Math 141
Evaluation Report

Fall 1996

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prepared
for

Professor Richard A. Brualdi

by
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1. INTRODUCTION

This report details the backgrounds and experiences of students in Prof. Richard A. Brualdi's section of Math 141 (offered fall semester 1996). Math 141 is designed as an alternative to Math 112 in fulfillment of the first component of the university's general education requirement in quantitative reasoning (QR-A).[1] Generally speaking, Math 141 is aimed at students who do not plan mathematics or mathematics-intensive majors; its general goal is that students will learn to think "mathematically" and become independent problem solvers.

This report, developed and presented by the LEAD (Learning through Evaluation, Adaptation and Dissemination) Center on the University of Wisconsin-Madison campus, is based on classroom observations and in particular on the inductive analysis of exploratory, semi-structured, interviews with 14 of the 34 students enrolled in this section of Math 141. The interviews were conducted by three LEAD researchers (Phil Miller, Ramona Gunter, and Lynn Squire) during the period November 13 through December 11, 1996. The analysis was overseen by a fourth researcher, project manager Susanna Priest.

Our approach is student-focused; we are interested in what kinds of students ended up in this course and what kinds of teaching strategies and techniques seemed most effective from a student point of view. The data in this report are intended to be used along with quantitative information (such as test scores or conventional student evaluation instruments) that the department and others concerned with QR-A planning have collected, and it should not be considered a definitive or summative statement about the course in and of itself. Rather, LEAD considers this "formative feedback" information designed to help the instructor, the department, and the university "fine tune" the QR-A program in response to student needs and perceptions and within the context of program objectives.

In the following paragraphs, interview excerpts from students in this particular section of Math 141 are shown in italics. Where there is no identification for the quote, it is the comment of a student interviewee. Where there is dialog, "I" signifies interviewer and "R" signifies respondent. Ellipses [(…)] in quoted material indicate deleted dialogue occurring within the reproduced material. Ellipses are used so that readers can appreciate the speakers' views on a particular issue without having to sort through parts of the raw dialogue which are not relevant or informative. Qualifiers are used to give an indication of how many students expressed any given viewpoint: "few" indicating 1-4 students; "many" indicating 5-11; and "most" indicating 12-14.

2. THE STUDENTS

2.1. Many students reported that they did well in their high school math classes.

All students enrolled in this Math 141 section began the course with the minimum credit hours in high school math mandated for entrance to the university. Many did well in their high school math classes, reporting that they often earned A's and B's. We acknowledge that the meaning of

[1] Several discipline-specific alternatives are available to fulfill the second half of the requirement (QR-B).

grades varies among schools. These student self-reports are not intended to suggest that the students were homogeneous in their levels of math skills, nor that they had mastered the material in high school math courses. In fact, most reported having struggled with various difficulties in these classes. But they do suggest, and their acceptance to UW-Madison confirms, that they were capable of developing skills and strategies helping them to get through typical high school math courses. Most of the students interviewed seem to be those who did not like or were not interested in math, or those who simply saw it as a waste of their time. The following comments illustrate these feelings:

> *Yeah, I took [math] up to trig, through, geometry, algebra, algebra 2, but I didn't take anything my senior year because I never really liked math. But I was trying to get into Madison so I knew I had to take a lot of math. (. . .) I just wasn't real interested in it. See, I don't think it's really bad, it isn't a bad class or anything, I guess, but I take such little interest in it [and so] it's harder.*
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> *I took math courses up until trig and then at semester time I dropped it. It wasn't because I was doing badly in it or anything like that, it's just that I didn't like it and I felt I was wasting my time when I could be using my time more effectively with other subjects.*

2.2. Students had various levels of math skills.

While students exhibited some similarities, as suggested by their high school math experiences and by their disinclination toward math, they were diverse in terms of their preparation going into this math course. All students had taken and passed the same basic high school math courses, but many did not remember how to solve specific types of problems. Many of these students' math placement scores placed them in one or more remedial algebra classes (prerequisites for Math 112) which do not satisfy the quantitative reasoning requirement. A few others reported they placed into Math 112 or Math 113 (both of which satisfy the QR-A requirement). The following excerpts illustrate the students' needs for remediation:

