say "yeah that's funny" "that's pretty funny")

Greg That's always entertaining.

Nancy I like it when he finds something new

(Laughter)

Bob Oh my gosh.

Nancy Yeah, he's like “Ooh, Oooo, I didn't know that.”

Bob Yeah he like plays with it.

(Laughter)

In the above segment, students comment that the loose atmosphere keeps their attention better than a “lecture and take notes” setting. It is curious, however, that even though they mention that the atmosphere makes it less threatening to speak up (“there’s no pressure”), students are still reluctant to do so based on their earlier comments that they would rather endure the “long pause and stare” than to “be that guy” who answers and would “be a geek.” Students appear to want to take the course in, and have their attention engaged, more than they want to participate in the course. While this may not be the desired outcome for the instructor of the course, at least the students are engaged on some level. Students in this focus group seem to appreciate the loose atmosphere and not see many detrimental effects to learning in such an environment. Adam even commented, “I really respect that because you don't feel like it's just a book that can talk.” This shows a marked difference between this group and the flip classroom who
were more critical of the loose atmosphere and the lack of respect (for themselves and the professor) it engendered. Students explore the potential negatives of the “loose atmosphere” effect on the learning environment for the whole class in the next segment.

Brenita: You seem pretty positive about the class overall. I mean it's a lot of really positive things about Professor Strayer, about the class, about the experience with statistics. Do you think you represent the class? I mean do you think that everybody is feeling pretty good about the class? No closet dissenters? No closet anti-Strayers?

Nancy: No, I think we all mostly feel the same way. Unless you're like ... ok obviously I have admitted I'm struggling. But like, I don't know, even if you're like really really struggling, I don't think you're gonna have a negative outlook on it too much. Because I mean obviously if you're struggling that much, like I've admitted, it's part of your own personal time and how you do things. So I think we're all pretty much. I mean everyone laughs at Strayer, and everybody enjoys him in both of the classes I've had with him. Because in the other class, he killed me.

Brenita: With humor?

Nancy: Yeah like, it was so funny. Like one day he was like, have you guys seen "cheaper by the dozen?" and we were like, "whoa, random." Like, he's very random. But it's fun and like people are just happy to be in a class like that where you're not pressured.

Carrie: Uh huh.

It is telling that Nancy is the first to speak up when Brenita asks if there are people who do not feel good about the course since, as Nancy reveals here, she struggled with this course. If anyone had reason to dislike the particularities of the learning environment it would be Nancy. She had taken a course with me in the past, and felt the loose atmosphere was comparable between the two courses. She did well in the first course, but struggled in this one. The next segment explores possible reasons for student struggles in the statistics course when Brenita asks what to expect from the course.

Nancy: I'd say be prepared to study. Obviously that's going to happen in any class that you do have, but like for some reason, I'm having the most difficult time in this class.

Brenita: What are the most difficult things?
Nancy  Like this is what I don't get - it's like he hands it to us. We had a test today, like he has the formulas and everything we need there, but for some reason I just don't pick the right numbers to go in the right spots. So like, it's just a matter of me sitting down and memorizing which number goes in the right spot. And for the SI stuff [tutoring sessions] too, like I would go but it's when I work. So like I can't go, and so it's hard for me to like I don't know figure it out I guess. Like, I was talking to one of my friends who are in the class and he was like, “Nancy, it's handed to you."

Brenita  Do you have any ideas about what would help you?
Nancy  Probably putting more effort into it in all honesty. But like, I'm just so busy trying to get everything done. Like prioritizing would be a good recommendation for me.

Brenita  So more of a personal thing versus what Prof Strayer could do differently?
Nancy  Sometimes I don't understand like when he's teaching something and he'll go, "Okay, is that right? Like, did I do this right?" and I'm like, "Shouldn't you know? Like, you're teaching us." And like, I know he's just saying it to get our attention and be like, "Well can you ... did I do something wrong to like make you think about it." But like, it's just funny, and so I mean he does things to make you pay attention and make you understand, but I'm just like . . . maybe it's because it's 8:00 in the morning. I'm just not focused. But that's my advice.

Brenita  Most of you guys feel like the pace is good and that you're doing well in the class? Do you feel like there are people who are really struggling?
Adam  I can think of one person who might, but... it's my study buddy. But he has put in extra time, even outside of like when we study. And I know how bad he wants to pass this class because he's failed it before. But, um so I don't think, unless you just don't show up for class, ...
Greg  At all (to Bob).

(Laughter)
Greg  I'm sorry.
Bob  Oh, I don't care - it's all right.
Adam  I mean you'd probably have to fall off the face of the earth to really ...
Bob  Yeah.
Brenita  What do you think has been your study buddy's biggest barrier to success?
Adam  Just not sticking to it. He just sometimes gets sidetracked. I think it's sometimes easy to get sidetracked, like oh I want to go do something else. I think that's what his problem is. But when he sits down, he's a really smart guy and um, so I think it's just finding the time and making the time to actually sit down and review your stuff.

Brenita  Cool.
Bob  I think it's just like sometimes because it just doesn't take a whole lot of time to do it. I know I like put it off until the very end of the night, and then my brain is already fried from my other class that I have that day and I'm like, you know what it's midnight, and he probably won't collect it anyway, I'll just skip the homework, so you know I mean...
Greg  And just skip class...
Bob Yeah. Oh yeah. Oh I'm like you know if I don't have the... The next morning I'm like, "I don't have the homework anyway."

(Laughter)

Bob You know, but I think a lot of times since it doesn't take much time to do it, I know a lot of times I kind of put it on the like the last priority. I'm not saying he should make it longer...

Nancy’s explanation for her learning struggles mainly involves taking personal responsibility for not putting enough effort into the course. She appears to believe that I am doing enough as the instructor of the course to teach the content and that she needs to put “more effort into it in all honesty.” There is some joking between Greg and Bob because Bob had earlier mentioned that he does not come to class as much as he should, and Adam believes that his study buddy is struggling in the course because he is “just not sticking to it.” All of these pieces of data show that the students in this focus group primarily locate their success in their own personal effort. Evidence for this is found in Nancy’s not ultimately blaming her struggles in the course on her frustration with my questioning techniques. The questioning techniques Nancy mentions were aimed at trying to engage students in the process (asking, “Is that right?”), and her frustration shows again the reluctance for some of the students to want to actively participate during class time (preferring me to engage their attention rather than their participation). When we consider the student likes and dislikes of the learning environment as a whole, it is still clear that students in this section of statistics felt they had ample opportunity to learn the course content (see the next focus group segment).

When taking a theoretical look at this segment, it is possible to interpret Nancy’s difficulties with the course material as a failure to move between levels in the hierarchy of activity (see Figure 2.6). Nancy appears to be working only at the operation level of
activity theory’s hierarchy of activity. Her strategy to memorize a routinized process oriented towards certain conditions in the task (when I see this kind of number, I need to memorize where to plug it in to the formula, etc.) hinders her ability to function at higher levels of activity that may help her understand the goal of a given task and act on concepts within the task to reach a successful outcome.

When Brenita asked about the pace of the course and how they learned statistics, students responded as follows.

Bob I think it's all pretty straightforward if you kind of pay attention during the lecture and take some notes. And the biggest thing for me was just getting the vocab down at the very beginning (yeahs from the girls) and then after that everything wasn't that bad.

Carrie I think it's very repetitive and you're doing the same steps and everything so that was really helpful - it's just that there are little things that are different. I mean so I thought that that was really easy because of ... just the order that we did things in and stuff like that. We weren't just jumping into something. Like we did it before and we pretty much just followed the same steps as before just in a little different way.

Bob I think it's not really like the class is moving slowly because each day it actually is like a different way of looking at a problem or something like that, but since we use a lot of the same ways to solve it, it kinda just seems like we're doing a lot of the same things over and over again.

(Unidentified girl grunts approval "huh" or “humm")

Bob So I think that's kind of why it seems slow but maybe it's not really. Because if he tried to go faster than that he'd probably end up losing us all.

(All girls say "yeah")

Carrie And like I think the reason it goes so slow is cause like he'll sometimes give like two different examples for the same type of problem [and], except for like he said, since you're doing it in such a familiar way, it seems slow. Like examples are really good for a lot of people. Like that's how I learn. You just give me a bunch of numbers and stuff and like I won't understand, but if you give me a problem that's like a problem that's going to be on the test, it's easier to learn that way and you're familiar with it when you see it again so I just think it's good.

Bob I think in this class it's a lot easier to see where the material overlaps each other. Like you can see that it's so clear that you need to know z-scores because we've been doing that all semester long...

Carrie Yeah.
Bob … but in Calculus or something like that, yeah you do derivatives, but then you leave it a little bit and them pick it up every now and again like once a chapter or something like that. So it's really easy to see how you like build on something. You never really let go.

Brenita And that's something that's different from other math classes?

Bob Yeah, because a lot of times you pick a little topic for this chapter and then you set it down and start something new.

Carrie I think it's very different than any other math class just because it's not like in my mind a lot of math. It's analyzing information and word problems and stuff.

Nancy Yeah.

Carrie I mean you're doing basic algebra with plugging numbers into a formula, but that's, like, it. I mean the actual math part of that, I don't know what the definition of math is, but … working with numbers, you don't work with numbers as much. I don't think, there's a lot more word stuff you have to kind of analyze.

Adam More interpretive

Carrie Uh huh

Brenita Oh.

Bob Logic based

Carrie Yeah.

Brenita Very cool.

Nancy Yeah, that could be my problem...

(Everyone laughs)

Nancy I'm NOT a logical thinker sometimes.

From the above interchange, we see that students were able to distinguish between the subtle conceptual differences in course content enough to appreciate why the course felt as if it were moving slowly at times. Students also understood course material enough to meaningfully compare and contrast it with other mathematics courses. They were able to see how the material was structured to build piece by piece on previous content as well as see that the course required skill in interpreting applied problems rather than just plugging numbers into formulas to get an answer. These data give evidence that students here were able to move to higher activity levels (action and activity) where their learning activity was oriented toward broader goals. Students were able to see the motives behind their activity and had the patience to persevere and successfully complete
tasks to reach desired outcomes. While these findings point to successful learning on the students' part, the traditional classroom was by no means perfect. Students struggled to pay attention at times in the course and they were frustrated by how the course was run at different points, as the next interchange shows.

Brenita  But, how do you usually act in class, and does that really reflect what's happening?
Carrie  I think it depends on what day it is. If I have a test the next period, that's the day I have my flashcards in there and I'm half paying attention and half looking at my flashcards for the next test. But, I would say depending on what we're doing in class, like some days I'll take notes and some days I won't. Like, if it's something I feel like we're reviewing, like we're doing a problem like we did last week, I won't take notes. I'll just sit there and kind of stare at him. But usually, I'll just write on the side of the notes he provides for us anyways - just little comments and stuff.
Bob  Yeah there's a lot of review and it seems kind of redundant just because it's still z-scores and t-scores and all that good stuff and there's only so many times you can do it and still fake being interested (group laughs). But, I mean usually I'm one of the people that tries to talk and keep the class moving or something, but um I don't know, I just kind of take notes with what I think is important.
Brenita  What would the homework be like?
Carrie  Annoying when you do it and he never collects it… (laughs)
Brenita  What's the rule on that?
Carrie  It's just random - I mean sometimes he collects it and sometimes he doesn't. But like I don't know like when we were doing Excel, for me it was frustrating because I don't have Excel on my computer so I'd have to go all the way down to the labs or something to use the computer and it's not like the work would take a lot of time, it was just hard to get access and stuff. And then I'd work so hard and he wouldn't collect it. I was just like, … I don't know.
Bob  Yeah, short and few and far between. (“yeah” and “uh huh” from Adam and Carrie)
Brenita  So not very much homework?
(everyone answers at once)
Adam  In the beginning there was…
Bob  In the beginning there was a lot.
Nancy  It's only like sporadic problems once we got more toward... It's like do chapter 12 section 4, but do problem 83 part a. So it's like one part of one problem. Which I mean granted we don't know the second part because it was the classical approach. I almost wonder if that's like the problem with me too because like when I was in his other math class, he had homework for us everyday and he collected it every day. Therefore I did it, I understood it, and then I
handed it in. And like with this it's like you do it and then once you find out he's not going to collect it you can run that risk of like well I don't have to do it because he might not collect it.

(everyone laughs)

Nancy  So like if you're like, “I have a paper to do,” well - there goes stats. So that's probably most of my problem is ‘cause like you can almost pick and choose what days he's going to collect it.

Brenita  So you have a system down? (laugh)

Nancy  Not completely - it's just like, I don't know, it's just a matter of a feeling I guess you could say.

Carrie  I think in the beginning the way he was doing it, like either you handed in your homework or you had a quiz - like that was really good because even if you figured we were having a quiz you still needed to know the material so chances are you did you homework. And I think so then you knew it for the test. Because I mean you're getting stuck either way.

Brenita  So, when did this change? When did the whole cycle change?

(chatter laughter - "I don't know.")

Bob  Probably midterm break.

Nancy  Yeah, right around midterm.

Brenita  What do you think about that?

