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College Algebra with a Classroom Communication System:

Students' Experiences of Multiple Feedback Sources in Two Technology-Enhanced Classrooms

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Abstract

This comparative case study describes students' experiences in two research-based college algebra classes taught using technology-enriched curriculum in an activity based setting with multiple forms of assessment and classroom feedback. Using purposeful sampling, semi-structured interviews of 7 students and instructor, and standard qualitative data analysis procedures and validation strategies, the report characterizes the nature of course feedback in parallel sections of college algebra taught by the same instructor. Both classes used technology extensively, including graphing calculators, web-based homework, and a secure course website. Students in the two sections were randomly assigned as part of a complimentary quantitative investigation of achievement and one of the sections used a classroom communication system, the TI-Navigator™, as a way of networking students via graphing calculators to promote classroom participation in warm-up exercises and in-class activities. Findings include a description of students' use of classroom feedback, an analysis of students' reliance on peer interaction and formal midterm exams for feedback, and ramifications for the use of graphing calculators and classroom communication systems in college algebra instruction.

College Algebra with a Classroom Communication System:
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Four days a week at 2:30 p.m., and again at 3:35 p.m., about 27 students in each of Michelle Anderson's college algebra classes sit down at 8 six-sided tables to do mathematics. Students talk with each other and the teacher, as Billy puts it, "about nothing really, just stupid stuff" and then start a short activity within the first four or five minutes. Sasha, a student in the 2:30 class, summarizes the beginning of class this way:

> Well, we normally start every day with a, I guess you can call it a warm-up activity—where she kind of does an attendance kind of thing. She'll put a problem up on the board and everyone has to answer it. And then sometimes if there's enough problems she'll have one person from every group go up to the board and answer one of the problems. And sometimes it's only a couple people, but that way we're all working as a class to answer the same problem and we go over it all so that everyone understands. So it's kind of a group effort but at the same time it's a class effort too.

The 3:35 p.m. class uses the TI-Navigator™, a classroom set of graphing calculators networked with Ms. Anderson's computer, to complete the warm-up activity. Students often do the "Quick Poll" questions individually and then submit an answer via their calculator. The Navigator software collects the responses and automatically displays the students' submissions anonymously on a projector screen, serving as a prompt for whole-class discussions.

Following the warm-up, students usually work in groups of three or four on an in-class activity. Interactions between students during these activities form the core of the research-based college algebra curriculum, and I collaborate with Michelle daily to develop and write the

handouts. The activities have titles like “Whoopie’s Psychic Code,” “Estimating Time of Death,” and “Building Rational Functions.” As Jackie describes,

> In class activities are usually long and in-depth and sometimes they are like really tricky. But, usually it’s ok though because you’re working with the person next to you and when you get stuck you can just raise your hand and she’ll [the teacher] like come to you. But, sometimes there are a lot of people raising their hands. Then, she’ll realize that there are a lot of people that are stuck at a particular point in the activity. So, then we’ll like go up to the board and she’ll help us explain it to each other.

Many of the in-class activities are designed to incorporate the Activity Center feature of the TI-Navigator™ system. As a result, students in the Navigator-equipped class often participate by “contributing” equations or points through their graphing calculators in response to a prompt in the activity handout or a teacher’s question to the whole class. The non-Navigator class participates in parallel ways by having one person from each group go the blackboard and write their groups’ equation or point on the board. Students work until the 50-minute class time is over and then leave, usually without a “wrap-up” or follow-up discussion.

Outside of the classroom, students taking college algebra with Ms. Anderson are asked to practice and learn new skills. On Mondays the students receive a “Pencil and Paper Homework” handout that includes mathematical information that, as Amy says, “sort of relates to what we’re doing that week in class,” together with some exercises that are meant to prepare the students for Friday’s weekly quiz. These pencil-based homework handouts often focus on standard mathematical procedures that are not discussed in class. A set of 7 to 10 web-based homework exercises, called “Webwork”, is typically due every Wednesday at 10:02 p.m. (The extra two minutes is to give students a chance to hit “Submit.”) Students access their Webwork

assignments from the course website, which they also visit almost daily to check grades and read announcements for college algebra and other classes they are taking.

Students in both classes report owning a graphing calculator (e.g., a TI-84) and using it "all the time" when they are doing mathematics. Haley is typical in her usage of a graphing calculator:

Haley: I pretty much use it for everything besides simple stuff. Addition. Subtraction. Simple stuff… So I use it a lot. [laughs]

Joe: What do you use it for?

Haley: Everything! Graphing stuff, plugging equations into your calculator, almost everything.

Joe: Is there anything that frustrates you about it?

Haley: The calculator? Not really. I guess sometimes I don't know how much I can do, so I might be doing something by hand that it could be doing for me [laughs]

The students I interviewed in Ms. Anderson's college algebra classes described a class that did not rely on a textbook and lecture, but instead emphasized, as Sasha says, "Being able to work in groups and being able to experiment with how to find it—as opposed to being told, 'This is what it is.'" While not all of the students liked the college algebra class, they expressed a universal view that the instruction methods, forms of assessment, and use of technology in their class made it different in many ways from their previous math classes. In the text that follows, I describe the students' experiences in college algebra in the context of feedback, technology, and related literature.

Purpose and Need for the Study

My purpose in conducting a comparative case study of Ms. Anderson's college algebra classes was to better understand the experiences of students in two sections of college algebra taught using technology-rich instructional approaches. The inquiry complements a concurrent quantitative investigation of student achievement, goal structures, and calibration (cf. Pajares & Kranzler, 1995) using a randomized control group design (Creswell, 2003). The experimental design called for a control section taught using graphing calculators and a treatment section using a TI-Navigator™, which is a kind of classroom communication system. Through emerging qualitative methods (Creswell, 2007), a case study of Ms. Anderson's two classes can assist in understanding the patterns of communication and feedback among the students in the two technology-enhanced college algebra classes.

The role of technology in the experiences of college algebra students is a key strand of the research design partly because it plays an increasingly central role in the lives of university students and mathematics instructors. As suggested by Haley's description of her graphing calculator use and the other participating students who reported owning graphing calculators since the 9th grade, graphing calculators have flooded middle school, high school, and university mathematics courses. Meta-analyses of hundreds of studies on calculator usage in mathematics classrooms point to positive effects on student learning and attitudes toward mathematics (Ellington, 2003; Hembree & Dessart, 1986). Students' use of graphing calculators while learning algebra, in particular, is associated with improved abilities to make connections between functions and their graphs as well as enhanced spatial visualization skills (Penglase & Arnold, 1996).

Experienced teachers and researchers investigating graphing calculators point to potential advantages of using graphing calculators while cautioning of an obstacle to using graphing

calculators effectively: the relatively small screen-size on graphing calculators makes sharing mathematics with peers and the instructor difficult for students (Doerr & Zangor, 2000). The potential hindrances to communicating with graphing calculators in the classroom stands in contrast to the importance played by educators on regular feedback and communication in mathematics classrooms (National Council of Teachers of Mathematics, 2000). Opportunities for students to check their work with their peers as well as formative assessments, i.e., opportunities for teachers to learn about students' thinking and progress, can have positive effects on achievement (Black & Wiliam, 1998). One approach to improving the effectiveness of graphing calculators is to use the capabilities of a classroom communication system for providing students and teachers new opportunities to view each other's work and share ideas through calculator-linked presentations.