> *In Math 101, I have a feeling that they teach you a lot of basic things, or just at least a refresher at some point. Because [in] math, it's like you're required to know your algebra, whatever else, I mean basic algebra. Just math 101 would have been a refresher. Because I forgot my algebra stuff, so I had problems like that. Like I didn't understand where the stuff came from. Even though I knew I [had] studied it I just, I kind of forgot it [somewhere] along the line. I mean Math 101 is probably a good course to take before you take Math 141, or something like that.*
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> *I hate math, but I think we shouldn't say we hate math, just that we can't dislike it. It frustrates me when I don't understand something but I need to understand it, math is the one subject in the world that I can't seem to get. When I do finally get it, it is time to move on to a different subject or something else. Everything we have done in our class I have done before, and I know I have done before. Yet, I can't remember how to do it right. At one point in time I must have done it right.*

Based on student comments there exists a diverse range of needs for remediation in their Math 141 classroom. By diverse it is meant that, while most students described the need for more explanation on how to do certain problem types, the specific problem types students needed help with varied. Therefore, students described situations where the professor spent time explaining problems to some students, while others waited for the lecture to continue.

2.3. Students talked about various aspects of the high school math classes they have appreciated.

Students talked about their attitudes regarding math, and reflected on how their middle and high school experiences (in math classes) affected the feelings they now have. Some of these students seemed to have had definite ideas about what kinds of things worked best for them. They identified certain aspects about the high school math classes they most liked and felt contributed to any positive experiences they have had with math.

2.3.1. Content

Some students identified a preference for a certain type of mathematical content. Some of these students articulated that the content they prefer is more real or concrete. As one student described, solving a problem within some larger or more meaningful context is helpful:

> *Geometry was, like, by far my favorite. (…) I think it was the fact that I could see, you know, what the math was doing, because in algebra you have all of these different problems, but you didn't know how to relate it to whatever, and you kept wondering, you know, "who thought of this?" You could see how, you know, if somebody was going to measure, like, a silo and how much you could put in it or whatever, I guess I could relate more to that type of thing. I think that's why I liked it more.*

One student described how context makes it easier to set up a problem:

> *Well, the best problem was in my freshman year, and I was the only one that got the solution so I was pretty happy. It was if you have a five quart jug and a three quart jug (…) -- how can you get exactly four quarts? (…) It was something I could say, you know now, not necessarily am I going to be like standing in the wilderness with two jugs needing four quarts, but at least the scenario [makes it] easier to set up…*

Another student stated that s/he liked geometry (over algebra) because s/he felt there was a "step by step" process which could be followed:

> *Algebra was more of like a thought process in that, and it was just teaching, you know, thought processes … the concepts were like abstract I guess; and then, geometry … that was more concrete. I mean, I could visualize things, it was just, you know, a picture in front of me … I had something to work with; it was a lot easier…. [In algebra] the problems were, well it wasn't like step by step, that was the hard part. I mean geometry was step by step, algebra required more thought as far as what is this problem really asking me.*

And another student referred to the "concepts":

> *I liked geometry. I did like geometry, and they say that a lot of times if people don't like algebra they'll like geometry or vice versa. Umm, but as far as mathematics [classes], in general, they're okay, but they're certainly not my favorite and I certainly don't excel in them, but I can usually understand the concepts and if I get the concepts I'll do okay, ...*

We note that the three examples provided are of students who liked geometry over algebra. This is not to suggest that the majority of students shared this preference. These three examples were chosen because they happened to articulate the particulars of the course which they liked: context

for a problem; step-by-step process; and concepts.