(chatter and laughter "I didn't care" "I like it")

Bob  Yeah a lot of my other classes hit me hard, so it was kind of nice.

Adam  Yeah, same with me.

Carrie  Uh huh.

Brenita  Do you feel that that affected your grade in any way by not having homework?

(chatter - "No" laugh. "No." "No I don't."

Bob  He went over it enough in class, that we could still make it.

Carrie  Examples...

Bob  Yeah.

Students definitely did not view this as the perfect course. Their comments above show their frustration with system maintenance and change aspects of their environment, particularly the need to have orderly and clear expectations. Students reveal their prioritizing of their in-class attention (if they have a test in another course, sometimes they will study during statistics class), and their out of class activities (doing a paper in another course rather than doing statistics homework). It appears as though students preferred a more structured homework environment, but they are not extremely upset by the way homework was ultimately handled.
Theme Analysis of the Two Learning Environment Cultures

The above sections presented particularly rich data and commented on surface patterns present. This was done to give the reader a rich description and general feel for what was happening in each of the classrooms. The next two sections trace the deeper qualitative analysis that was conducted using grounded theory methods. This section develops a theme analysis from the data to provide insight into the first guiding question of the investigation: How does the learning environment of a classroom flip classroom compare to the learning environment of a lecture-homework classroom?

The overall qualitative analysis began with an initial open coding of the body of data. This coding included 115 codes such as student interactivity, learner engagement, task completion, confusion, humor, relaxed, and shift-in-thinking. For a full list of codes see Appendix H. Through the process of memo writing and constantly revisiting the original data and original codes (often recoding data under new codes), I was able to determine the following major categories in the data: classroom relations, logistics of class, theoretical influences on learning, practical influences on learning, personal/emotional influences, and classroom peculiarities. Next, I revisited the data and, reflecting on possible linkages between codes, I observed properties for each category and built dimensional ranges for each property. For example, two of the properties of the logistics of class category were atmosphere (which ranged from structured to loose) and innovativeness (which ranged from same old to new). After a number of properties and dimensional ranges for each property were identified, I returned to the data to check the fit of these properties with the data. I went through this process multiple times and as the
analysis progressed, I felt I was swimming in the data. There was just so much going on and so many directions the analysis could go.

I allowed the first guiding question of this investigation to focus a theme analysis of the data on the cultures of the two environments under study. When I investigated the interconnectedness of categories’ properties and dimensional ranges in the data in light of the culture of the classroom, three areas (types of activity, homework dynamics, and in-class dynamics) emerged as major contributors that shaped how students interacted with the material, the professor, and each other in the classroom.

*Types of Activity*

The flip classroom completed a number of different types of learning activities throughout the semester. The course began with a three-week Jack investigation that was quite open ended. After this, students revisited the Jack data to complete smaller investigations that lasted from half a class period to two class periods. Students also completed other smaller investigations from data examples at various times. Finally, students completed longer problems toward the end of the semester to practice inferential statistical techniques. Peppered throughout the semester in the midst of these activities, I would offer explanations, examples, and lectures during class.

All of this varied activity influenced the culture of the classroom so that students never really settled into a pattern for “how to do class.” At times, students clearly did not know what to expect or where class was going. In one interview a student expressed this by saying, “He tries to explain stuff well, but he doesn’t explain stuff from the beginning.” Jenny, from the focus group, expressed her dislike for math that “magically appears on the screen,” and the rest of the focus group clearly stated that most students
felt lost and did not know what was happening in class. All of these statements are examples of the confusion caused partly by such varied activity in the classroom.

In another individual interview, a very bright student (Laura) said class moves really fast because “there’s always something to do … there’s always something to do.” Laura spoke in her interview of being uneasy with different class activities and being troubled about “taking a stab in the dark” at different problems. In an interesting turn of phrase that illustrates the difficulties of adjusting to varied activity, Laura said “I’d rather him pick a problem we were actually working on at home, either in class or exam type problems. I would get lost when he would make up a scenario and keep going because a lot of it just came out of his head.” The problems that “came out of my head” were problems in which I would include students in a hypothesis test problem by collecting data from them as part of the problem. For example, if I wanted to do a hypothesis test that compared two means, I could test the hypothesis test that women have a differing number of pairs of shoes than men and collect data from students in class to see if this hypothesis is supported. When I did investigations like this in class, I would have the problem written out in an excel file and ask the students to copy it down. Then I would ask students to enter the data into the computer as we collected it so we could go through the analysis together. Laura reacted to activity that “just came out of his head” because it felt arbitrary; she preferred to have a problem written out exactly the way it would be on homework or the exam. Laura represents those students in the class who found it difficult to learn from and see the value in the many different types of in-class activities in which the class engaged.
With the traditional class, we see a strikingly different activity pattern in class. There was a set blueprint for class activity, and we rarely deviated from it. Speaking of both me and the course in an individual interview, Mark (a mathematics major) said, “You always know what to expect from him. There is structure in the class. He'll tell a story to get people's attention then take notes from PowerPoint, then 1 or 2 examples from what we learned, then we've pretty much used up the class period.” Another student (Jacob) gives a nice contrast to Laura’s statements above when he said in an individual interview, “Sometimes he'll just make up a problem that we'll do. We'll go through the PowerPoint. He's good at making sure we don't rush through everything. He's good at making sure you pick up on the key points.” Jacob clearly does not seem to have a problem with problems I “make up.”

These key quotes capture nuances in the differences between the two different classes’ learning activity types and how these differences influenced the overall culture of the classroom. For the traditional classroom, having a set pattern to class activity made it possible for students to better tolerate slight changes in the way class was run. However, for the flip classroom, students seemed to always be on edge, never feeling completely comfortable with how to engage the material or the class time.

Homework Dynamics

Although the flip classroom completed homework using ALEKS and the traditional class completed homework out of a book, there were certain similarities in the homework dynamics between the two classes. Students in both classes clearly expressed that it was difficult to stay with the homework and complete what was assigned. For the flip classroom, the homework was due every two to three weeks, so it was easy to put off
and try to complete all at once. Many students felt guilty about this since I encouraged them to work regularly on ALEKS, but this guilt was not a successful motivator. For the second group, students in the traditional class were never sure if I would collect the homework or not on any given day. They felt the homework was easy, and many of them put it off until the last minute. These students were frequently willing to not complete the homework and just hope that I would not collect it that day. Clearly, for both classes, completing homework was not a top priority for everyone.

Though there were similarities, there was a significant qualitative difference in the homework dynamics between the two classes. To get the most out of the homework in the flip class, students needed to not only complete the ALEKS assignments, but they also needed to connect the concepts from our in-class activity to the assignments in ALEKS. Sometimes ALEKS explained concepts and procedures slightly differently than we did in class, so it took a considerable amount of discipline and effort for students make the connection between the two. In an environment where students struggled to just complete the ALEKS assignments, it was unlikely that many students would be able to consciously make the in-class connections with ALEKS.

Students in the traditional class, on the other hand, did not experience this complication. When the students from the traditional class completed their assigned homework, it looked very similar to what we did in class. If some students did not complete their homework, they would still get to see some of the assignment completed if a student asked a question over it at the beginning of the class when it was due.

When the traditional classroom students received sample exams to study from, all of the problems looked similar to what they had seen in class and what they had practiced
in homework. Due to the online nature of ALEKS, it was inevitable that the exams and assignments we did in the flip classroom would look and feel different from ALEKS work. In theory, this could be a benefit. Students in the flip section would see concepts in many different contexts: from diverse in-class activities to varied online assignments in ALEKS. In this environment, students have the opportunity to transfer their knowledge between contexts and thus strengthen their understanding. However, the way the class played out, the environment was just not focused enough for students to successfully pull this type of learning off in practice.

**In-Class Dynamics**

The dynamics of the in-class interaction between persons and the material for both classes were quite complex. I worked to make the general atmosphere of the class times pretty loose. I wanted students to feel free to speak up when they had questions or comments, and I wanted them to feel engaged by the material and the professor, as well as to engage the material *in class* as much as possible. We have already painted a pretty full picture of the loose atmosphere in the instructor’s and students’ take sections above.

One point to note about the loose atmosphere is that students in the flip classroom commented mainly on the negative things that the loose atmosphere brought to the classroom, and students in the traditional classroom talked mainly about the positive things the loose atmosphere brought to the class. Students in the flip classroom said that I was good at being a friend to them, but bad at gaining respect and being a professor. These students wanted to be told to get in line and shape up so they would have “dignity” in their work; they wanted someone to “make them care.” Students in the traditional classroom, however, said that they appreciated a professor who was more than a “book
that can talk.” They liked feeling that the person up front had a personality and cared. Needless to say, this dynamic created a tangible difference in the culture of the two classrooms.

By the end of the semester, students in the flip class were more willing to work together and engage activity in the classroom on some level than the students in the traditional classroom. The students in the flip classroom exhibited a desire to want to explain concepts to other students, feeling as though this is the best way to learn something thoroughly. Students in the traditional classroom, however were not as willing to engage in the class activities. They appreciated the humor and loose atmosphere, but when it came down to participating in class, there were often long moments of silence after I asked questions. They tended to want their attention engaged, but they did not want their participation solicited during class.

Although students in the flip class were more willing to participate in class, they definitely had a love/hate relationship with activity in the classroom. These students stated that the Jack problem at the beginning sent the message that this course was a “blow off” course, and as the course got more and more difficult, students struggled to stay engaged. The learning activities were of many different types, and students were asked to do many different things as the semester progressed. Many of them found it very difficult to successfully navigate these in-class expectations. Students were not clear what was expected of them, and eventually they were convinced that most of the students in the class were “lost” by the end.

As I have already stated, I believe the feeling of “being lost” in the flip classroom is partially explained by the varied activities in the class. In this atmosphere, students
were more likely to disengage the material sooner than students in the traditional classroom. Evidence for this dynamic in the class is given by the way students in the flip classroom failed to see the subtleties between similar problem types. When confronted with the activities meant to lift out these subtleties in the material, students in the flip classroom tended to “savor the boredom” rather than engage the material. Students in the traditional class, however, were more able to distinguish the subtle differences between similar problem types, as evidenced in the focus group data.

A Study of Activity in the Two Learning Environments

In this section, I will show the development of the qualitative analysis of how learning activity functioned in the learning environments under study. I homed in on the second guiding question of this investigation: How does the activity in a classroom flip classroom compare with that of a lecture-homework classroom, and what is the influence on learning? In light of the theme analysis that was already conducted, I looked for a core category or controlling metaphor that would allow the data to speak to this second research question. The results of this search and analysis are as follows.

As I focused on the leaning activity in both classrooms, the data spoke loud and clear that students tended to resist active learning in the classroom more than they embraced it and entered freely into it. I searched for a way to delve into this phenomenon of resistance and analyze what was happening. I first thought the metaphor of “learning activity as household chores” would be a good lens through which to develop the analysis. When I revisited the data however, the metaphor felt artificial and it fell apart. I would have had to distort the data to make it work, so I dumped it.
Earlier, I had found that the paradigm model of axial coding was a productive way to investigate process in the data, and this model helped me find a way forward. Looking at different processes helped illuminate what was happening in the classrooms regarding resistance to and participation in learning activity. As the paradigm model outlines, I studied the causal conditions, context, intervening conditions, strategies for action and interaction, and consequences of various phenomena in the study (like resistance to learning activity). I identified categories (each with properties and dimensional ranges) that make up each part of the model and then looked for connections between categories and concepts.

For instance, when looking at the “participation in activity” process, the main phenomenon of “participation” had a property of “level” that ranged from “superficial” to “thoughtful.” The intervening conditions (which describe the context that influenced participation) included many categories. One key category under intervening conditions was “student desire to work in class.” This category had a property of “importance” that ranged from “just show me how to do it” to “working helps me learn.” As I studied this process, by constantly going back and forth between the model and the data, I continued to identify other categories with their properties and dimensional ranges. Going through this exercise helped to explain the process of participation. I also did a similar process analysis for the process of resistance to learning activity.

While investigating these processes, I became aware of my desire to find direct relationships between the categories’ properties and dimensional ranges. For instance, perhaps I could conclude that if a student exhibited a “just show me how to do it” mindset toward learning activity in class, then maybe their participation level would tend to be
at the “superficial” side of the dimensional range rather than the “thoughtful” side.

However, when I returned to the data I found things were not so clear cut. There appeared to be no \textit{direct} link between where a student was on the dimensional ranges of properties among the key categories. This caused me to again rethink the structure of the analysis to develop a more dynamic account of what was happening in the data. The next section explains what I found.

\textit{Comfortability and Learning Activity}

Students in both learning environments in this study showed various levels of comfortableness with learning activity in the classroom. I characterize this \textit{comfortability} using the three properties of \textit{structure}, \textit{approach}, and \textit{mind-set}. When engaging in learning activity, some students preferred that the \textit{structure of the activity} be step by step, while others were okay with a more open-ended activity. The nature of some students’ \textit{approach to the activity} was “I want you to show me,” while others had an “I want to struggle through and ask questions when I get stuck” approach. Finally, students’ \textit{mind-set toward learning activity} varied from some who just wanted to do what was necessary to get the activity done to others who wanted to understand the purpose behind the activity.