Methodology

Case Study as a Qualitative Tradition

Qualitative research is characterized by a researcher's emphasis on "*understanding the meaning people have constructed*, that is, how they make sense of their world and the experiences they have in the world" (Merriam, 1998, p. 7, emphasis in the original). My intentions reflect this basic aim and many of my choices in conducting this study are typical of the paradigm (Creswell, 2007), including decisions to conduct the research in a natural setting, use multiple sources of data, analyze data inductively, and to present my interpretations in holistic rather than reductionist forms (Patton, 2002).

Of the five qualitative traditions—narrative, phenomenology, grounded theory, ethnography, and case study (Creswell, 2007)—the proposed study fits within the case study genre. Although a case study can be thought of in terms of both the unit of analysis and the end

product (Merriam, 1998), “the single most defining characteristic of case study research lies in delimiting the object of study, the case” (p. 27). The “bounded system” represented by the proposed case study includes two college algebra classes taught by a single instructor and is limited by a relatively short duration (i.e., one academic semester).

Theoretical Perspective

As part of the research design and methodology, I am influenced by the philosophical perspective of constructionism (Ernest, 1996; Crotty, 1998). In a broad sense, constructivists claim that people act with agency and curiosity and “that meanings are constructed by human beings as they engage with the world they are interpreting.”(Crotty, p.43) Underlying this perspective about knowledge formation is an ontological rejection of a single objective reality and an adoption of the belief that meaningful reality exist in, and only in, the context of human interactions. Objects exist and humans think about external objects, but meaning is “developed and transmitted within an essentially social context.” (Crotty, p. 42)

My constructionist philosophical view is also mediated by a radical constructivist (von Glasersfeld, 1996) perspective on learning. In this endogenous (mind-centered) view of learning, there is no objectively “true” knowledge and individual constructions do not necessarily need to match external measures or socially negotiated norms. Instead, in the tradition of Piaget, I view learners as constantly assessing the viability of their constructions within their dynamically changing interpretations of their experiences (Driscoll, 2004). This perspective on learning and knowledge influenced many aspects of the case study, including data collection methods that allowed for flexible interview questions and efforts to present students’ constructions of their classroom experiences in their own words.

Participants and Setting

I conducted the study at a moderately sized, liberal-arts public university in the Mountain West serving approximately 12,000 undergraduate students. The sample of students eligible for participation in the broader quantitative study was a randomized group of 128 undergraduates who enrolled in four sections of college algebra in Fall 2007. About four weeks into the semester, Ms. Anderson provided me with a list of 5 participants from each class that she believed would provide the greatest possible range of information regarding students' experiences. The only additional criterion was that the students must have attended class regularly, which she took to mean "had missed no more than one day per week." I invited each of the selected students to participate in a single 30 minute interview as, which subsequently took place in the students' regular classrooms at agreed upon times during a two-week period in the middle of the semester. Five females and 2 males agreed to participate (3 males declined to be interviewed), and at the time of the interviews two students were earning an A in the class, three were earning a B, and two were earning a C. Amy, Jason, and Sasha were in the 2:30 p.m. (non-Navigator) section, and Haley, Jackie, Billy, and Jordan were enrolled in the 3:35 (Navigator) section. Interviews ranged in duration from 22 to 36 minutes.

At the time of the study, Michelle Anderson was a 35 year-old graduate student with 5 years of part-time college teaching experience. Prior to the course, Ms. Anderson was proficient in using graphing calculators, but had limited experience using calculators in instruction and no prior experience with the TI Navigator™ system. She learned to use the Navigator system in the weeks before the classes began. Ms. Anderson estimates that she eventually reached proficiency in using every aspect of the technology in the two classes around the 10^{th} week of the semester. I interviewed Ms. Anderson for an hour in the 12^{th} week of the semester to collect supporting data and to member-check preliminary themes.

Researcher Stance

My position as a researcher and co-participant in the study is influenced by a central role in developing the curriculum for the college algebra class with Ms. Anderson. I concurrently taught a similar course using the same instructional materials, and so undoubtedly brought preconceptions regarding what constitutes effective instruction in the course. This shared experience as an instructor of college algebra had advantages, though; it gave me intimate knowledge of the instructors' experiences and the participants' in-class assignments and curriculum. As a researcher, I also brought biases regarding how students learn and the positive role that I think technology can play in undergraduate mathematics. I believe that modern educational technology can stimulate meaningful innovation in college mathematics teaching and many of my teaching and research efforts reflect this belief. My positive prior experiences with technologies and six-plus years of teaching undergraduate mathematics at mid-sized universities has impressed me with a strong preference for technology- and activity-based instruction.

My personal views of technology and instruction may affect my interpretations of qualitative data and possibly indirectly affected the experiences of the students I interviewed. Although Ms. Anderson made many instructional choices in the classes, I co-developed the instructional materials and consequently affected many of the activities and experiences of students in the classes. My on-going professional relationship with Ms. Anderson required considerations of the intersubjectivity (Glesne, 2006) of the data collection and analysis process and the contributions of the participants to my interpretive process. It also engendered a need for reflexivity in the research, which for me meant keeping a researcher journal and attending to questions surrounding the age, gender, class, language, and values of my participants, myself, and my audience (Patton, 2002).

Data Collection

I relied primarily on semi-structured interview data and classroom documents in conducting the case study. The methods of qualitative research are designed to be emerging, so I addressed the research question using the following multiple data sources (in order of reliance):

1. Digital recordings of seven semi-structured interviews (Seidman, 1998) with students in Ms. Anderson's algebra classes. See Appendix A for the interview protocol.
2. A 45-minute unstructured interview with Ms. Anderson using initial themes from data analysis and the student interview protocol as a guide.
3. Typed transcripts all personal interviews. Of the 8 interviews, I transcribed five verbatim and the remaining three partially. See Appendix B for examples of full and partial transcripts.
4. Computer records of classroom activities and "Quick Poll" responses.

Analysis and Procedures

"Data analysis in qualitative research consists of preparing and organizing data for analysis, then reducing the data into themes through a process of coding and condensing codes, and finally representing the data in figures, tables, or a discussion." (Creswell, 2007, p. 148) In my attempts to understand and describe the students' experiences with feedback in Ms. Anderson's algebra classes, I followed Creswell's general processes as well as some more specific procedures. I analyzed the data inductively with the goal of finding both common themes in the students' accounts and the unique qualities that inevitably characterized each student's experiences with the class. This approach manifested itself through open-coding (Patton, 2002) transcripts to summarize the content of students' responses and collecting the open-coded portions into first-level categories (Glesne, 2006). In an effort to "let the data speak

for itself," I generally coded relatively large portions of the transcripts (several lines at a time) and tried to avoid the reductionist tendencies I have inherited from a background in mathematics. Also, partly due to my interests in technology, I placed special emphasis on students' descriptions of their experiences with the TI-Navigator™, graphing calculators, email, web-based homework, and the course website during the data analysis phase.