2.3.2. Formulas

Many students indicated that they preferred working with formulas. That is, they felt comfortable solving problem sets (groups of similar problems) using formulas or equations, especially after the process had been modeled by the teacher. When it comes to a choice between math classes, these students said they were most comfortable (when it comes to math) with a traditional algebra class.

2.3.3. Pedagogy

Other students indicated that aspects of the math classes they liked best had to do with the teacher's particular method of teaching. Students described techniques including thorough explanation of problems, repetition, and the ability to answer students' questions in various ways, depending on the needs of the students. Some appreciate teachers who are willing to go over the basics as needed and others appreciate teachers who do not go into too much detail at that level. Following are several quotes which illustrate the variety of student perspectives on pedagogy:

> *I: And what did he do? How did he teach the class?*
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> *R: I guess, it was fun for me because he taught in the style that I like, which is not necessarily {pause} explaining things. A lot of people like it better when teachers take their time and spell everything out on the board, but in some ways I feel that that's wasting time. Especially because I understand it - I don't know.*
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> *R: My teacher would really get the notes down right so you would have something that was concrete that you could look back on and that was a big help. I think geometry was about the best. I have never been a great person in math.*
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> *I: Can you be a little more specific?*
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> *R: I suppose it was a little bit easier in geometry because you had the postulates and theorems and everything. She spent time actually going through the basics and making sure you understood better enough to move on to the harder problems. I also found it helpful that with the harder problems, she would help explain some of it too. I have found that in algebra especially, you would go through the basics so much, which was great, then you would understand. But when you went on to the harder problems, that is maybe when [I see] that I am having trouble and I know you are supposed to be using what you learned at the beginning to help you with the other stuff. On the tests, I have found that they throw all of these things at you that you have never gone over before and I suppose that is a part of learning. But it seems that should be done prior to the exam, on homework assignments or something like that, that would be turned in. So you would have to at least be thinking about it because a lot time I would get to the exam or the test and these problems that you had never even thought about are thrown at you, along with the pressure of an exam or test anyway, makes it really hard to concentrate unless you are really a math person.*
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> *I think that it seemed that [the high school teachers I liked] were friendlier. They went through it more I suppose, more repetition on the board not through homework.*
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R: The biggest problem I think I have ever encountered with math is that teachers only know how to teach it one way. A lot of us don't understand that one way. We would sit in class and see how frustrated some of the teachers would get when a student didn't get it. If you didn't get it, you just didn't get it that way. A lot of times that would happen to me. I would ask and I would stay after and I still wouldn't get it. It wasn't just me, that was the problem, there were others also.(…) I suppose it is because [the teachers] were only taught one way, or they probably have only done it one way. When I got to my senior year, and we had pre-calculus, the teacher actually, if you didn't understand, would go over it with you until you did understand. Or maybe he would show you another way. That was the best way I ever learned.

(…)

I: But [you had a teacher who] would not try to change the way she showed it?

R: Oh, I don't actually think that they know how to show you another way. When I got to pre-calculus, he did show us another way. Or he would show us a short cut and you could understand the short cut better than how he showed it.

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I: How did [your high school math teacher] get a class of students to do the work without telling them what to do?

R: Um, some of the examples he would use. He would use, like, people from class that we were talking about. I don't know. He just applied it to real life, I guess, more than some other things, made it a little more interesting.

2.3.4. Personality, teaching style

Many students reported experiences in math classes which affected, both positively and negatively, their attitudes about the classes in general, and in some cases, about the specific subject matter. Experiences in a class can affect students' feelings about going to class, and about learning the subject.