\textit{Structure}. For our two classrooms under study, the structure of the learning activities looked very different. In the flip classroom the Jack problem was open-ended, but some of the smaller problems we worked specifically stepped students through what to do (i.e., sampling distributions). Other activities we did on probability were somewhere between “step by step” and “open ended.” The structure of the activities in the flip classroom was quite varied in this respect. In the traditional classroom, students
were asked to participate in classroom activity by listening to lectures, taking notes, and responding to my questions along the way. The questions I asked sometimes required a response to move forward (e.g., if I asked them to tell me what the mean was for a data set), and other times the questions were meant to check student understanding (if I asked “Does this make sense?” or “Is this right?” or “Did I make a mistake here?”). Loosely, the activity these types of questions engendered also ranged from step by step to more open ended activity.

**Approach.** In both classrooms, some students approached an activity wanting me to tell them exactly what to do, while others wanted to struggle through the activity and ask questions when they got stuck. This was most visible in the flip classroom since working on assignments was a regular part of classroom activity. Here, students’ approach to the activity often manifested itself when students just wanted to know where to put the numbers in the formula and nothing more. This happened on the ALEKS homework (as already discussed) but it also occurred during in-class examples and assignments. One student commented that the professor “explains the why but not the how,” and that he does not explain “from the beginning.” These comments exemplify students who wanted to be specifically told what to do in learning activity.

Even though it was more subtle, students in the traditional classroom, also exhibited these “approach” characteristics. When going through an example problem or lecturing on a concept, some students dutifully took notes and never asked questions. They just wanted to be told exactly what to do. At the other end of the spectrum, some students were always on the verge of a question. I could almost feel that if I did not
explain a concept fully, or if I skipped a step in an example, there would be questions from certain students in the class.

*Mind-set.* Some students approached learning activity in the classroom with an “I’ll do what I have to do to just get done” mind-set, while others had an “I want to understand the purpose behind the activity” mind-set. In the flip classroom, a student’s mind-set toward the activity manifested itself when students spoke of “not caring about” or “not having dignity in” their work. When this mind-set was present, students were less likely to push through the difficult parts towards the middle and end of the activity. If students got stuck and the professor was not readily available (because I was helping another group), students with this mind-set toward activity were more likely to surf the web, play games, “zone out,” or engage in some other off-task behavior. When I made it over to answer these students’ questions, they often only wanted to answer exactly what was asked in the problem, even if it was what I said word for word. They sometimes even stated that they did not care why the answer was what it was. They just wanted to complete the activity. Students who wanted to understand the purpose behind the activity, on the other hand, often asked questions that extended beyond the immediate questions in the activity itself. These key examples of student behavior express the difference between students who just wanted to make it through the in-class activity and those students who wanted to engage the material at a deeper level by understanding the purpose behind their learning activity.

In the traditional classroom, students with a “just make it through” mind-set were harder to spot. While these students were less likely to engage in classroom activity by answering and asking questions, the lack of verbal communication did not directly
indicate where the student fell on the mind-set spectrum. To understand the purpose behind the activity as we worked through an example or answered specific students’ questions, a student would need to pay attention and engage the discussion about the material. While it is possible to engage without contributing verbally to the discussion, students would tend to show their interest in some way (eye contact, note taking, additional reading, etc.).

Synthesis. As we have just outlined, the overall comfortability a student has with a learning activity will be related to the structure of the activity, the student’s general approach to the activity, and the student’s mind-set toward the activity. These properties loosely fit together for each individual student to influence a student’s experience with the activity. For instance if a student approaches an activity wanting to be shown exactly what to do along the way, but the activity structure is open ended, then the student will be more likely to be frustrated than if the activity structure were step by step. The same goes for the other direction. If a student approaches an activity wanting to be allowed to struggle through and come up with creative solutions, but the activity structure is step by step, then the student will be more likely to be frustrated than if the activity structure were open ended. If the student’s mind-set toward activity is “I just want to do what I have to do” then the student will be more likely to prefer a step by step structure and will approach the activity wanting to be shown what to do step by step.

We need to be careful to note that the interaction is not simple and linear, but dynamic. Where a student falls on these properties will be influenced by many factors, and students will not tend to be firmly in one specific place with regard to the properties for all activities. Depending on the specific activity, a student may either prefer to
approach it wanting to be shown, or wanting to struggle through. It will depend on the student, the subject matter, and the specific day. This situation revealed itself in the flip classroom focus group when students expressed their dislike for certain classroom activities, and then minutes later asked to do more activities with similar properties to the activity they just complained about (helping other students, applying what they have learned, etc.).

*Comfortability and Participation*

At this point, I want to investigate how the properties of comfortability in learning activity influence students’ level of participation in that activity. Some students participated at a superficial level while others participated at a very thoughtful level. In the same way, the students’ comfortability influenced the level of resistance to the activity. Some students resisted by really digging in and not wanting to progress through the activity while others just needed a nudge to get going. The dynamic interaction between the comfortability properties worked on varying levels to influence participation or resistance depending on each individual student. Both focus groups gave clear evidence that students resisted participating in learning activity while in the classroom. Each class resisted in their own way due to the differing environments, but they resisted nonetheless.

The structure of the activities in the traditional class made it more suitable for students to listen during the class time and then do work later. In this way, classroom activity did not heavily require participation by the students. For class time to be productive, students needed to engage the material with their attention, but during class students were not called upon to regularly learn via participation in activity. Even though
I tried to encourage student participation using various questioning techniques, students
did not need to actively engage to make class work. During the lectures, I could carry the
bulk of the interaction with the material by discussing the major points of the chapter and
going through the necessary examples in the slide presentations. Students in this
environment had the freedom to approach classroom activity as they saw fit. Students
could take notes according to their preferences, talk when they felt comfortable, or do
other things (study for other classes, doodle, pleasure read, do homework for this class,
etc.) without disrupting the class that much. The students’ varying mind-sets toward
classroom activity were just as unobtrusive as their approach. If students just
wanted to do what they had to do to get by during classroom activity, they had the freedom to do
that with little negative effect. If students wanted to understand the purpose behind the
classroom activity, they had the freedom to ask the questions and engage due to the loose
atmosphere in the classroom.

Students in the flip environment, on the other hand, had less freedom to act in the
classroom. The structure of the activity to be completed (whether Jack or a smaller ½-
sheet investigation) was set by the professor before class, and students were expected to
actively engage with it during class. If students’ approach to the activity did not fit well
with the structure of the activity, this caused disequilibrium for the student. In this
environment, students had to negotiate the space between the structure of the activity,
their approach to the activity, and their mind-set towards the activity. Sometimes this
negotiation worked well and students progressed successfully through the activity. Other
times, students failed to make it through and they struggled to make sense not only of the
specific activity, but also of the direction of the class in general. In the flip classroom, it
was not enough for students to engage the material only with their attention; they also needed to participate in classroom activity for class to go smoothly.

If students in the flip classroom were struggling to make the learning activity work for them, the environment was organized in such a way that it made it disruptive for students to do other things during class like study for other classes, read other material (in a book or on the Internet), or just complete their homework (ALEKS). When students did these other things, I repeatedly re-directed their attention to work on the activity at hand. In the traditional classroom, students could study for other classes, read other material, or do their homework with minimal to no disruption of students around them. Thus, in the flip classroom, I spent considerably more energy trying to manage students’ learning activity during class compared with the traditional class.

Since so many different types of learning activities were required throughout the semester in the flip class, students spent energy deciphering what was required of them each class period and working to make sure they met these requirements. This challenge was something the traditional class never had to face on a regular basis. As a result, the task orientation and system maintenance and change aspects of the learning environment differed considerably between the flip and the traditional classrooms.

Blending the Quantitative and Qualitative Analyses

In this section, we consider the results from the quantitative and qualitative analyses taken together. We specifically look for areas of agreement between the analyses regarding the learning environments under study.
Cooperation and Innovation

The CUCEI survey given towards the end of the semester indicated that the flip classroom students were more open to cooperation when compared with the traditional classroom students in both their preferred learning environment and their actual classroom experience. This result was borne out in the qualitative data. Many students from the flip class mentioned the value of learning with partners when prompted to describe the way successful learning should occur in the classroom. Significantly fewer students in the traditional class mentioned group learning when reflecting on what a successful course would look like.

Even though the qualitative data indicated that students in the flip classroom had difficulty making sense of some of their learning activity, it is interesting that these students preferred more innovation in the classroom, and they said they experienced more innovation in the classroom when compared to the traditional students (based on statistically significant CUCEI results). In the qualitative data, students from the flip classroom mentioned that a successful learning environment would include activities that help them to apply what they have learned. Even though it was a semester full of adjustment for these students, perhaps a semester full of varied learning activities shaped them in ways that made them more open to different kinds of learning activity in the future. In order to reach this conclusion with greater certainty, we would need baseline data from the beginning of the semester to see how similar the two groups of students were starting out (which we do not have), but based on the student’s experiences and the qualitative analysis this result certainly seems plausible.
Task Orientation

Scores from the CUCEI showed that students from both the flip and the traditional classrooms preferred the same level of task orientation, but students in the flip classroom indicated that in their actual classroom, they experienced significantly lower levels of task orientation than their traditional classroom counterparts. This is the strongest and most supported result in the study. While students in the traditional classroom did have some issues with task orientation (not knowing when homework was going to be collected and experiencing frequent awkward pauses), the overall climate of the classroom was very predictable. The settled nature of the traditional classroom compared to the fragmented nature of the flip classroom is a robust feature of the qualitative analysis.

Though the flip classroom was more fragmented than the traditional classroom, it was far from a “free for all.” At the beginning of the semester, students were given a syllabus and we discussed when exams would happen, what the ALEKS homework would look like, how the grading scale would be divided among tasks and exams, and how the class would be run generally (with investigations, mini-lectures, and ALEKS homework). As the instructor of the course, I felt that after some adjustment, most students would “find their feet” and become comfortable with how class was run. While some students were able to make the adjustment, many still struggled with how to orient themselves to the activity in the classroom and learn the material. The qualitative data indicated that even students who worked hard and were motivated to make the course work for them found it difficult to hold things together. A specific illustration of this point is when Amy in the focus group spoke of how she had to adjust how she asked me
questions during the small group investigations. She not only had to make sense of the assignment itself, figure out how to use computers (and other tools) to solve the problem, and work with a partner to negotiate meaning from the activity, but she also had to adjust how she asked questions to me because of the time crunch I was under to answer all the groups’ questions. These types of adjustments to how students approached in-class tasks were simply not present in the traditional class.

Adjusting one’s orientation to in-class activity is not necessarily a negative thing. There are often benefits to taking a different approach (or even multiple approaches) to a specific task, and anytime this is done students will need to make adjustments to how they orient themselves to the learning activity. In the flip classroom, however, it seems students constantly had to make these adjustments. The orientation to the many specific tasks were so varied, and the ALEKS homework felt so different than the lectures and in-class work that students experienced a higher level of unpredictability and unsettledness when it came to orienting themselves to the learning task at hand.

The more focused task orientation environment in the traditional classroom produced an environment with a supporting structure that allowed students to patiently see subtleties within the concepts we studied. This environment produced favorable conditions for students to also see the inner-connectedness between these concepts (this was lifted out in the qualitative analysis above). In contrast, the less focused task orientation environment in the flip class made students more likely to plug numbers into formulas and disengage when activities got boring (again, supported in the qualitative analysis).
To help us get a fuller picture of the difference between the two groups of students’ grasp of the concepts in the course, we close this chapter with a transcript section from both focus groups. In these transcripts, Brenita (the focus group leader) has told students that a friend is asking for their help on a statistics project where the friend asks a sample of people the following 5 questions:

1. Are you a Christian? If so, what is your denomination?
2. How many Sunday morning church services have you attended this semester?
3. Are you male or female?
4. Did you vote this year?
5. In a typical week, how many days do you read the Bible?

Brenita asks the focus group what advice they would give for how their friend should go about making conclusions from the collected data. Here are the focus group responses presented back-to-back.

From the *flip classroom* focus group:

Brenita Um let's say a friend of yours here at the school is collecting data for a project they are doing in a religion class. They've already collected data for the following variables (listed them). They come to you and ask you to help them. They want to know what kinds of conclusions they can draw from the data. What would you tell them?

Jim If they already have the data.

David This is like the Jack problem! This is exactly like the Jack problem!

Charles So what are we doing now?

David It's the Jack problem only for Christians.

Jenny They could draw connections between males and females and whether they get up on Sunday morning. They could draw connections between whether you go to church and whether you read the bible. (Under her breath: since they're both numerical, they can be on a scatterplot).

Jim If they said they were a Christian, you could see how they respond to a question like reading the bible and Sunday morning services.

Charles Vote is just kinda like, hey!

Jenny Yeah that's kinda random.

Amy That's kinda, yeah.

Jim That doesn't really follow.

Charles I guess if they're male or female you could see the ratio there.
Charles You could see the ratio between Christian and non-Christian and whether they vote.