The overarching goal of the data analysis procedures was to understand the participants' experiences and to develop a descriptive account of the case. In a case study design, as Merriam (1998) says, "conveying an understanding of the case is the paramount consideration in analyzing the data." (p. 193) Toward that end, I engaged in a number of validation strategies, many of which altered the final representation of my findings and my participants experiences. Using Creswell's (2007) terminology for validation strategies, I engaged in 1) triangulation (by collecting and corroborating multiple forms of data), 2) peer review with two researchers (including one who observed Ms. Anderson's classes on a regular basis), 3) member-checking with Ms. Anderson, and 4) efforts to provide rich-thick description of the case in order to enable readers to make decisions regarding the transferability of my findings.

Findings

Students in Ms. Anderson's college algebra classes have varied mathematical backgrounds and diverging goals. Most of the participants, for example, expressed a strong preference for daily group work and in-class activities as alternatives to textbooks and lectures as ways of learning mathematics. In contrast, Billy expressed a dissatisfaction with "attendance points" and graded in-class activities because they required him to attend classes that he believed contributed little to his understanding of mathematics. Billy, along with Jordan and Sasha, had

four years of high school mathematics experience (including some calculus) and described much of the college algebra content as review of previously learned material.

The participating students with what might be characterized as "excellent" prior mathematical preparation for college algebra appeared to seek classroom feedback as a gauge of their performance in the class and their understanding of the material. The other four students, however, intimated that the information they gathered from the course helped them to learn mathematics, view concepts in new and different ways, and track their progress in understanding algebraic topics.

Multiple Forms of Feedback Used in Multiple Ways

In seeking to understand the ways in which students experienced feedback in the technology-enhanced classrooms, I gathered students' descriptions of course components from the perspective of how the information they gained help them in their experience of the course. The results suggest that classroom feedback in Ms. Anderson's college algebra classes is derived from many sources, including in-class activities, student-to-student conversations, teacher-student conversations, whole-class discussion, warm-up activities, midterm exams, weekly quizzes, pencil and paper homework, web-based homework, email, the course website, the TI-Navigator, the instructors' office hours, and graphing calculators. Table 1 summarizes some of the sources of course feedback in Ms. Anderson's college algebra class in the context of common questions students seem to use the information they derive from feedback to answer. Ultimately, the two sources of feedback on which students appeared to rely most heavily were daily student-to-student interactions and midterm examinations.

Students seemed to rely heavily on each other as a source of feedback for their day-to-day progress and efforts to understand mathematics. Jordan stressed the importance of "working

at a good table where you can ask each other questions" and mentioned that "whenever one of us gets the answer, we'll show everyone how we did it." Amy duplicated the belief that working with others was important to her learning, saying

> I know a lot of people because we move around the tables, so a lot of us come before class to explain homework or stuff to each other. It helps to have someone else explain it in a different way, maybe another way from how the teacher might say it.

Table 1.

Sources of course feedback aligned with common questions asked by students.

Questions	Are my answers correct?	How am I doing in the class?	Am I on the right track on these problems?
Sources of Feedback	• Ask another student • Ask the instructor in class • Discuss as a whole class • Submit the answer on Webwork • Check with a calculator • Compare to other answers on Navigator • Visit the instructor during office hours	• Check grades on Blackboard • Look at exam grades • Compare scores to class averages • Compare performance to previous math classes • Talk with or listen to classmates discussing performance	• Talk to a group member • Ask the instructor in class • Ask students in another group • Check with a calculator

Students in Ms. Anderson's college algebra classes talked with their group members partly to gather information about the correctness of the mathematics they had constructed and partly because *they felt they had to* in order to successfully complete activities. This group-interdependence is exemplified by how Sasha described one of the in-class activities:

> Um, in the last one we did, there were interest rates and investment stuff. As a group, we had to figure out how much money we had with us at that point in time. So, we each pulled out our wallets and counted up our money. And we had to figure out, at our chosen percentage rate, how much that was going to increase. And if we invested our set amount

> of money how much it was going to increase. And we had to do it for annual and then compounded quarterly. Instead of going, "Here's the equation, now plug in all these numbers and come up with an answer," it was "What's the next value going to be?" and "Come up with it yourself." So, it was, we could calculate it without an equation initially, because you just multiply it by the percentage rate and you get the next number, and then you multiply that one… So, from there—after we figured out all these numbers—we then had to go back and apply an equation to the situation we had come up with and we'd found the answers to.

Another prominent role of course feedback surrounded the midterm examinations. While few students could remember specific items on the two exams, they all remembered their scores on the exams. Students generally expressed the view that exams were fair, reflected the major topics in the course, and were a good way of assessing understanding. As Jason said, "I think exams are hard, but I also don't think there is a lot of trivial stuff or anything. They basically are the main topics and the stuff we've done in class." Haley, who usually struggled in mathematics classes, focused great efforts in preparing for exams by carefully working through study guides, preparing "note cards for any equations we have to remember," and visiting Ms. Anderson during office hours with any questions she had prior to exams. Haley viewed exams as a valid form of comprehensive feedback on her understanding:

> I like them [the exams] because they're pretty obvious as a way to know about how you're doing. They're not too hard I guess. They're pretty accurate to what we've been doing, so that's good. They totally cover it and stuff, so that's good. It's not just random stuff that we've never seen before.

Jackie comments about her performance on exams hints at an even deeper internal connection between exam scores and Jackie's perception of her understanding. She said,

> The first exam… I felt good. It was fine to me… And the second exam, I don't know, I just did not feel as confident. And, the first exam I got an A, I'm pretty sure, and the second exam I got a C, so I was like "Oh gosh, is it me?". But then I heard that the class, overall, didn't do as well, so I was like ok. And also, the first exam I finished before time and I was set, but with the second exam I like took the whole class period and I still wasn't done after it was let out. I don't know, maybe it was a hard exam or maybe I should have studied more. Even though I thought I knew the material well enough, I maybe should have wanted to know a little more.

Frequent Formative Assessment in a Supporting Role

Ms. Anderson's use of educational technology and her students' experiences of multiple forms of feedback can be considered in the context of frequent informal assessments. By the end of the semester, students in Ms. Anderson's class earned grades on 50-plus assignments (including quizzes, homework, and in-class activities) and engaged in at least as many warm-up or "Quick Poll" assignments. In addition, the frequent discussion between students and the teacher during in-class activities combined to characterize Ms. Anderson's class as being rich in low-stakes formative (or informing) assessment.

Many researchers have touted the beneficial effects of using formative assessment strategies in university courses (e.g., Keppel, Au, Ma, & Chan, 2006; Ulmer, 2000). The use of formative assessment, Black and Wiliam (1998) argue, is "at the heart of effective teaching" (p. 140) and frequent performance-specific feedback often leads to marked improvement in student performance, especially among low-achieving students. Supporters of formative assessment

includes take the view that learning is interactive and that student-learning is benefited by frequent opportunities to check thinking against peers and physical realities. Technology-enhanced learning environments can include instructional strategies that are particularly good for promoting formative assessment (Keppel et al., 2006) and can benefit students when coupled with low-stakes self-assessments (Ulmer, 2000)— including the kinds of self-assessments envisioned by the makers of classroom communication systems (Dufresne et al., 1996).