Jenny You could look at if they don't go to church and they don't read their bible and they don't vote either, then they must not care about anything. You could maybe try to draw something like that.

Amy In my opinion, you could be able to see why Bush won.

(Brenita - laughs)

David You could ask who you voted for and see if Christians voted for Bush or not.

Bill Like if you're a Christian you probably got morals and so you probably voted for Bush.

(laughter)

Amy Not necessarily!

Brenita Careful.

Jenny You could get ratios of the denominations and the population of the student body, where we all come from. And make comparisons of like if all the Naz kids actually go to churches and all the non Naz kids don't ever go to churches.

Brenita When you say Naz, do you mean Nazarene?

Jenny What I meant was the kids who are Nazarene and go here, do they go to church more than those who aren't Nazarene and go here. That was the point.

Jim All right. These little pieces of paper like scare me now.

Brenita I know, I'm so sorry, that's why I kept them hidden under my paper until now.

Jim Then you were like, (fast sound of paper flying out).

(everyone laughs)

Jim I was scared. Like, histogram, go!

(laughter)

Brenita Any other comments whatsoever?

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From the *traditional classroom* focus group:

Brenita Go ahead and pass this around (a piece of paper)

(Brenita gives them a sample problem and reads it)

Brenita Your friend asks for your help in analyzing this data. They want to know what kinds of conclusions they can draw from this data. What would you tell them?

Carrie I would say you'd have to set up more than one. Like obviously you're going to be doing like hypothesis testing and stuff and you would have to figure out what are the answers she's looking to get, because that's how you would set up your alternative. And then she would have to set up a series of them, you couldn't just bunch them all together you'd have to like split them up. Like just do a couple of numerical variables together, and then do like a categorical variable.

Brenita Could you give me an example?

Carrie Yeah, like just are you male or female, that would be a categorical variable and you can use that then say like um are you a Christian, that's also a categorical variable, so there's a set test for that one. But if you would just say are you male or female and how may Sunday morning church services that's a numerical so
that's a different test, so that's why you couldn't just put them all together like that.

Bob It kinda seems like the "did you vote" just kind of comes out of nowhere. The male and female seems like a pat answer for a survey. But um a lot of these are Christian, Sunday morning, bring your bible, and then "Vote." So are they trying to tie voting to do lots of Christians vote? So maybe they should have maybe more questions about you know voting related activities if there are things. Like you know are you registered as a Republican, Democrat, or whatever. You might get a better idea of what you're looking for if that's what you're looking for and if your not, then you might not want to have it in there.

Brenita It's kinda random.

Bob Yeah

Adam Uh hum

Brenita What else? What other conclusions or comments?

Bob I think people would be prone to lie. I mean on Sunday morning church services, you know I can't give you the exact number, but if I'm gonna throw one out, it's always gonna be better that what it probably actually was. And the same thing with the reading your bible. You know that always like, no one wants to be the sinner, so…

(laughter)

Bob You know in an environment full of Christians, no one wants to be the one person who like, you know everyone else reads their bible seven days a week.

Brenita Any other conclusions you could draw from the data?

Carrie I think if you're gonna ask, “What's your denomination?” Like, that would be really hard because there are so many. Like, I don't know.

Bob Broad.

Carrie Yeah, like that would be really hard. You might need to narrow it down, it just would be hard to do you know.

Nancy If you're doing this school's students though, I think

(Laughter)

Nancy I know there are a lot of religions, and there are quite a few different religious people here, but I think that you might find the majority of the same religion.

Bob You're gonna get a lot of categories of that and so that might skew your data possibly

(everyone - ooo)

Nancy Good word

Brenita You mentioned that if you have these variables, then you run this kind of test, and if you didn't have these other variables, then you run another test. What are those tests?

Carrie Well, if you have like … um … pressure

(laughter)

Brenita You know what, they can all help you

Carrie Yeah,

Keith Get out the flow chart

Carrie Yeah
Bob That he never gave me!
Nancy You missed it he passed them out in class
Bob I know, I know!
Adam He did it twice!
Bob Yeah he did
(laughter)
Brenita Do you not have a friend that could give you a copy?
Bob No, I was definitely absent both days he handed them out
Carrie That was definitely his fault too!
(laughter)
Bob Yeah that was my fault
Carrie Well with the denomination, you would have to do an ANOVA test because there are so many. And you would only be able to see if there is a difference. You know you can't see if one denomination compared to another anything because it's so broad and general. But like, if you just do a, for like a categorical variable, depending on if it's like a proportion, or if you're just doing the mean, like you just do like the, where if it's independent of dependent, you just do like a, what's it called? Like a t …
(everyone talks at once)
Bob T star
Carrie T stat
Bob Or is it t-stat?
Adam T-stat, paired or um...
Carrie Paired
Keith F
Bob Yeah, it all depends on what standard deviation they give you. Whether they give you from the sample or the population
Carrie Sample or population, yeah.
Brenita And what kinds of graphs could you make from this data
(answer together)
Bob Graphs and charts
Carrie Graphs and stuff.
Brenita Do they have any fancy names?
(answer together)
Carrie Scatter plot, box and whisker,
Nancy Box and whisker
Adam Box and whisker (laugh)
Carrie Fancy names! (laugh)
Brenita Just 'cause it sounds cool...
Bob Bar graphs
Adam Histograms
Bob Histograms, I remember
Brenita I'm sorry, histogram? Cool. I have no more questions. Do you have any more comments?
After students complete an introduction to statistics course, it should be plain to them that in addition to doing exploratory data analysis (finding percentages and means or making graphs and charts), it is necessary to perform various hypothesis tests in order to draw conclusions about a larger population based on a sample. In the sections above, the *flip classroom students* never mention performing a hypothesis test, and their comments remain at a surface level. The students react to the question because it reminds them of the Jack problem, and the only analysis they mention doing is a comparison of ratios and graphical displays of the data. The *traditional classroom students*, on the other hand, discuss the features of the questions at a deeper level, mentioning various difficulties with the questions themselves as well as the need to do hypothesis tests. The students suggest using the flow chart I had given them as a tool to help decide which hypothesis test to use, and they begin trying to decide which hypothesis test would be appropriate even without the flow chart. Even though the *flip classroom students* had the same training and tools (i.e. Excel spreadsheets, the flow chart, etc.), not one of the flip classroom students so much as hinted at the need to move their advice toward even one hypothesis test. The data in this focus group excerpt offer another bit of support for the claim that the traditional classroom in this study offered a more supportive environment for students to connect ideas into a coherent whole and use those ideas to begin solving specific problems.
CHAPTER 6

CONCLUSIONS AND IMPLICATIONS

In this chapter, I summarize the research project and briefly present the major findings of the study. In light of the findings, I present conclusions with regards to previous research and theory reviewed earlier in this document.

Summary

This study began as an investigation of what happens when a classroom is “flipped.” In a traditional college classroom students are introduced to concepts and examples in a classroom lecture, and then they complete homework that gives them practice engaging concepts on their own. In a flip classroom, this pattern is switched so that students spend the majority of classroom time completing activities that help them engage the concepts and major ideas of the course, and they spend the majority of homework time being introduced to material and working through examples. In this particular investigation, I wanted to see how flipping a classroom influenced (1) the learning environment and (2) the learning activity in such a classroom.

I chose two different introduction to statistics classes and asked the students to participate in this study. I taught one of the classrooms traditionally, giving lectures with examples and assigning homework out of a book. I flipped the other classroom in the following way. Students completed work on an online intelligent tutoring system called
ALEKS where they could see explanations of concepts, see examples of those concepts in action, and interact with those examples until they could successfully complete similar examples on their own. During class, I gave students activities to complete (mainly in groups of 2). These activities were sometimes open ended investigations, and other times the activities clearly stepped students through the investigation and asked them to explain what happened.

My data collection team and I collected data for this investigation by giving the CUCEI (the College and University Classroom Environment Inventory) survey, audio taping class sessions, writing in a researcher’s journal, observing class, taking field notes, soliciting written student reflections on their experiences in the course, conducting individual student interviews, and conducting student focus groups. The quantitative data were analyzed using exploratory analysis techniques including observing patterns in means and standard deviations. Also, t-test hypothesis tests were performed and multivariate statistical analysis was used to look for significant relationships between aspects of the learning environments.

The qualitative data were analyzed using grounded theory methods. I open coded the body of data and, looking for similarity in the codes, I grouped them into broader categories. Once categories were identified, I delineated the properties that function within each category being careful to note each property’s dimensional range. All through this process, I continually moved back and forth between the coding and category development on the one hand and the data itself on the other. It was important to move back and forth from the data to the analysis so that the developing analysis remained grounded in and faithful to the data as much as possible. Once the categories
(with their developed properties) took shape, I looked for connections between properties (at the micro level) and the categories (at the macro level) that informed the classroom culture and learning environments in the two classrooms. These connections formed the basis for a theme analysis of the two classroom cultures in this study. I furthered the qualitative analysis using the core category of comfortability with learning activity to get a clearer picture of what was happening in the classrooms with regard to learning activity. By examining various processes in the classroom, I outlined a study of learning activity in both of the classrooms under study.

The mixed-methods data analysis revealed that after a semester of conducting class in different ways for the two introduction to statistics classrooms, there were some differences evident in the two learning environments. Students in the flip classroom both preferred and experienced more innovation and cooperation in their classroom learning experience when compared to the traditional classroom students. This consequence could be a result of attending a class for an entire semester where more cooperation was required, and innovative methods were employed in an effort to successfully “flip” the classroom. Another significant difference between the classrooms is that students in the flip classroom were less satisfied with how the structure of the class oriented them to the learning tasks in the course. The analysis showed that the variety of learning activities in the flip classroom contributed to an unsettledness among students (a feeling of being “lost”) that students in the traditional classroom did not experience.

A further analysis of activity in the two different classrooms led to a study of students’ comfortability with various learning activities in the class. Students’ comfortability with the learning activity tended to influence how vigorously they
participated in or resisted completing the activities. Activities that the instructor asks students to complete will have a certain inherent structure to them (from open ended to prescribed). No matter the structure to the activity, students tend to approach the activity falling somewhere between wanting to be shown exactly what to do and wanting to struggle through on their own and ask questions when they get stuck. The students’ approach and the structure of the activity itself will influence how comfortable the student is with the activity. In addition to the structure of the problem and the students’ approach to the activity, students will also tend to have an attitudinal disposition toward the activity in general. Their mind-set will be somewhere between wanting to just do what they are required to do to complete the activity and wanting to understand the purpose behind the activity. These aspects of structure, approach, and mind-set shape how comfortable a student will be with the learning activity in the specific learning environment and will influence how willing the student is to engage and participate in the activity.

Conclusions in Light of Past Research

Some of the aspects of the unsettled learning environment and dissatisfied task orientation results in this study were expected, but some were surprising. The pilot study I conducted suggested that students would need time to adjust, and this was true of the larger study. Therefore, I expected students in the flip classroom to be a bit off balance with regards to the way class was run. The Frederickson, Reed, and Clifford (2005) study showed that students in a technology rich environment where the professor is less visible require different things than students in a traditional lecture course. One of their significant results stated that students learning with technology need more re-assurance
that they were “on the right track” during the learning process, suggesting that the rules, division of labor, and structure of the community are all significantly affected (and changed) when students use a different major tool (technology) to learn content when compared to a traditional lecture course. This, as already stated, was expected in this study. However, I believed that after a few weeks, students would settle in and “find their footing” so to speak with how to successfully navigate the course. While this happened for some students, an unexpected percentage of the students were left struggling, and I did not anticipate this result, particularly when reflecting on studies in the literature.

Many of the studies reviewed in this report showed that when students were given the opportunity to use multiple representations of the same mathematical concept and translate between those representations, then their understanding of the concept would deepen. Other studies gave evidence that it is useful for students to develop their own approaches to solving problems, and that even inventing their own representations for mathematical concepts can be a useful way to deepen their understanding of the concepts under study. I structured the flip classroom with these results in mind so that students would be put in situations where they were encouraged to use different representations when working with statistical concepts using ALEKS, during open investigations or smaller activities, and during mini-lectures. It was therefore surprising to observe how consistently students struggled with accomplishing specific academic objectives in the flip classroom no matter if it was completing ALEKS, participating in in-class activities, or tracking during lecture time. A close inspection of the findings drawn from the data in this study may allow us to draw further conclusions which shed light on why some results differed so surprisingly in this respect from other studies in the literature.
Setting this study in an introduction to statistics class with traditional aged students made it unique from other studies in a few important respects. An argument can be made that the ALEKS intelligent tutoring system is a more natural fit for some topics and a less natural fit for others. As an example, the Canfield (2001) study reported that students who were using ALEKS to learn basic algebra in a remedial college course believed that they learned more than in past similar mathematics classes and that they would happily take another course where the ALEKS system was used. Now, the structure of the content in a basic algebra class lends itself to the hierarchical structure of the ALEKS knowledge space theory. For instance, it is more natural to see that students would not be able to find the roots of an equation if they had not mastered multiplication of binomials or factoring (a basic algebra ALEKS assumption) than it is to see why students would not be able to perform a hypothesis test if they had not mastered all of the probability rules and problem types (a statistics ALEKS assumption). Students in the flip classroom were often frustrated because when they performed poorly on the probability section of an assessment, they were not even given an opportunity to show that they could complete a confidence interval and hypothesis test problem (since it is assumed they would not be able to within the structure of the ALEKS knowledge base). While most introduction to statistics instructors would agree that it would be useful for students to see the connections between all of the probability concepts and hypothesis testing, many do not insist on such a strict connection for their students to learn how to complete a hypothesis test or confidence interval problem. Because of issues like this, perhaps ALEKS is best suited to be used with subjects that have clear connections within course content and not as well suited for more complex content areas.
It is important to note that the Baker (2000) study on the classroom flip was set in an upper division course and not a lower division introductory course with a majority of non-mathematics majors, as in the present study. The Frederickson, Reed, and Clifford (2005) study was set in a statistics course, but it was at the graduate level. The success of the Baker study suggests that the flip format may work best in a setting where most of the students in the course are deeply interested in the content to begin with. Students in this position would be motivated to take it upon themselves to do what it takes outside of class so they will be productive during activities carried out inside the classroom. Baker’s aims for flipping his classroom (to reduce time spent on lecturing, focus on understanding and application, provide students with more control over their own learning, give students a sense of responsibility for their learning, and give students an opportunity to learn from their peers) requires a level of maturity and a persistence that may just naturally fit better with an upper division course than with a lower division course. With the Frederickson et al. study, students in the flip and the traditional groups both performed at the same level, but students in their flip classroom had concerns about the structure of the classroom. That graduate level students struggled with adjusting to the flip classroom format further suggests that an introductory level course may not be the best place to implement the classroom flip.

The “introductory course” dynamic could explain other features in the data as well. Doerr and English (2003), diSessa et al. (1991), and Lehrer and Schauble (2000) all concluded that activities which require students to develop their own approaches to representing and solving problems provide a rich environment for mathematics learning to take place. These studies also warned of the dangers of guiding students toward one
specific way of representing or solving a problem. However, in an introductory course, it is likely that students come in wanting to be introduced to the subject rather than come up with their own ways of thinking about the subject. I would argue that this is a practical dynamic of introductory courses that cannot be ignored. No matter how convincing the instructor is at explaining the benefits of making deeper connections to course content through in-class activity, there will always be some students who just want the instructor to convey the basics of the course so they can make it through this course that is required by their major but not specifically a part of their discipline. This may not be a large issue if innovative classroom activity is used 3 or 4 times throughout the semester, but when the entire course structure rests on such activity, this may be a problem for introductory courses.

I also want to reflect on students’ comfortability in learning activity in light of past studies. We have seen that the structure of the flip classroom as it was implemented day to day made it more difficult for the students to feel comfortable with their learning activity when compared to students in the traditional classroom. Recall that student comfortability was analyzed using the properties of the structure of the activity and the students’ approach and mind-set toward the activity. Now, in the Lage and Platt (2000) study, their motivation for inverting the classroom was to give students a chance to learn economics according to their individual learning style. They flipped their classroom by giving students multiple ways to be introduced to and see examples of the major concepts of the course outside the classroom including reading a textbook, interacting with PowerPoint presentations with sound, or watching a video lecture. The primary goal was to let students choose the homework structure that best fit their individual learning style.
This freedom likely had an impact on the students’ mind-set toward in-class learning activity, thus affecting how comfortable the students were with the activity. On the other hand, in the present study, students in the ALEKS flip classroom had no choice of how content was delivered outside the classroom. This makes for a significant difference between these two studies, and gives insight into the mind-set component of activity comfortability.

Other studies reviewed in this report also have related features. The Broad, Matthews, and McDonald (2004) study used technology to make course content available to students in an effort to accommodate various learning styles that existed among the different students in the class. This focus of letting students choose how they interact with the content was, again, not a part of my classroom flip study. It is significant that in this Broad et al. study, evidence showed that students in the technologically rich learning environment became less and less interested in focusing only on what was necessary to complete the assignments (being pragmatic learners), but rather they began to engage in theoretical discussions and to explore the implications of the concepts they were learning. The opposite seemed to be happening in my flip classroom. Perhaps the Frederickson et al. (2005) conclusion that students become more aware of the learning process and course content in a flip classroom setting ties into the discussion at this point. In my introduction to statistics course, the classroom structure did make students more aware of the learning process and content, but the class was not structured sufficiently to help them engage in theoretical discussions and explore the implications of the concepts they were learning.
A similar result occurred in Elen and Clarebout’s (2001) study of students who completed a project that relied heavily on technology as groups of students worked collaboratively to develop a position paper to present to a European Parliament member. Elen and Clarebout observed that students’ belief in the usefulness of collaboration decreased. This result is similar to my pilot study result that sometimes working in groups can deal a blow to student confidence. The decreased belief in the usefulness of collaboration was surprising for Elen and Clarebout. Due to the review of literature that they conducted, they were sure that the project would produce positive results with regard to beliefs toward collaboration. The apparent conflict led Elen and Clarebout (2001) to conclude there was a difference in the learning environment as planned and the learning environment as implemented. I had a similar experience in the flip classroom during this research. I expected more positive results with regards to students settling into the way class was conducted, and I was thinking that perhaps I did not successfully implement the plan. However, in both Elen and Clarebout’s study and my study, I would go a step further and say that the plan is the beginning of the project. There were flaws in the plan. I believe the plan did not sufficiently take into account the ways in which open-ended projects would influence the “system maintenance and change” dimension of the learning environment (Moos, 1973). This deficiency in the plan resulted in effects on students’ mind-set towards the learning activity and put a strain between the student’s approach and the structure of the activity in general.

Conclusions in Light of Theory

The results of this research can contribute to our understanding of how theories of learning, self-efficacy, and the learning environment work their way out in practice. This
section will explore these avenues. Of particular note is how the concept of student comfortability with activity that emerged in this study is compared and contrasted with the concept of self-efficacy.

**Learning Theory**

The findings of this research speak to theories of learning that address imitation and higher mental functions. Bruner’s (1990) application of *rebus* to learning helps us see how “things” can control our activity. We can do an activity without understanding why we do it. But for higher mental functioning to occur, it is important for students to eventually understand the why and for meaning to dominate their learning activity rather than just acting for action’s sake. Students’ experience with the ALEKS intelligent tutoring system brought this aspect of learning theory to life. Many students were interested in figuring out how to get the right answer in ALEKS so they could complete their assignment; that is all. These students viewed the problem explanations in ALEKS so they could see the patterns in the problem (the first number mentioned goes here in the formula, the second number mentioned goes here, etc.) without sufficiently understanding the statistical concepts behind the patterns in the problem. For instance, they did not understand that the first number was the mean and it goes here in the formula for a specific reason, et cetera. One of Thompson’s (1989) criticisms of intelligent tutoring systems of this type is precisely that they encourage imitation, or as he more aptly describes it, “reasoning without meaning.” Imitation without meaning was a common activity among those students who just wanted to get through the ALEKS homework. Even though I verbally encouraged students to complete ALEKS using our classroom notes so they could make connections between classroom activity and ALEKS,
the structure of the classroom did not strongly encourage them to make meaning of their actions in ALEKS.

According to the relevant learning theorists (Vygotsky, Piaget, and van Oers), higher mental function occurs when students are given an opportunity to reflect meaningfully on their activity. Some argue that practicing this reflection (sometimes called reflective abstraction or orientation) should be the main focus of the learning process. Further, some argue that the main role of the instructor in the classroom should be to help students negotiate ways of making meaning of their learning activity. This negotiation looks different for each student, and requires multiple cycles of feedback between instructor and student. An inspection of the data in this study clearly shows that encouraging reflective abstraction was not a major focus of the flip classroom. Due to the varied activities in the course and the use of many different representations, the learning theory states that students needed space for reflection to negotiate meaning. While I, as the instructor, tried to create space for such reflection at various points in the semester, I believe the findings of the study indicate that the flip classroom students needed more opportunity and more support for this reflection to take place and successful learning to occur.

Self-Efficacy and Comfortability

The core category of comfortability with activity as developed in this analysis bears some resemblance to Bandura’s (1997) concept of self-efficacy. Self-efficacy refers to a person’s perceived ability to plan and carry out a course of action (using certain tactics) that will help the person attain a specific goal. Thus, if a student is presented with a task he perceives as too difficult to accomplish considering the skills he possesses, his
low level of self-efficacy will likely lead to poor results. The power of a person’s self-efficacy to influence how he feels, thinks, and is motivated has been well documented (Bandura, 1997). Thus, a student’s self-efficacy will have an effect on the student’s level of comfortability with a learning activity.

When considering self-efficacy, it is important to distinguish it from self-esteem and academic ability. Whereas self-efficacy regards a person’s judgment of her ability to exercise control over a situation to attain a goal, self-esteem is more concerned with judgments of a person’s self-worth. A person can judge that she does not have the abilities and skills to complete a given task but still have high feelings of self-worth. Academic ability is different from self-efficacy, but it is not unrelated. A person’s academic ability will influence the confidence a student has about her ability to successfully complete a task; however, students with the same academic ability often have varying levels of self-efficacy when it comes to planning and carrying out a strategy for completing an academic task (Bandura, 1993). Further, these varying levels of self-efficacy have a significant effect on the students’ performance on the learning task at hand independent of the students’ academic ability.

Another aspect distinguished in the literature relates to students’ self-efficacy for learning and students’ self-efficacy for performance (Lodewyk & Winne, 2005). Some students can learn material without being able to perform well on tests or learning tasks, and some students can perform well on tasks without thoroughly comprehending the material and procedures in the course. Self-efficacy for learning relates to students’ judgments about their ability to choose tactics that will help them accomplish specific learning tasks well. Self-efficacy for performance relates more to students’ judgments
about their ability to succeed at achieving a desired outcome. This important difference illuminates the distinction that self-efficacy for learning involves students’ perceptions about their specific skills to accomplish a specific task rather than more broad perceptions about their general skills as they relate to being a successful student as relates to self-efficacy for performance.

Some studies have focused on students’ changing levels of self-efficacy while they are in the process of completing tasks. Bandura (1986) argues that paying close attention to students’ engagement during learning is the best way to garner information about their self-efficacy with regards to the learning task. As students are engaged in the task, their changing self-efficacy levels will influence the strategies and tactics they choose to employ during the task (Winne, 1995). The success or failure of the strategies and tactics will, in turn, either reinforce or disrupt students’ self-efficacy for learning.

A study that investigated how the structure of learning tasks is related to self-efficacy found that when students complete open-ended (or ill-structured) tasks, self-efficacy for learning was lower at the beginning of the task, even when students’ self-efficacy for performance was high (Lodewyk & Winne, 2005). As students progressed through the learning task however, the gap between these two types of self-efficacy narrowed. This gives further evidence of the importance for monitoring students’ levels of self-efficacy, particularly at the beginning and middle of an open-ended learning task.

Student comfortability with learning activity was linked in this study to the structure of the task, the approach of the student to the task, and the mind-set of the students as they completed the task. While self-efficacy (how confident the student is in her ability to plan and carry out strategies that will help her successfully complete the
learning task) will most likely influence the student’s approach to the activity and mind-set when completing the activity, it is different conceptually from these aspects of comfortability. No matter the student’s level of self-efficacy, the student could still fall anywhere on the dimensional range for approach (from “I want to you to show me” to “I only want to ask questions when I get stuck”) or mind-set (“I will do what I have to” to “I want to understand the purpose behind this activity”). A lower or higher level of confidence in abilities would not necessarily require a specific approach or mind-set toward the activity.

Learning Environments

More theoretical conclusions can be drawn from this study when we view activity in the flip classroom in light of: (1) Moos’ (1979) three dimensions of social environments, (2) Moos’ (1979) model for the relationship between environmental and personal variables and student stability and change, and (3) the activity theory model for learning. According to Moos, the main dimensions of the classroom (or any human environment) are related to relationship, personal growth, or system maintenance and change. When students are confronted with a classroom learning activity, their personal system and social environment system will interact as they go through the learning process. This interaction between systems in the learning process (student stability and change) is pictured in Figure 6.1.

The model for student comfortability with activity developed in this research fits well into Moos’ (1979) interaction model. The activity itself will provide the spark that sets the interaction in motion, and this activity will have a specific structure (ranging from step by step to open ended). Students will have a preferred approach to the activity
(ranging from “I want to you to show me” to “I only want to ask questions when I get stuck”) as well as a *mind-set* toward the activity (ranging from “I will do what I have to” to “I want to understand the purpose behind this activity”). Both the *approach* and the *mind-set* characteristics fall under the cognitive appraisal stage of Moos’ interaction model, and they will influence how the student responds to the activity at the “activation or arousal” stage. As students work through the activity, they will encounter disequilibrium (borrowing from Piaget) in their personal systems and make efforts to adapt and cope with the learning activity to eventually reach a place of stability and change.