Classroom Communication System and Graphing Calculators

The only interview question that resulted in nearly identical student-responses was the interview question "Do you have a graphing calculator, and if so, how often do you use your calculator?" All of the respondents reported that they owned a graphing calculator from high school and that they used their graphing calculator at least daily. As Haley described in the introduction, her only frustration with using her graphing calculator was a sense that there might be features she could use to do less of the work by hand. Six of the seven students reported using their personal calculator "all the time" and many suggested that it was essential to graphing and doing complex (and sometimes even simple) arithmetic calculations. Billy responded typically, "I've got the TI-83 Plus Silver and I've had it since 9th grade or something like that. I use it all the time for math, so whenever I'm doing math I'll use it pretty much."

Ms. Anderson started the semester with "an anti-calculator personality" and worried that it could be "used as a crutch." By the time I interviewed her about her students' calculator use, though, she reported that it was an important aspect of students' experiences in the class:

> My students can not survive without their calculator. They use it everyday and the directions on the handouts are so good that there's very little focus on learning how to use the TI-calculator. The class is not more about the calculator than the math, which is

surprising for an anti-calculator personality. This is the first semester that I've seen it used as a tool and not just a crutch.

Positive learning effects of calculator use in mathematics instruction are well documented. Ellington (2003), in a meta-analysis of 54 graphing calculator studies on student performance, largely agreed with prior research (Hembree & Dessart, 1986) when she concluded that calculators do not negatively affect development of mathematical skills, but instead are associated with significant student gains in problem solving and operational skills. However, Ellington's findings included an important potential pitfall of using graphing calculators in upper-level mathematics: advanced technologies such as graphing calculators are most effective when they are fully integrated in both instruction and assessment. In their review of graphing calculator research, Kastberg and Leathem (2005) suggest three themes related to graphing calculator-based instruction:

1. Even limited access to graphing calculators is associated with improved student achievement and problem solving skills.
2. Positive effects of graphing calculators are greatest when curriculum is designed with the features of the tools in mind.
3. When access and curriculum are controlled, the most important factor in student learning outcomes is pedagogical practices.

While it is probably largely due to the general acceptance of calculators in secondary mathematics classrooms, it seems likely that a significant supporting reason for the seemingly positive role of calculators in Ms. Anderson's class is the activity-based curriculum for the course. The daily handouts often included instructions for analyzing graphs or modeling data with a calculator, so students may have quickly adopted graphing calculator use as a norm for the

course. The role of graphing calculators in the context of the TI-Navigator™ is another theme in the students' responses.

The use of classroom communication systems in teaching mathematics is grounded in decades of attempts to use personal response systems as tools to support interactive lecture methods in introductory college physics courses (Judson & Sawada, 2002). Researchers working with one such system, *Classtalk*, found that combining personal response systems with small-group work could be particularly successful in encouraging cooperative learning and actively engaging students (Dufresne et al., 1996). As the direct successor of *Classtalk*, TI-Navigator™ research suggests potential effects of the system on student achievement, classroom learning environments, and the nature of student and teacher interactions (Davis, 2002; Dougherty et al., 2005; Owens et al., 2002; Stroup et al., 2005).

After using the TI-Navigator™ system for brief durations, Dougherty et al. (2005) and Stroup et al. (2005) found significant gains in algebra achievement of eight and ninth grade students, respectively, who participated in classes using the systems. While improving student achievement is an important educational goal, there may be even greater potential for classroom communication systems to affect the learning environment of mathematics classrooms. Owens et al. (2002) found that the use of a TI-Navigator™ system positively affected mathematics learning by promoting learner-, knowledge-, assessment-, and community-centered instruction (Bransford, Brown, & Cocking, 2000). Dougherty et al. (2005) found that eighth grade students who used a classroom communication system had greater positive attitudes regarding the use of technology in mathematics and engaged in more student-to-student interactions. The real-time capabilities of the system to present student-generated mathematics is also linked to improved

opportunities for informal formative assessment in classrooms using the TI-Navigator™ (Owens et al., 2002; Davis, 2002).

The experiences of students engaged in the TI-Navigator classrooms with formative assessment and feedback did not appear to be significantly different from the students in the non-Navigator classes. The students enrolled in the Navigator-equipped section appeared to not view it as an essential component of the course in the same way they viewed in-class activities, exams, and using graphing calculators as core components. In fact, at least two of the students believed that the primary role of the Navigator was to take attendance. Billy summarizes the general sentiment towards the role of the TI-Navigator:

> **Joe**: Do you think if I took it out of the class—the navigator—do you think your class would be different? Better or worse?
>
> **Billy**: I don't think it would be any different, because maybe she would just put the problem on the chalkboard and we would do it on a piece of paper and turn it into her. So, I don't think it would really make a difference. It's just sort of a fun extra thing.

Jackie's view of the TI-Navigator is quite different from that of her peers, however. She thought of the TI-Navigator primarily as a tool for the teacher to learn about the students' thinking as well as for the students to deepen their understanding of mathematics.

> **Joe**: How about math questions. Does your teacher ever ask the whole class math questions?
>
> **Jackie**: Yes, usually we'll start our day off and she'll have a math question on the board and it's a Quick Poll and everyone will enter an answer into the calculator. Either the problem is something that we've done before or it's something that she just wants to see if we know how to do it. Or, if we didn't finish a problem from the homework, then

people will put it in. Then afterwards if she sees that not many people got it right or if there are various answers, then she'll solve it on the board to make sure that everyone knows. If most of the class gets it right, then she usually doesn't go over it because she thinks that we all understand the concept well enough.

Joe: So, what's that like? What makes that different from if she just asked everyone to try this problem on a piece of paper?

Jackie: Well, to me it's just a quicker way to see… Everyone could write down their work on a piece of paper, but she'd have to go around and collect all the papers and look at each person and see who got it right and who got it wrong. So, with the calculator she just sees everyone's answer that they figured out and it's just up there on the screen and the rest of the students can see what other people got and what they got. Like, "Ok, I got that too" or "It's just me" or "Wow, was I the only person who got that answer?"

The potential for the TI-Navigator™ to be used in the way Jackie describes is very real, but may have been hindered by the research design. As a teacher that was relatively new to using the Navigator and teaching in an activity-based format, Ms. Anderson was additionally burdened by requirements to present college algebra in two *different* ways in a span of two hours each day while simultaneously co-developing curriculum for both courses. Given the circumstances of the research, the fact that the TI-Navigator™ may not have been used to its full potential may have been unavoidable.