*Figure 6.1. A model of the relationship between environmental and personal variables and student stability and change*  
(Adapted from Moos, 1979, p. 5; used with permission.)

The social environment of the classroom in our conceptual framework is represented by the bottom of the activity system triangle in Figure 6.2. Classrooms operate according to a set of spoken and unspoken rules that influence how students in
the course interact with the activity and each other. The social environment is made up of the entire community in the classroom. The students and professor have different types of work to complete (division of labor) as they progress through the learning activity. The way the learning environment is structured according to this model will have the greatest influence on the last two stages of Moos’ model discussed above (adaptation and coping, and student stability and change). For students to reach a place of stability and change, the learning environment must be structured so that they have space to reflect on their activity in this adaptation and coping process. Not only must students have space to reflect, the professor must act to help students negotiate between the personal sense they have made of the content as a result of their learning activity and the things they still need to learn before the activity is complete. Such an environment will require multiple ways for students to express their learning and multiple cycles of feedback from the professor.

![Figure 6.2. The structure of a human activity system (Engeström, 2003, n.p.) (Used with permission.)](image)
An adapted model for the interaction between the personal and social systems of students as they complete classroom activity in light of the structure of the classroom is presented in Figure 6.3. Note how the properties of students’ *comfortability with learning activity* interacts with “cognitive appraisal” and “activation or arousal” and how the *classroom structure* will either support or hinder “efforts at adaptation and coping” and “student stability and change.” The classroom structure will support students’ learning if the person responsible for structuring the classroom pays close attention to the system maintenance and change aspects of the learning environment. Key questions to consider involve: How orderly and clear are the expectations for the activity? Who has ultimate control over learning and activity? and How responsive is the environment to change?

*Figure 6.3. Student comfortability, the classroom structure, and learning activity*
Recommendations for Practice

Based on the conclusions of this study, I recommend that teachers who plan to implement the classroom flip consider the following suggestions. *First*, the flip structure seems to be more productive when students have a choice between multiple ways of interacting with the content of the course outside of class. When the focus of the flip is on giving students the freedom to interact with the content according to their own learning style preferences, the flip seems to be more successful. *Second*, if the flip is used in an introductory course, the in-class activities should be less open ended and more “step by step” in structure. If some activities are open ended, try to keep them brief: one to two class periods. Students in introductory courses will often have little tolerance for prolonged uncertainty in the course content and the course structure. In more advanced classes, students will be more willing to push through prolonged investigations, but the structure of the classroom must support their meaning making in the activity. This leads to the *third* recommendation. A flip classroom is structured so differently that students will become more aware of their own learning process than students in more traditional settings. Students will therefore need to have more space to reflect on their learning activities so they can make the necessary connections to course content. The teacher must structure a major component into the course structure that will allow for this reflection to take place and for the teacher to be able to see and comment on specific aspects of student reflection. This feedback cycle will be crucial for student learning.

At this point, I also want to give a few recommendations for structuring a flip classroom that will help students cope, adjusting to various learning activities so they will eventually reach stability and change. It would be useful for the teacher in the flip
classroom to help students become self-aware of how they approach classroom activity and what their mind-set is toward that activity (using the aforementioned properties and dimensional ranges). This self-awareness could help students understand the difficulties they encounter, contribute to an increase in their self-efficacy for learning, and provide a way for the teacher to support students when they are struggling. Also, in a flip classroom, we have mentioned it will be important for students to have a structure for reflecting on their different activities. Thus, at least weekly, it would be useful for the teacher to give writing assignments (such as ½-page reflection papers) where students address a very specific question designed by the teacher that ties together the major concepts of recent classroom activity.

The disequilibrium or unsettledness that students face in a flip classroom is not necessarily at cross-purposes with successful learning. It is just extremely important that the teacher adjusts the system maintenance and change dimensions of the learning environment to support students’ meaning making from activity in the flip classroom. These support structures must be built into the course so that teachers and students alike can monitor student self-efficacy as they complete tasks, particularly at the beginning and middle of open ended tasks. Depending on the classroom, these adjustments could have serious practical challenges. Therefore, it may be preferable for some teachers to do a less radical classroom flip that gives students an opportunity to view course content outside of the classroom in a number of different formats, but still includes regular 30 minute lectures followed by 30 minutes of learning activity and homework out of a book. Other teachers may see a radical classroom flip that includes only learning activity in class and total introduction to course content outside of class would work well for their class.
The final recommendations are for teachers planning to use ALEKS in their classroom. I recommend having students use a textbook as well as ALEKS. This gives students a choice in how they will interact with content outside class, the benefits of which were discussed above. As much as possible, use the same terminology as the ALEKS explanations and allow students to use the tools ALEKS uses for finding areas under curves or computing probabilities. It may be difficult to find a textbook that matches well with the terminology and the ALEKS tools, but it is well worth the time to try to make these match as closely as possible. Students in this current study found it difficult to do things one way in the computer program in class and do the same activity another way in ALEKS. If students complete tasks one way in the book or in class and another way in ALEKS, I recommend assigning a graded project or paper that requires students to reconcile these differences and explain how both methods produce the same mathematical results.

Further Research

The conclusions of this research have hinted that the classroom flip may be better suited for certain classrooms or courses than others. This is the first area for future research that I suggest. What are the characteristics of course material that would lend itself to being taught in a course using the classroom flip structure? Are there certain characteristics of a group of students that would tend to make the classroom flip structure work better with them than with a group of students with different characteristics? These are just a few questions that could be pursued along these lines.

The concept of student comfortability with learning activity was presented and developed in this study. I believe exploring this concept would provide a second way this
research could be extended. The *structure* of the activity and student *approach* and *mind-set* toward the activity provided the framework for considering comfortability with the activity. Comfortability with activity does not mean students think the activity is easy. Rather, comfortability refers to how well (or how unhindered) the students are able to enter into the activity and use it productively to learn. I believe it would be useful to further explore the three properties of comfortability with activity outlined in this study (structure, approach, and mind-set). Another avenue for investigation would be to look for properties that influence comfortability other than the three mentioned here. There may be other productive ways to conceive of student comfortability with learning activity than the properties lifted out here. Further, an examination of the disequilibrium students feel when faced with a challenging learning activity and the fit of the activity to their level of comfortability could possibly yield interesting results. Disequilibrium does not necessarily hinder the learning process, but can in fact spur students on toward successful learning. A final potential thread of investigation related to comfortability I want to suggest involves “pragmatic learners.” These learners are defined by Broad et al. (2004) as only being interested in completing assignments and not exploring implications of concepts. I believe it could be productive to investigate pragmatic learners’ comfortability in classroom learning activity.

The *third* area for potential research relates to the ALEKS computer program and intelligent tutoring systems in general. After using ITS as a major tool for learning in class, I am inclined to heed the warnings of Lesh and Kelly (1996) that ITS-like behavior is not the best way to help students learn. I do not believe, however that there is no place for ITS in education. So the first question I would like to see more research on relates to
how ITS can be used productively within the classroom. This question, of course, depends on how the ITS operates and who the student are, but as ITS get “smarter and smarter,” it would be helpful to have stronger guidelines for when and how to use ITS effectively in the classroom. Secondly, it would also be interesting to investigate ITS use specifically in light of the classroom learning environment. Perhaps there are certain conditions in the learning environment that make it helpful for an ITS to be used for student learning. Finally, I would find it helpful to see more research on the teacher’s role in the classroom when ITS is used as a learning tool in the class. All of these avenues for future research would be good ways to extend the findings of this present study.
REFERENCES


"inverted classroom", Panel Discussion at Southern States Communication Association Convention.


Schauf, J. J. (2002). The classroom flip in practice at Edgewood College, *Presentation and testimonial received via e-mail from Wes Baker*.


AI – Artificial Intelligence

ALEKS – Assessment and LEarning in Knowledge Spaces (an online ITS program)

CAI – Computer Assisted Instruction

CMS – Courseware Management System(s)

CUCEI – College and University Classroom Environment Inventory

ICT – Information and Communication Technology

ITS – Intelligent Tutoring System(s)

QRQ – Quantitative Reasoning Quotient

SRA – Statistical Reasoning Assessment

TRA – thought revealing activity(s)
APPENDIX B

THE THINKWELL PILOT STUDY QUESTIONNAIRE
<table>
<thead>
<tr>
<th>Questions</th>
<th>Please Circle Your Responses Below</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender</td>
<td>Male OR Female</td>
</tr>
<tr>
<td>2. Does the use of technology in this course (compared to a more traditional approach) cause you to feel more or less connected with other students?</td>
<td>More Connected OR Less Connected OR About the Same</td>
</tr>
<tr>
<td>3. Does the use of technology in this course (compared to a more traditional approach) cause you to feel more or less connected with the professor?</td>
<td>More Connected OR Less Connected OR About the Same</td>
</tr>
<tr>
<td>4. When we first started the semester, were you hesitant or enthusiastic about using technology in this course?</td>
<td>Hesitant OR Enthusiastic</td>
</tr>
<tr>
<td>5. Now that we are almost ½ way through the semester, are you hesitant or enthusiastic about using technology in this course?</td>
<td>Hesitant OR Enthusiastic</td>
</tr>
<tr>
<td>6. Do you feel the technology in this course gives you a better opportunity to master Precalculus, or do you feel you have a worse opportunity to master the subject?</td>
<td>Better Opportunity OR Worse Opportunity</td>
</tr>
<tr>
<td>7. Before enrolling in this course, would you say that you were “into” computers and technology?</td>
<td>Yes OR No</td>
</tr>
<tr>
<td>8. When something goes wrong with the technology, do you first try to play around with it to get it to work, or do you immediately have someone else work on helping you fix the problem?</td>
<td>Play Around First OR Get Help First</td>
</tr>
<tr>
<td>9. Do you feel the technology in this course helps you be more in control of your learning or less in control of your learning than in more traditional approaches?</td>
<td>More in Control OR Less in Control</td>
</tr>
<tr>
<td>10. Are your grades on exams Higher, Lower, or About the Same compared to other math courses you’ve had?</td>
<td>Higher OR Lower OR About the Same</td>
</tr>
<tr>
<td>11. Have you learned more math in a shorter period of time in this course?</td>
<td>Yes OR No</td>
</tr>
<tr>
<td>12. Please elaborate (on the back of this page) on how you think technology has helped you and how technology has hurt you in this course.</td>
<td></td>
</tr>
</tbody>
</table>
Ages of “At-Home” Business Workers

Millions of Americans get up each morning and go to work in their offices at home. A reporter at the [city] Times has agreed to pay you $500 to help her investigate the ages of people who work out of at-home offices in Knox County. The growing use of computers is suggested as one of the reasons more people can operate at-home businesses, and there is a sense that younger people are more comfortable with computers than older people. The following is a sample of the ages of 20 Knox County residents who work at home.

22 58 24 50 29 52 61 31 30 41
44 40 46 29 31 37 32 44 49 29

The Times reporter would like to include some specific things in her article. In particular, she would like to:

1. Know: What is the “typical” age of people who work out of their home in Knox County?
2. Know: On average, how different is the rest of the sample from the “typical” age?
3. Have some description of how spread out the ages are.
4. Have a graphic that will summarize the age breakdown for these 20 people.

Prepare a report that you will submit to this Times reporter where you address the four points above. Give two or three different answers for each of the above points, and describe (in a way the reporter can understand) how you came up with your answers so that she can decide for herself which of your statistics to include in her final article.
APPENDIX D

THE FLIP PILOT STUDY CONFIDENCE SURVEY
Confidence Survey

Directions: For the questions below, indicate how confident you are that you could correctly answer the question. Please, DO NOT SOLVE the following problems, just give your level of confidence that you could correctly answer the question.

#1) Voters participating in a recent election exit poll in Minnesota were asked to state their political party affiliation (Republican, Democrat, or Independent). A sample of 25 voters was taken, and the data collected is listed below:

<table>
<thead>
<tr>
<th>Voter #</th>
<th>Party Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Independent</td>
</tr>
<tr>
<td>2</td>
<td>Republican</td>
</tr>
<tr>
<td>3</td>
<td>Democrat</td>
</tr>
<tr>
<td>4</td>
<td>Independent</td>
</tr>
<tr>
<td>5</td>
<td>Republican</td>
</tr>
<tr>
<td>6</td>
<td>Independent</td>
</tr>
<tr>
<td>7</td>
<td>Independent</td>
</tr>
<tr>
<td>8</td>
<td>Democrat</td>
</tr>
<tr>
<td>9</td>
<td>Republican</td>
</tr>
<tr>
<td>10</td>
<td>Independent</td>
</tr>
<tr>
<td>11</td>
<td>Independent</td>
</tr>
<tr>
<td>12</td>
<td>Democrat</td>
</tr>
<tr>
<td>13</td>
<td>Republican</td>
</tr>
<tr>
<td>14</td>
<td>Republican</td>
</tr>
<tr>
<td>15</td>
<td>Independent</td>
</tr>
<tr>
<td>16</td>
<td>Democrat</td>
</tr>
<tr>
<td>17</td>
<td>Independent</td>
</tr>
<tr>
<td>18</td>
<td>Republican</td>
</tr>
<tr>
<td>19</td>
<td>Independent</td>
</tr>
<tr>
<td>20</td>
<td>Democrat</td>
</tr>
<tr>
<td>21</td>
<td>Independent</td>
</tr>
<tr>
<td>22</td>
<td>Democrat</td>
</tr>
<tr>
<td>23</td>
<td>Republican</td>
</tr>
<tr>
<td>24</td>
<td>Republican</td>
</tr>
<tr>
<td>25</td>
<td>Independent</td>
</tr>
</tbody>
</table>

a. Develop a frequency distribution for the data.
b. Construct a bar graph.
c. What does the data suggest about the strength of the political parties in Minnesota?