Advanced use of technology, multiple forms of feedback and assessment, and activity-based instruction, appeared to have converged in ways that left Ms. Anderson's students with the impression that they were engaging in a very different type of mathematical learning experience. While the picture is still not completely clear, the qualitative data in this case study sharpens

some of the characteristics surrounding students' experiences in the Ms. Anderson's class on those four days a week at 2:30 p.m., and again at 3:35 p.m., when about 27 students sat down at 8 six-sided tables to do mathematics.

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Appendix A

Interview Protocol

Thank you for agreeing to participate in this interview about your college algebra experience. Specifically, the goal of this interview is to collect some information from you about how you gather information in college algebra. The interview is expected to take about 30 minutes.

Is it okay if I record our interview? [If yes, turn on microphone and repeat the question so it is recorded]

When I write about this interview I'd like to give you a fake name for confidentiality purposes. What name would you prefer that I use?

[After each of the following questions, ask one or two clarification or probing questions]

How has college algebra been going for you this semester?

What's your favorite part of the class?

What's your least favorite part of the class?

Can you describe one or two times that you've communicated with your instructor this semester?

One of the things I'm interested in is the ways that you get information about how you're doing in the class. I'm going to list some ways of getting feedback.

Could you talk about each one of the things I mention in terms of how they may or may not have helped you know how you're doing in the class?

- In-class activities
- Quizzes
- Exams
- Questions asked by the teacher to the whole class
- Conversations with other classmates
- Talking with the teacher
- Visiting the teacher during office hours
- Online Homework
- Email
- Blackboard
- Your calculator
- [If applicable] The TI-Navigator

Can you think of any other ways you get information about how you're doing in the class? [If yes, ask to please describe]
Well, that's all the questions I have for you today. Is there anything you'd like to ask me?
Thank you for taking the time to talk with me.

Appendix B

Example Interview Transcripts

Full Transcript of an Interview with Sasha.

Date/Time:	Thursday, October 25th at 4:30pm
Pseudonym:	"Sasha"
Total Length:	32 minutes, 50 seconds
Comments:	I knew "Sasha" from a visit she made to my office to talk with her instructor. She came in to talk about a physics problem, but her instructor was busy so I helped her (unsuccessfully) for about 10 minutes to solve the physics problem. Sasha is very aware of what's going on in her college algebra class, is extremely good at recalling and describing her experiences in the class, and—along with Jackie—ultimately provided the most in-depth responses.

Time	Person	Transcript
		Recording STARTS with Joe speaking into the recorder to give the date and time of the interview. Joe says the real name and pseudonym of the interviewee and gets Sasha's consent to be audio-recorded on the tape.
00:24	Joe	Ok, so the purpose of the interview is to find out about your, um, college algebra class. My first question is, What do you think of the class?
	Sasha	Um, I really like it. I definitely like the fact that it's not centered around a textbook. It's more centered around group work. Cuz, you get to know the other students, and you get to talk with them, and it's problem after problem after problem. It's let's figure out how to do this on our own as opposed to "Here's how to do it, now try to figure out how to adapt that to the problem we give you."
1:04	Joe	So, have you had that kind of math class before?
	Sasha	Yeah, mostly throughout high school. It was… They'd kind of do a little bit of like the lecturing in class and they'd go over some of the problems, but then it would be like a list of 50 some problems for homework that you'd somehow have to figure out what they gave you in class to adapt it somehow to the homework problems. Whereas, in this class, it's much more let's figure out how to do it on our own, rather than being given the way how to do it. I think I end up understanding better.
	Joe	That's great. So what would be your favorite part of the class?
	Sasha	Being able to work in groups and being able to experiment with how to find it—as opposed to being told "This is what it is". Like the other day, yesterday in class, we were working with transposing… We were working with, not transposing graphs, but we were working with equations and with compounding interest and we were trying to find the equation as opposed to being given the equation.
	Joe	The equation?

	Sasha	The principle and then in parenthesis you've got one plus the percentage rate over the number of times compounded, and then outside the parenthesis it's like to the power of—that was the part we were having trouble with—I think we ended up coming up with it was 4q. Four times the number of quarters or time times the number of times it's compounded. Something like that. [laughs] That was the one we had problems with [laughs], so..
	J	No, that's great. That's very good and I'm surprised that you remember that.
2:46	S	Yeah, I have kind of like a photogenic memory, so I see something and I can pick up on it really fast.
	J	Oh, so you can actually picture/
	S	/The actual page that we were working on yesterday and where on the page the problem we were working on was written down.
3:12	J	That's a very useful skill. Yeah, that's great. So, let's see. Can you give me a story of a time that you've talked with your instructor directly?
	S	Umm, there's lots of them. Because I've come in to meet with her multiple times. I think the most recent one was with the webwork. Because it has a very particular way of how it wants you to put in the answer, and it's not always clear in the question how it wants you to put in the answer. For instance, if I put in the higher number first, and then the lower number second (if there were two answers), then it told me I got it wrong. I put in/ It was like 2.5 and 3.5 and if I put in 3.5 comma 2.5 it told me I was wrong. I had to put in 2.5 comma 3.5 and to me that wasn't something it would naturally, something would have to go in like increasing order like that. So, I've run into a couple problems like that, where I couldn't figure out why. I'm like, "I have the right answers here. I've done it quite a few times." So she ended up just helping me figure out I have to flip it around and showing the different ways I have to write the answer I've come up with.
4:23	J	Uh huh.
	S	I've actually also gone in to talk to her/ I'm taking a physics class right now and so I've asked her and you actually questions about my physics homework. You just have a more, a different way of explaining it that can. Like different from the professor, so it gives me a better understanding of and broader perspective of the problem.
	J	Hm. I think that always sort of helps to have somebody else explain something. So, in class, does that happen, where you have someone else/
5:08	S	Yeah, because usually in class we'll start as working in our groups. In our four working together. And we'll either finish that problem that day and then as a class do it on the board so you get everybody's different way of doing it as opposed to just your way. Because sometimes somebody else will have a way that's easier than yours. Or, just different that you understand better, that kind of thing. So, if we don't do it the same day, we'll do it the next day or at least we'll go over it so we know for sure that everybody understands the entire thing so that we get the entire thing.