#2) The data listed below are the weights in pounds of a sample of workers:

a. Construct a class frequency distribution for the data.
b. Construct a histogram for the data.
c. Describe the shape of the histogram.

<table>
<thead>
<tr>
<th>Worker Weight (in Pounds)</th>
<th>Worker Weight (continued)</th>
<th>Worker Weight (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>164</td>
<td>165</td>
<td>168</td>
</tr>
<tr>
<td>148</td>
<td>145</td>
<td>154</td>
</tr>
<tr>
<td>137</td>
<td>168</td>
<td>151</td>
</tr>
<tr>
<td>157</td>
<td>163</td>
<td>174</td>
</tr>
<tr>
<td>173</td>
<td>162</td>
<td>146</td>
</tr>
<tr>
<td>156</td>
<td>174</td>
<td>134</td>
</tr>
<tr>
<td>177</td>
<td>152</td>
<td>140</td>
</tr>
<tr>
<td>172</td>
<td>156</td>
<td>171</td>
</tr>
<tr>
<td>169</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 2 3 4 5
no confidence at all very little confidence some confidence much confidence complete confidence

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#3) Create a stem-and-leaf plot for the data above in question #2.

```
 1 2 3 4 5  
no confidence at all  very little confidence  some confidence  much confidence  complete confidence
```

#4) Find the median for the data above in question #2.

```
 1 2 3 4 5  
no confidence at all  very little confidence  some confidence  much confidence  complete confidence
```

#5) Find the 35th percentile for the above data in question #2.

```
 1 2 3 4 5  
no confidence at all  very little confidence  some confidence  much confidence  complete confidence
```

#6) Find Q1 and Q2 for the above data in question #2.

```
 1 2 3 4 5  
no confidence at all  very little confidence  some confidence  much confidence  complete confidence
```

#7) The bacteria levels for 5 water samples taken from the Kokosing River are reported below.

a. Find the variance for this data by hand and show all of your work.
b. Find the standard deviation for this data by hand and show all of your work.

```
5.6 5.6 5.8 5.9 6.0  
```

```
 1 2 3 4 5  
no confidence at all  very little confidence  some confidence  much confidence  complete confidence
```
APPENDIX E

INTERVIEW QUESTIONS AND FOCUS GROUP QUESTIONS
Interview Questions

I’m a friend of yours from high school and I’ll be taking Prof. Strayer’s stats class next semester:

1. What would you tell me to expect from the course in general?

2. What should I expect to experience during the class periods?
   a. Do you feel like you are learning the same things as other students in the class?
      How important is this to you?
   b. Is learning in the class too fast for you? To slow? How do you adjust so that you can maximize your learning?

3. What should I expect from the homework in Prof. Strayer’s class?
   Is learning with the book (or ALEKS) difficult or easy? Talk about that. How does it work?

4. Let’s say I want to get an ‘A’ in Prof. Strayer’s course?” How do you respond?

5. Ok, so what if I just wanted to pull a ‘C’ in the course. How should I do it? What advice would you give?

6. Again, say I’m a friend of yours from High School and I’m planning on taking Prof. Strayer’s stats course next semester. I ask you, “Will this course be like other math courses we’ve had?” How would you respond?
   a. What do you think students should be expected to do in the classroom?
   b. What should the professor do?
   c. How do you go about learning when the actual class doesn't match up you’re your expectations? What adjustments do you make?
Focus Group and Interview Questions

I’m a friend of yours from high school and I’ll be taking Prof. Strayer’s stats class next semester:

1. What would you tell me to expect from the course in general?

2. What should I expect to experience during the class periods?
   a. Do you feel like you are learning the same things as other students in the class?
      How important is this to you?
   b. Some kind of “rate of learning” or “pace of the class” and how it affects the environment of the classroom question.

3. What should I expect from the homework in Prof. Strayer’s class?

4. Let’s say I want to get an ‘A’ in Prof. Strayer’s course?” How do you respond?

5. Ok, so what if I just wanted to pull a ‘C’ in the course. How should I do it? What advice would you give?

6. Again, say I’m a friend of yours from High School and I’m planning on taking Prof. Strayer’s stats course next semester. I ask you, “Will this course be like other math courses we’ve had?” How would you respond?
   a. What do you think students should be expected to do in the classroom?
   b. What should the professor do?
   c. How do you go about learning when the actual class doesn't match up you’re your expectations? What adjustments do you make?

7. Let’s say a friend of yours here at [this school] is collecting data for a project they are doing for a religion class. Your friend is asking a random sample of [this school’s] students questions like, “Are you a Christian?”, “If so, what is your denomination?”, “How many Sunday morning church services have you attended this semester?”, “Are you male or female?”, “Did you vote this year?”, “In a typical week, how many days do you read the Bible?”

Your friend asks you for help in analyzing the data. They want to know what kinds of conclusions they can draw from this data. What do you say?
Jack's Computer Store collected data from 72 randomly selected customers' files. Specifically, Jack was interested in whether or not the customer was a business user or a home user, the number of days it took the customer to pay their bill, the number of items (computer, printer, network equipment, camera, etc.) the customer purchased, location of the customer (In City, In State, or Out of State), and how many orders this customer has placed with Jack in the last 2 years.

Jack wants to use this data to get an idea of the typical amount of time it takes customers to pay their bill, and the typical number of items in an order. He also wants to use this data to get an idea of what would be considered a long time to pay the bill, what would be considered a large (or small) order, or what would be considered a large (or small) number of orders within the last 2 years.

Further, Jack wants to get an idea of the different types of customers he has, and he wants to know if there are relationships between these types of customers and the other data in the study.

Jack hires you as an independent consultant to analyze this data and report back to him.

<table>
<thead>
<tr>
<th>Kind of User</th>
<th># of Days</th>
<th># of items</th>
<th>Location</th>
<th># of Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
<td>19</td>
<td>8</td>
<td>City</td>
<td>3</td>
</tr>
<tr>
<td>Business</td>
<td>15</td>
<td>10</td>
<td>City</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>43</td>
<td>5</td>
<td>City</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>39</td>
<td>4</td>
<td>City</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>35</td>
<td>11</td>
<td>State</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>31</td>
<td>5</td>
<td>State</td>
<td>5</td>
</tr>
<tr>
<td>Home</td>
<td>38</td>
<td>4</td>
<td>State</td>
<td>1</td>
</tr>
<tr>
<td>Home</td>
<td>38</td>
<td>3</td>
<td>Out of State</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>38</td>
<td>2</td>
<td>Out of State</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>34</td>
<td>8</td>
<td>City</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>34</td>
<td>4</td>
<td>State</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>34</td>
<td>2</td>
<td>Out of State</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>30</td>
<td>5</td>
<td>Out of State</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>30</td>
<td>25</td>
<td>State</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>26</td>
<td>24</td>
<td>State</td>
<td>1</td>
</tr>
<tr>
<td>Home</td>
<td>26</td>
<td>7</td>
<td>City</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>21</td>
<td>7</td>
<td>Out of State</td>
<td>1</td>
</tr>
<tr>
<td>Business</td>
<td>16</td>
<td>12</td>
<td>State</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>34</td>
<td>24</td>
<td>City</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>30</td>
<td>26</td>
<td>City</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>26</td>
<td>19</td>
<td>State</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>26</td>
<td>10</td>
<td>State</td>
<td>1</td>
</tr>
<tr>
<td>Business</td>
<td>18</td>
<td>14</td>
<td>City</td>
<td>3</td>
</tr>
<tr>
<td>Business</td>
<td>16</td>
<td>16</td>
<td>City</td>
<td>2</td>
</tr>
<tr>
<td>Home</td>
<td>43</td>
<td>8</td>
<td>State</td>
<td>2</td>
</tr>
</tbody>
</table>

(This is just a sample of the data given to students.)
<table>
<thead>
<tr>
<th>Scale Name and Items</th>
<th>Item</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personalization</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The instructor considers my feelings.</td>
<td>A1</td>
<td>3.70</td>
<td>1.01</td>
<td>46</td>
</tr>
<tr>
<td>The instructor is friendly and talks to me.</td>
<td>A2</td>
<td>4.08</td>
<td>1.05</td>
<td>48</td>
</tr>
<tr>
<td>The instructor goes out of his way to help me.</td>
<td>A3</td>
<td>3.74</td>
<td>1.03</td>
<td>47</td>
</tr>
<tr>
<td>The instructor helps me when I am having trouble with my work.</td>
<td>A4</td>
<td>3.96</td>
<td>1.14</td>
<td>47</td>
</tr>
<tr>
<td>The instructor moves around the classroom to talk with me.</td>
<td>A5</td>
<td>3.52</td>
<td>1.26</td>
<td>46</td>
</tr>
<tr>
<td>The instructor is interested in my problems.</td>
<td>A6</td>
<td>3.68</td>
<td>1.24</td>
<td>47</td>
</tr>
<tr>
<td>The instructor is unfriendly and inconsiderate towards me.</td>
<td>A7</td>
<td>4.75</td>
<td>0.57</td>
<td>48</td>
</tr>
<tr>
<td><strong>Innovation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New ideas are seldom tried out in this class.</td>
<td>A8*</td>
<td>3.74</td>
<td>0.97</td>
<td>47</td>
</tr>
<tr>
<td>My instructor uses new and different ways of teaching in this class.</td>
<td>A9</td>
<td>3.31</td>
<td>0.99</td>
<td>48</td>
</tr>
<tr>
<td>The instructor thinks up innovative activities for me to do.</td>
<td>A10</td>
<td>3.08</td>
<td>1.03</td>
<td>48</td>
</tr>
<tr>
<td>The teaching approaches used in this class are characterized by innovation and variety.</td>
<td>A11</td>
<td>3.21</td>
<td>0.92</td>
<td>48</td>
</tr>
<tr>
<td>Seating in this class is arranged in the same way each week.</td>
<td>A12*</td>
<td>1.34</td>
<td>0.82</td>
<td>47</td>
</tr>
<tr>
<td>The instructor often thinks of unusual activities.</td>
<td>A13</td>
<td>2.92</td>
<td>0.96</td>
<td>48</td>
</tr>
<tr>
<td>I seem to do the same type of activities in every class.</td>
<td>A14*</td>
<td>2.75</td>
<td>1.00</td>
<td>48</td>
</tr>
<tr>
<td><strong>Student Cohesion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My class is made up of individuals who don’t know each other well.</td>
<td>A15*</td>
<td>2.77</td>
<td>1.03</td>
<td>47</td>
</tr>
<tr>
<td>I know most students in this class by their first names.</td>
<td>A16</td>
<td>2.23</td>
<td>1.02</td>
<td>48</td>
</tr>
<tr>
<td>I make friends easily in this class.</td>
<td>A17</td>
<td>3.23</td>
<td>1.12</td>
<td>48</td>
</tr>
<tr>
<td>I don’t get much of a chance to know my classmates.</td>
<td>A18*</td>
<td>3.06</td>
<td>1.06</td>
<td>48</td>
</tr>
<tr>
<td>It takes me a long time to get to know everybody by his/her first name in this class.</td>
<td>A19*</td>
<td>2.79</td>
<td>1.01</td>
<td>48</td>
</tr>
<tr>
<td>I have the chance to know my classmates well.</td>
<td>A20</td>
<td>2.51</td>
<td>0.95</td>
<td>47</td>
</tr>
<tr>
<td>I am not very interested in getting to know other students in this class.</td>
<td>A21*</td>
<td>3.29</td>
<td>1.17</td>
<td>48</td>
</tr>
<tr>
<td><strong>Task Orientation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I know exactly what had to be done in this class.</td>
<td>A22</td>
<td>3.79</td>
<td>1.18</td>
<td>48</td>
</tr>
<tr>
<td>Getting a certain amount of work done is important in this class.</td>
<td>A23</td>
<td>4.11</td>
<td>0.91</td>
<td>47</td>
</tr>
<tr>
<td>I often get sidetracked in this class instead of sticking to the point.</td>
<td>A24*</td>
<td>2.96</td>
<td>1.09</td>
<td>48</td>
</tr>
<tr>
<td>This class is always disorganized.</td>
<td>A25*</td>
<td>4.00</td>
<td>1.01</td>
<td>48</td>
</tr>
<tr>
<td>Class assignments are clear and I know what to do.</td>
<td>A26</td>
<td>3.96</td>
<td>0.97</td>
<td>48</td>
</tr>
<tr>
<td>This class seldom starts on time.</td>
<td>A27*</td>
<td>3.65</td>
<td>1.08</td>
<td>48</td>
</tr>
<tr>
<td>Activities in this class are clearly &amp; carefully planned.</td>
<td>A28</td>
<td>3.79</td>
<td>0.80</td>
<td>48</td>
</tr>
<tr>
<td><strong>Cooperation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I cooperate with other students when doing assignment work.</td>
<td>A29</td>
<td>3.96</td>
<td>1.13</td>
<td>48</td>
</tr>
<tr>
<td>I share my books and resources with other students when doing assignments.</td>
<td>A30</td>
<td>3.33</td>
<td>1.17</td>
<td>48</td>
</tr>
<tr>
<td>I work with other students on projects in this class.</td>
<td>A31</td>
<td>3.10</td>
<td>1.39</td>
<td>48</td>
</tr>
<tr>
<td>I learn from other students in this class.</td>
<td>A32</td>
<td>3.02</td>
<td>1.21</td>
<td>48</td>
</tr>
<tr>
<td>I work with other students in this class.</td>
<td>A33</td>
<td>3.40</td>
<td>1.14</td>
<td>48</td>
</tr>
<tr>
<td>I cooperate with other students on class activities.</td>
<td>A34</td>
<td>3.89</td>
<td>1.09</td>
<td>47</td>
</tr>
<tr>
<td>Students work with me to achieve class goals.</td>
<td>A35</td>
<td>3.33</td>
<td>1.08</td>
<td>48</td>
</tr>
<tr>
<td><strong>Individualization</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am expected to do the same work as all the students in the class, in the same way and in the same time.</td>
<td>A36*</td>
<td>1.79</td>
<td>1.13</td>
<td>48</td>
</tr>
<tr>
<td>I am generally allowed to work at my own pace in this class.</td>
<td>A37</td>
<td>2.96</td>
<td>1.18</td>
<td>48</td>
</tr>
<tr>
<td>I have a say in how class time is spent.</td>
<td>A38</td>
<td>2.42</td>
<td>1.09</td>
<td>48</td>
</tr>
<tr>
<td>I am allowed to choose activities and how I will work.</td>
<td>A39</td>
<td>2.17</td>
<td>1.00</td>
<td>48</td>
</tr>
<tr>
<td>Teaching approaches in this class allow me to proceed at my own pace.</td>
<td>A40</td>
<td>2.65</td>
<td>1.04</td>
<td>48</td>
</tr>
<tr>
<td>I have little opportunity to pursue my particular interests in this class.</td>
<td>A41*</td>
<td>3.40</td>
<td>1.09</td>
<td>48</td>
</tr>
<tr>
<td>My instructor decides what I will do in this class.</td>
<td>A42*</td>
<td>1.98</td>
<td>0.89</td>
<td>48</td>
</tr>
<tr>
<td><strong>Equity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The instructor gives as much attention to my questions as to other students’ questions.</td>
<td>A43</td>
<td>4.52</td>
<td>0.92</td>
<td>48</td>
</tr>
<tr>
<td>I get the same amount of help from the instructor as do other students.</td>
<td>A44</td>
<td>4.29</td>
<td>1.15</td>
<td>48</td>
</tr>
<tr>
<td>I am treated the same as other students in this class.</td>
<td>A45</td>
<td>4.40</td>
<td>1.12</td>
<td>47</td>
</tr>
<tr>
<td>I receive the same encouragement from the instructor as other students do.</td>
<td>A46</td>
<td>4.35</td>
<td>1.18</td>
<td>48</td>
</tr>
<tr>
<td>I get the same opportunity to answer questions as other students do.</td>
<td>A47</td>
<td>4.44</td>
<td>1.13</td>
<td>48</td>
</tr>
<tr>
<td>My work receives as much praise as other students’ work.</td>
<td>A48</td>
<td>4.40</td>
<td>0.95</td>
<td>47</td>
</tr>
<tr>
<td>I have the same amount of say in this class as other students.</td>
<td>A49</td>
<td>4.51</td>
<td>0.97</td>
<td>45</td>
</tr>
</tbody>
</table>