	J	[Coughs] Okay, um, so it sounds like you're really enjoying the class. But, if there's something that you just really don't like? If you had a shot, you could just get rid of it. Or maybe not necessarily something you would get rid of, but something that's your least favorite?
	S	Um, [pause] Well I guess I've taken in high school up through Precalculus, so some of the different things we've been doing have seemed to me a little like below what I've done before. That kind of thing. So, it's like reworking a problem from the beginning when I already know what the answer is. Or, already know the equation and sometimes I feel it's a little bit slower and I want to move at a faster pace. But then again I know there are a lot of people that haven't had all the experience I had in high school of knowing the equations ahead of time kind of thing. So, sometimes I wish she'd go a little faster pace, but other than that I really enjoy the class.
6:46	J	So, we've talked about a story when you've talked with the instructor. [pause] Oh, ok. One of the main things that's associated with our research is the fact that your class is set up so that it has more than just a couple ways of doing things. So, I have a list of some of the various parts of your class. So, what I'm interested in is if you can describe for me what your experience has been. Have you found them to be a useful part of the class, that sort of thing. And I know that was a lot/
	S	/Ok, can you go back because there was too much in that question for me to get it completely. [laughs]
	J	[laughs] Yes. I'll give you an example. You do some in class activities in your class.
	S	Mmhmm.
	J	What do you think of those in class activities and what are they usually like?
8:03	S	In the in-class activities, we're usually given a piece of paper that has a scenario on it. Um, in the last one we did, there were interest rates and investment stuff. As a group, we had to figure out how much money we had with us at that point in time. So, we each pulled out our wallets and counted up our money. And we had to figure out, at our chosen percentage rate, how much that was going to increase. And if we invested our set amount of money how much it was going to increase. And we had to do it for annual and then compounded quarterly. Instead of going, "Here's the equation, now plug in all these numbers and come up with an answer," it was "What's the next value going to be?" and "Come up with it yourself." So, it was, we could calculate it without an equation initially, because you just multiply it by the percentage rate and you get the next number, and then you multiply that one/ So, from there—after we figured out all these numbers—we then had to go back and apply an equation to the situation we had come up with and we'd found the answers to. So, I guess you can say it's much more I guess you can say hands-on as opposed to just being given the equations and finding the answers.
9:17	J	That was a beautiful description. [laughs] Very articulate.
	S	[laughs] Okay.

J So, can you give me a couple other examples. It sounds like that was a sort of recent example involving interest and working with a money scenario, can you sort of rattle off the top of your head any other ones you can remember?

S Um, we've done a bunch with transposing graphs and different curves of graphs and how to move the graphs different directions. We've done ones with systems of equations and matrices and how to add two different equations. That kind of stuff. Um, I actually have every single one that we've gotten back so far.

J Great

10:15 S Let's see here. We've done.. that's a graphing one, this one is another graphing one dealing with an item of food and how long it would take to prepare it and comparing that to the temperature. Um, we have… We did one with stick figures where we were given shapes with sticks in these visual pictures here and we had to then go through and find the next one. So, we were doing recursive equations and also trying to figure out how many sticks it was going to take to make, say the 20^{th} figure. We were given the first, second, and third. We did ones with M&Ms and probability. We had a cup of M&Ms and poured it out and find out how many were considered sunny side up, or with the "m" facing up and the probability of that one. There was, we got to choose a movie and then the professor went out and found the statistics of that movie of the sales for the first couple weeks that it was out. And we had to then create lines of best fit for a graph that we'd created with different points.

We worked/ um.. Each/ Our table came up with an equation and we graphed it. So we were given a parent function—ours was x squared—and had to transform it to move it to somewhere else, and then we had to give our graph to another group. They had to figure out what our equation was and we were given their's and we had to figure out what their equation was. So that was working with another group. [flips through papers for a few seconds]

Um, and then we worked with functions composite, or function compositions where we were given two different equations and we had to figure out how to multiply them together. And we were given an x and we had to find f of g of x or g of f of x. We did that in a bunch of different kinds of ways and that was another one where each group had an equation and we had to use another group's equation. We did rational functions, figuring out how to find the x intercept, y intercept, horizontal intercept, vertical intercept, intervals of increasing and decreasing, intervals of concave up and concave down—which was really confusing—and end behavior.

And yeah, those are all the different ones we've done.

13:40 J That's a lot.

S Yeah, we've done a lot of different activities. It's almost an activity, not quite every single day of class, but it's pretty close.

J Alright, um, how important do you think they are to the class? In other words, if I removed the activities from the class would it be the same kind of class to you?

S No, because that would be a textbook class, where we sit there and we're given a textbook and we're given, "Here's the equation, now go do the problems with the equation." Whereas these activities get us to figure out what the equation was. And, yes, we do have to do the same kind of problems with the equations, but they do have a little bit more application because we actually have to figure out what the equation was ourselves. Instead of "Here's the equation, now we're going to give you a random abstract situation and you somehow have to figure out how they go together." Unh-uh.

14:39 J Ok, so how about the quizzes. The weekly quizzes. What do you think of them?

S Um, they're over the pencil and paper homework that we get at the beginning of every week. And sometimes it's a little confusing because what's on the paper homework is very, very different from what we're doing in class that week. Yes they relate, but we never actually go over in class the pencil and paper homework. So, sometimes it's a little more difficult because if you have a question on that, it's not like you can go over it. You have to come in on your own, which is fine, but at the same time I sometimes wish that we actually go over it. Even just a little bit. Not even to necessarily say, "Here's how to do it", but even if it's just on Thursday, say "Here's all the right answers." If you have any questions, you could go in and ask about it so that if there's something that you did wrong or that you didn't understand, you could figure it out before the quiz on Friday. So, I think something like that could be helpful because those can be a little confusing at times. But most of the time, they're fine. It's just the pencil and paper homework definitely helps with the quiz, because you can know what the quiz is going to be over already. And if you actually do the pencil and paper homework, you get some practice in doing it beforehand.

16:10 J So how have you ended up doing on these quizzes?

S I think I've gotten one 16, one 19, one 19.5, and the rest of them were all 20s.

J Oh, wow. I'm impressed that you remember that [laughs]. I think I'm impressed by all the things you remember. Ok. So, quizzes, exams, and in-class activities. These are sort of pencil and paper kinds of things.

S Yes.

J Um, how about your instructor. When she… If she sometimes talks with you in class. Does she ever ask questions to the whole class? That are sort of designed so that anyone can answer or everyone can answer. That kind of thing.

S Yeah, well, we normally start every day with a, I guess you can call it a warm-up activity—where she kind of does an attendance kind of thing. She'll put a problem up on the board and everyone has to answer it. And then sometimes if there's enough problems she'll have one person from every group and answer one of the problems. And sometimes it's only a couple people, but that way we're all working as a class to answer the same problem and we go over it all so that everyone understands. So it's kind of a group effort but at the same time it's class effort too.

17:35 J How about times that you've talked with your classmates. So have you ever used

that to learn the math?

S Yes, when every day we get our activities we all work together as a group to answer the questions and help eachother so that everyone in the group understands.

J How many people are in your group?

S My first group was 4, the second group was 3, and now I'm in a group of 4.

J Okay, do you remember any of the peoples' names in your group?

18:06 S Um, my first group it was me, a guy named Andrew, a guy named Brandon, and a guy named John. The second group it was me, a girl named Erin, and for part of the time there was a girl named Elizabeth in our group but then I think she dropped out of the class. And then currently, it's me, Brandon—who was actually in my first group, a girl named Eva, and a guy named Preston.

J Oh, okay. Wow. We've already talked about you visiting your teacher in her office hours. How many times would do you think you've gone to see her?

S Um, I almost want to say every other week.

J Oh, okay.

S Yeah. [laughs] Maybe I haven't gone in quite that often, but I know I've gone in 3 or 4 times already at least. It's not even always going in and meeting with her, it's sometimes I'll email her a question. Sometimes she can answer my questions through email. Yeah, but it's normally kind of just… even if kind of just to check in and get my questions answered.

J So what do you think if, a college freshman were coming in and planning to take college algebra, how many times do you think they should visit their instructor during their office hours?

S I think it's a good idea to go in and check with the teacher at least once a month. That way you go in and you're keeping track of everything. But I know there are students who will never go in because I know I've had classes where I've never met with my professor. But most of the time, when it's a class that's this involved, um, I would say you've got to go in at least once a month. Probably even more often than that.

20:00 J So, we've talked about email.

S Yes.

J And you said you've emailed your instructor. About what kinds of things?

S Um. Well, normally, when I end up with a problem with—it's normally been the webwork—I'll say, "I've gone through and done it all. These are the problems I'm having trouble with, because for some reason they're not going into the computer. I'm not entering them correctly some how." And most of the time when it comes to webwork, it's easier for me to come in and actually meet with her and show her, so she can see exactly what it is I'm doing wrong. Because when I try to explain it in an email it's not always the clearest because it's just kind of difficult to explain "this number was here, this number was here and" It's just easier to go in and show

her how I did it.

20:49 J And I can imagine it's hard because each student gets their own/

S /gets different problems. Yeah. So I'll email her that, and then normally she'll get back to me. And other… There was one time she said, "You've got all the right answers, here's how to enter them" and then other times it's been "Ok, come on in and I'll show you how to enter them in."

J Has the instructor ever emailed you?

S Yes. We had to send her an email like in the very first week of class telling her something about ourselves as math students and we got an email from her—kind of more of a personalized reply back on that one. We've gotten a couple of other ones, but a lot of times she'll put a note for us on Blackboard as opposed to sending an email. And I happen to be one who checks Blackboard at least once a day. So we get all sorts of notes up on there. Like there was one last week about there being a copy of our exam and along with an answer sheet so we could study on our next quiz.

J Ok. So what's Blackboard?

S [laughs]

22:08 J [laughs] I mean I know, but let's pretend I don't know what Blackboard is. And why do you visit it?

S Ok [laughs]. Blackboard is a… I'm not sure who put it together, but it's a website that students and professors use to communicate. I'm pretty sure the school probably goes through and… I don't know if it's the school or the teacher who goes ahead and puts in all of their students and their email addresses and gives them access to that specific class' Blackboard website. So, on that website we can access our grades for the class, our teachers can leave messages there. We've got access to email their, so we can email our professor. We've got access to other students' email so we can contact them. It's kind like a class website so we can communicate.

23:07 J Okay, so now how about calculators. Do you use a calculator in your class?

S All the time. [laughs] Like every day. Yes, we use our calculators all the time, whether it's putting in a graph, for calculating things. We've been working with log and natural log, and those aren't especially easy to calculate on paper, so we've kinda been using the calculators for that kind of thing.

J What kind of things do you use calculators for? Calculating logs…

S We'll put graphs in there, and when you put in the equation for a graph it'll come up with a line on the graph and you can also make a table out of it. So, you'll be able to find more exact values. You can put in a table and be able to trace to an exact value and find the equivalent value of x and y that goes with it. Um, we did stuff before with the quadratic equation, and from my high school I actually have a program in my calculator with the quadratic equation, so I just have to enter a, b, and c. But other people they actually calculate it all out in their calculator. So, we

use it a lot.

24:26 J So, coming into the class, did you know a lot about it, or have you learned about the calculator from the class.

S Not a lot about my calculator. Having taken trig and Precalculus in high school, they teach you all about it there. So, I have my same calculator from them, so I have all sorts of things in the calculator.

J That's great. I actually had a calculator from my freshman year of high school until just really recently when I decided to get the newer one.

S Yeah, I didn't need it my freshman year, but from my sophomore year I've had the same calculator. At my high school you could like loan them out and get a number on your calculator, and you get that one to use for the year. But when I started trig and you had to maybe personalize it a little more, and then you try and go get the one you personalized the day before and somebody messed it up.

J Do you like that, having a personal calculator?

S Yeah, because I've gone through, and like, put in the sine of 30 degrees is one half. So I have certain things programmed into my calculator so I don't have to go in and calculate it everytime.

25:47 J Do you remember that the sine of 30 degree is ½?

S Is it?

J It is.

S [laughs] I was pretty sure that was right, but…

J Cause I'm actually kind of curious if you remember that.

S Well like there are a more limited number of values that I know I have to guess from there. I know there's ½, the square root of 3 or something along those lines, but yes.

J Wow, so are you sure college algebra is the right class for you?

26:19 S No. [laughs]

J Because I'm thinking calculus might be/

S /Well. Yeah. I had the option of taking calculus in high school but I didn't particularly care for the instructor. He taught the Precalculus class and I barely scraped through that class. It was very difficult because that professor had one limited way of explaining things and if you didn't understand that you didn't get through the class very easily. So I chose not to take calculus in high school because of that professor. And I was a little worried about coming into math again because I did have that bad experience in precalc, but I've been really enjoying it. And… I'm a transfer student. I went to the University of Denver last year. So I came in with a lot of credits, and technically I didn't have to take math, because I took a math class at DU that would've covered for the math requirement and my ACT score or something was high enough so I didn't have to take math. But it's been almost 3 years since I've had an actual like math math class, so going into business I figured

		it was a good idea for me to brush up on things and be prepared/
28:01	J	Why don't you tell me about that. What are your plans with majoring in?
	S	I'm here to major in business. I don't… I'm not quite sure what exactly my emphasis is going to be. It'll either be management, general business, or something with computer information systems. I haven't really decided which one, but I have to soon because I need to declare my major at the end of this quarter. Um… but… One of the business prereqs is as part of your liberal arts core requirements you have to take this class. And, yes, I could have gotten out of it because I've got the other things from high school and last year, but at the same time I took algebra my freshman and sophomore years of high school. That was a really long time ago. And yes it's easier for me to pick up on things, but at the same time I wanted to really refresh myself so that when I really did jump into calculus, I wanted to feel like I had a basis, a recent basis to build off of. So I don't know if I'll take calculus or topics in calculus, but I'm definitely looking to take one of those next semester.
	J	Their both good classes for you, with a business major topics in calculus/
	S	/Yeah I have to take one of the two.
	J	So, we've actually hit all the questions I've had. So I wanted to give you a chance to… If there's anything you've ever been curious about your class or me as the researcher, or why we're doing any of these things.
	S	So, let's see. I think I've got that you guys are going to be putting together a video to help math teachers become math teachers.
	J	That's part of it, yeah. Some of the classes are being videotaped and so that videotaping part is being used to put together examples of college teaching to give to new college teachers, usually graduate students. To help them out and show them some of the different ways that you can teach classes. The other part of it is to look at teaching the college algebra class using group work and/
	S	/Yeah the more nontraditional way.
	J	And the question we're trying to answer is how do students experience the class and do they do better? Do less people fail? That kind of thing.
31:03	S	Well I don't really think I have to worry about failing. [laughs] But I definitely have to say I like it the way that this class is being taught as opposed to the regular lecture for awhile and here's a whole list of problems for you to try and figure out how they relate.
	J	And you may not know this, but your instructor has actually taught lots of college classes, but this is actually the first one that she hasn't done in the traditional way.
	S	Well, it's interesting because on Monday, Wednesday, Friday I go straight from my physics class to my math class. And my physics class is taught the traditional way, "Here's the lecture, here's an example, here's a whole bunch of equations, and now here's a whole bunch of homework problems to got try and figure out." And I've discovered that I end up having a lot more questions in that class and feel a lot more confused in physics, because they don't always match up quite how I think

		they're supposed to. So, we're given all these equations and then we're given a situation and I'm like well, "I think I'm missing this" or "I don't know how these equations go together," so I end up having a lot more questions in physics and end up not understanding it as well. Whereas, in my math class where it's a lot more hands on and a lot more group work, I understand everything easier.
32:25	J	And what might be interesting is, could it be that you have a lot of questions in math class but they get answered in class?
	S	Yeah. Probably. Because we work more as a group and I get my question answered by everybody here, so I don't have to sit at home trying to do my homework and not understanding.
	J	Ok, Great. Thanks so much.
		RECORDING STOPS!