* Reverse scored items

** College and University Classroom Environment Inventory
### Item means and standard deviations for preferred version of CUCEI **

<table>
<thead>
<tr>
<th>Scale Name and Items</th>
<th>Item</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personalization</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>The instructor would consider my feelings.</td>
<td>P1</td>
<td>4.16</td>
<td>0.95</td>
<td>45</td>
</tr>
<tr>
<td>The instructor would be friendly and would talk to me.</td>
<td>P2</td>
<td>4.47</td>
<td>0.65</td>
<td>47</td>
</tr>
<tr>
<td>The instructor would go out of his way to help me.</td>
<td>P3</td>
<td>4.47</td>
<td>0.72</td>
<td>47</td>
</tr>
<tr>
<td>The instructor would help me when I am having trouble with my work.</td>
<td>P4</td>
<td>4.66</td>
<td>0.56</td>
<td>47</td>
</tr>
<tr>
<td>The instructor would move around the classroom to talk with me.</td>
<td>P5</td>
<td>4.15</td>
<td>0.86</td>
<td>47</td>
</tr>
<tr>
<td>The instructor would be interested in my problems.</td>
<td>P6</td>
<td>4.25</td>
<td>0.98</td>
<td>48</td>
</tr>
<tr>
<td>The instructor would be unfriendly and inconsiderate towards me.</td>
<td>P7*</td>
<td>4.85</td>
<td>0.62</td>
<td>48</td>
</tr>
<tr>
<td><strong>Innovation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New ideas would be seldom tried out in the class.</td>
<td>P8*</td>
<td>3.52</td>
<td>1.17</td>
<td>48</td>
</tr>
<tr>
<td>My instructor would use new and different ways of teaching in the class.</td>
<td>P9</td>
<td>3.85</td>
<td>0.95</td>
<td>48</td>
</tr>
<tr>
<td>The instructor would think up innovative activities for me to do.</td>
<td>P10</td>
<td>3.77</td>
<td>0.99</td>
<td>48</td>
</tr>
<tr>
<td>The teaching approaches used in the class would be characterized by innovation and variety.</td>
<td>P11</td>
<td>3.91</td>
<td>0.86</td>
<td>47</td>
</tr>
<tr>
<td>Seating in the class would be arranged in the same way each week.</td>
<td>P12*</td>
<td>2.09</td>
<td>1.28</td>
<td>47</td>
</tr>
<tr>
<td>The instructor would often think of unusual activities.</td>
<td>P13</td>
<td>3.32</td>
<td>1.25</td>
<td>47</td>
</tr>
<tr>
<td>I would do the same type of activities in every class.</td>
<td>P14*</td>
<td>3.60</td>
<td>0.87</td>
<td>48</td>
</tr>
<tr>
<td><strong>Student Cohesion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My class would be made up of individuals who do not know each other well.</td>
<td>P15*</td>
<td>3.62</td>
<td>1.11</td>
<td>47</td>
</tr>
<tr>
<td>I would not know most students in the class by their first names.</td>
<td>P16</td>
<td>2.06</td>
<td>1.16</td>
<td>48</td>
</tr>
<tr>
<td>I would make friends easily in the class.</td>
<td>P17</td>
<td>3.98</td>
<td>1.17</td>
<td>47</td>
</tr>
<tr>
<td>I would not get much of a chance to know my classmates.</td>
<td>P18*</td>
<td>4.06</td>
<td>1.07</td>
<td>47</td>
</tr>
<tr>
<td>It would take me a long time to get to know everybody by his/her first name in the class.</td>
<td>P19*</td>
<td>3.83</td>
<td>1.03</td>
<td>47</td>
</tr>
<tr>
<td>I would have the chance to know my classmates well.</td>
<td>P20</td>
<td>3.73</td>
<td>1.20</td>
<td>48</td>
</tr>
<tr>
<td>I would not be very interested in getting to know other students in the class.</td>
<td>P21*</td>
<td>3.77</td>
<td>1.28</td>
<td>48</td>
</tr>
<tr>
<td><strong>Task Orientation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would know exactly what had to be done in the class.</td>
<td>P22</td>
<td>4.90</td>
<td>0.37</td>
<td>48</td>
</tr>
<tr>
<td>Getting a certain amount of work done would be important in the class.</td>
<td>P23</td>
<td>4.21</td>
<td>0.92</td>
<td>48</td>
</tr>
<tr>
<td>I would often get sidetracked in the class instead of sticking to the point.</td>
<td>P24*</td>
<td>4.31</td>
<td>1.01</td>
<td>48</td>
</tr>
<tr>
<td>The class would always be disorganized.</td>
<td>P25*</td>
<td>4.51</td>
<td>1.10</td>
<td>47</td>
</tr>
<tr>
<td>Class assignments would be clear and I would know what to do.</td>
<td>P26</td>
<td>4.73</td>
<td>0.77</td>
<td>48</td>
</tr>
<tr>
<td>The class would seldom start on time.</td>
<td>P27*</td>
<td>3.98</td>
<td>1.21</td>
<td>47</td>
</tr>
<tr>
<td>Activities in the class would be clearly &amp; carefully planned.</td>
<td>P28</td>
<td>4.54</td>
<td>0.68</td>
<td>48</td>
</tr>
<tr>
<td><strong>Cooperation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would cooperate with other students when doing assignment work.</td>
<td>P29</td>
<td>4.06</td>
<td>1.09</td>
<td>47</td>
</tr>
<tr>
<td>I would share my books and resources with other students when doing assignments.</td>
<td>P30</td>
<td>3.85</td>
<td>1.11</td>
<td>48</td>
</tr>
<tr>
<td>I would work with other students on projects in the class.</td>
<td>P31</td>
<td>3.77</td>
<td>1.20</td>
<td>47</td>
</tr>
<tr>
<td>I would learn from other students in the class.</td>
<td>P32</td>
<td>3.88</td>
<td>1.08</td>
<td>48</td>
</tr>
<tr>
<td>I would work with other students in the class.</td>
<td>P33</td>
<td>3.81</td>
<td>1.15</td>
<td>47</td>
</tr>
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<td>I would cooperate with other students on class activities.</td>
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<td>1.07</td>
<td>47</td>
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<tr>
<td><strong>Equity</strong></td>
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</tr>
<tr>
<td>The instructor would give as much attention to my questions as to other students’ questions.</td>
<td>P43</td>
<td>4.81</td>
<td>0.50</td>
<td>47</td>
</tr>
<tr>
<td>I would get the same amount of help from the instructor as do other students.</td>
<td>P44</td>
<td>4.85</td>
<td>0.51</td>
<td>48</td>
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<td>0.38</td>
<td>48</td>
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<td>48</td>
</tr>
<tr>
<td>I would get the same opportunity to answer questions as other students do.</td>
<td>P47</td>
<td>4.78</td>
<td>0.59</td>
<td>48</td>
</tr>
<tr>
<td>My work would receive as much praise as other students’ work.</td>
<td>P48</td>
<td>4.81</td>
<td>0.49</td>
<td>48</td>
</tr>
<tr>
<td>I would have the same amount of say in the class as other students.</td>
<td>P49</td>
<td>4.85</td>
<td>0.42</td>
<td>47</td>
</tr>
</tbody>
</table>

* Reverse scored items

** College and University Classroom Environment Inventory

229
affiliation
attention focused on computer
before class activity
book vs. computer
bored
classroom different from others
classroom same as others
common experience as a class
communication
conceptual understanding
confusion
content drives learning
contradiction
control
correct answers
correctness of responses
diversity of learning approaches
emotion
fairness
familiarity.computers
familiarity.material
feedback
focus.external factors out of my control
focus.personal learning strategies
game playing
going it done but not learn it
getting help
group learning
homework
human-computer interaction
humor
hypotheses
immaturity
incorrect answers
introducing new information
key quote
kind words to professor
large group participation
learner.discomfort
learner.engagement
learner.freedom
learner.involvement
learner.opinion-has-changed
learner.opinions
learner.responsibilities
learner.understand profs thinking
learning.application
learning.auditory
learning.constructing-knowledge
learning.continuous practice
learning.creative-thinking
learning.difficulty
learning.evaluation
learning.example problems
learning.explain-it-to-me
learning.guided
learning.hands-on...experiential
learning.helpful
learning.lecture
learning.making-it-stick
learning.on-your-own
learning.problem based
learning.projects
learning.questioning
learning.re-reading
learning.repetition
learning.step-by-step
learning.taking notes
learning.textbook
learning.time
learning.used words
learning.visual
learning.with computer
learning.work load
like mathematics
locus of control - external
locus of control - internal
managing the class
material not exciting
math does not come easy
meta-monitoring
negotiation
pace
plugging numbers in previous learning
important
professor confused or frustrated
professor explains
professor frustrated or confused
professor.responsibilities
professor.responsive
professors attitude
relaxed
repetitive
representation
transformation
response to professor
review
seating
shift-in-thinking
student interactivity
student-professor interaction
students are attentive to class activity
students inattentive to class activity
students silent
students varied abilities
task completion
task orientation
test
time.management
time.quick
time.slow
transfer
understanding
unkind words to professor