Partial Transcript of an Interview with Michelle Anderson.

Date/Time:	November 6, 2007 at 11am
Pseudonym:	Michelle Anderson (instructor of college algebra)
Total Length:	43 minutes, 06 seconds
Comments:	This interview with the instructor of the course was designed to triangulate data collected from student interviews. The discussion is lengthy and **paraphrased/summarized** below.

Time	**Person**	**Transcript**
		Recording STARTS with Joe speaking into the recorder to give the date and time of the interview. Joe says the real name and pseudonym of the interviewee and gets Michelle's consent to be audio-recorded on the tape.
	M	Overall the class is going well, but some students fight the method. The same students would fight any method I think though.
4:00		The main difference in the two classes is the navigator, but the navigator class has a haze of negative attitude because a few students don't think I'm teaching enough, not giving enough information for how to do things. There is a tension with 2 or 3 students who have seen the material somewhere somehow and doing well but don't like the method. A couple students randomly show up because they don't like it.
5:00		The explanation I've given as to why the course is taught the way it is has definitely worked more in one of the classes than the other. This is the first time teaching this way, and the thing I like the most is watching the frustration of the students. Not in a sadistic way, but just watching the students trying to figure things out together is the best part.
7:00		Sometimes the atmosphere gets too loud and no math is getting done. I definitely am responsible for setting the tone, but sometimes it gets out of control and I'm not

good at bringing the students back to the math.

9:00 Conversations with students. One on one conversations have only been positive, complaining happens in groups. Compliments come in groups and one-on-one.

10:00 In Class Activities. Usually the first 4 or 5 minutes of doing a group activity is chaotic. I'll usually talk a bit about homework or something first, but not about the activity. I'll just give it to them, "Here you go" and good luck. Usually that's followed by some complaining, someone asked if this was in English. Everyone laughed and immediately started reading the activity. From the way I run the class, it is definitely a group activity class.

12:30 Description. The in-class activities are set-up amazingly beautiful. There's usually a third of a page description of something and the rest asks the students to try to make sense of the information and do something. The activities that stick out as being good ones are the Time of Death Activity. I really liked the Psychic Code one because it really emphasized the different method of finding the inverse and the students had to struggle with there being such a long message. I also liked the Building Rational Functions and the M&M one. I really liked the way the Polynomials one really had very conceptual problems that had all the information that I would have lectured on. The students were just as excited as I was to find the patterns.

16:00 Quizzes are open notes, once a week. This is the first time I've run it like this. I was convinced when we planned for the quizzes that everyone would get 20/20's. I think it's doing a pretty good job, because not everyone's acing them.

17:00 The exams are required and not any kind of surprise. They look just like the in-class activities and pencil and paper homework.

18:00 Asking the Whole Class a Question.

When I lecture, I ask the whole class "What do I do next?" What's the answer?

Other types of questions. Was the Quiz Fair? How did the exam go? How did it compare to the rest of the class?

I ask questions a lot. I don't think I make any move without some direction from somebody in class.

20:00 "Students talk a lot to each other and you can definitely tell the leaders of the tables. There's always a time when one or two of them don't get it and they'll jump in and help each other out."

As a teacher I get to understand several things: how they're thinking, how they're looking at a problem, what they understand.

"I think I have a better grasp on student understanding than I ever have just from listening to them talking to each other."

21:30 They look at each other as peers and they're willing to talk to each other more openly because they feel less judged.

"When they ask me, they're looking for a right answer. When they ask each other,

they're looking for a "No Way" or some sort of validation, they're looking for a wall to bounce-off of."

22:00 Office hours are rarely used. Students come in to talk about their grades or get help on webwork. Out of the semester, the average person comes in .5 times.

I have a crappy attitude about online homework, and my students know it. I know it's not going away, so I pretend it's ok and this semester I don't get a lot of complaining. I think I've gotten five emails about it all year. Not sure why someone would like webwork. Maybe the instant feedback, maybe because I can get my roommate to do it or do it in my pajamas with my boyfriend or girlfriend to help me. Also, maybe it's nice to be able to blame the computer.

27:00 Email is used for whole class announcements. Used more than any class I've ever had. I have students email me if I forget to post a grade online. Why did she put a 0 when right here I have a 10? The amount of emails is just right. They sometimes email me because I'll never remember a make-up quiz I've scheduled with them. I liked the emails they sent me about "Tell me something about yourself" because I got a plethora of things. I got some interesting personal things, while other people just said "This is Neo" and that was it.

I got impressions about some of the students. One of the students was in the Marines so I was expecting a stellar performance from this guy. He started randomly showing up and when he did show up he was mooching off his table mates. One day he just refused to work with his group, and I've never seen him since.

"My students can not survive without their calculator." They use it everyday and the directions on the handouts are so good that there's very little focus on learning how to use the TI-Calculator. The class is not more about the calculator than the math, which is surprising for an anti-calculator personality. This is the first semester that I've seen it used as a tool and not just a crutch.

33:00 I don't think the students who knew more about the calculator have an advantage.

The TI-Navigator is a computer program that we hook up to calculators and an interactive tool between teachers and students. We use activity center, which I finally feel comfortable about running. We use the quick poll almost every day, which I do like.

37:00 The activity center is used to ask students to enter an equation or a dot… to participate in some way in creating a graph. They hit enter, and the screen is chaos. We ask students pretty conceptual questions and they do their best to send in an answer.

When someone sends in a wrong answer, sometimes on purpose to make people laugh, we talk about the answers. We sometimes talk about how someone could get the answer right while 30 other people got it wrong.

I don't think it would make a big difference if the Navigator was removed from the class, but I think it helps student see each others' answers and get ideas. It helps them understand there might be more than one correct answer.

40:00 Grand Tour on “Should I take your class?”:

I would say it definitely depends on what kind of learner you are. I would never take this class. It’s not my type of learning. I would ask them a few questions about what they like and dislike about lecture, if they like working in groups, and about how they feel about being dependent on other people and working with total strangers. Then I would give my recommendation as to whether to take my class or not.