I: *How about the way the classes were taught in high school? Anything that you can say about …*

R: *Um, my algebra teacher was very fun! And that made it a lot better. He would, he was like everybody's friend. He would joke around a lot and stuff. I don't know. It made you feel like you wanted to come to that class. You know, you didn't dread it or anything, because he was such a nice person.*

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I always had really strong mathematics information. Got checks and pluses in elementary school, got A's up until eighth grade. And I had a really traumatic experience with my algebra teacher in eighth grade. He was horrible. He mumbled to himself, he talked to himself, I couldn't discern a word that he said. I couldn't make anything out. (...) I got C's in algebra. I

> *had a fantastic experience with my geometry teacher, which led me to believe that I was more inclined towards geometry, even through I always liked algebra more. Um, so I was very confused. (…) It was ridiculous because I was pretty much a straight A student, and there was no reason why I shouldn't be doing well, but of course if you get a bad teacher and you just don't want to try, you don't want to go to class, because, you know.*

Math 141 students have varied mathematical skill levels and a range of attitudes regarding the subject. Since most are not confident and self-motivated math learners, particular attention to teaching techniques and presentation of material can be crucial to their math experience.

2.4. Most of the students can be characterized as math avoiders.

With a number of exceptions, these students would probably be more accurately characterized as math avoiders, rather than somehow incapable of doing math. Their preferences seemed to be strong enough to dictate, in many cases, their programs of study and choices of classes. The following student is typical of math avoiders' approach to choosing a field or study:

> *I know for a fact that what I'll probably do is look for a field in which I don't have to use math. If I am forced to take math I'll probably look for an easier class, easier courses, [or] nothing. I mean I'm not going to say that I don't want to challenge myself, but just a little simple course would probably challenge me; but since I don't like it it's just kind of, you know, I'm more not willing to learn it.*

2.5. Many students stated that math is important.

Despite the fact that most students reported a tendency to avoid math and math-related courses, they did express an awareness of the importance of math in their everyday lives:

> *As far as future learning, I'm not planning on taking many other courses, but as far as after I graduate -- I mean math is, as far as a whole even though I don't like it that much, is obviously important in everyday life. Computing and geometry as far as building things, because I like to work with wood and stuff so I like carpentry-type stuff, so it has its place and it's important in everyday living as far as buying stuff and things such as that. But as far as doing, like, statistics or anything like that, I kind of try to shy away from statistics so, you know-- I mean it will be there of course.*
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> *I realize that, like eventually down the line I will end up taking maybe [more] math, like one or more math courses, `cause you can't just completely annihilate math. I wish you could, but you need to -- you need it. I'm not going to say that you don't `cause it does help you in the real world.*

One student stated that it was not specific math content, but rather the reasoning processes utilized in mathematical problem solving that are important life skills:

> *I don't know if it's the math concepts themselves that is important because a lot of times I don't remember the equations or whatever, but I don't think that is the important thing. I think it is the reasoning that goes with math, I think that that is important for everybody whatever field you are in. You know what I mean? You need to kind of have that deductive reasoning and kind of just be able to be rational. It is pretty important.*

While students admitted that math is important, they also didn't feel that the kind of math, or the level at which they were expected to learn the math, was personally relevant. A few of these students felt they already knew all the math they would use in their everyday lives. One stated: "I know you need [math] in life, but I think I pretty much for the most part know how to do that, what I need to do". Another student said:

> *[Math] probably would play some role [in my life], I mean, I believe that I have the math I need to know underneath my belt. (…) I'd say it would play some part, but, it really does take a back seat to a lot of other stuff.*

3. WHY THESE STUDENTS TOOK MATH 141

3.1. Most students heard about Math 141 at SOAR.

Most students heard about Math 141 through SOAR, the summer advising process. Based on student descriptions of their advising experiences, there appeared to be two situations which prompted SOAR advisors to suggest Math 141 as an alternative for satisfying the QR-A requirement: the student had placed into a remedial math course; and/or the student indicated that s/he did not want to take math.

3.2. Many of the students had specific expectations when they enrolled in Math 141.

According to students, SOAR advisors described Math 141 to students in one or more of the following ways: a course dealing with "real-world" problems; the last math course the student would have to take; and a course intended for students who don't like math or don't do well in math. Also, a few students mentioned that Math 141 is not a prerequisite for any other math courses. We interpreted that students viewed it as less threatening because it was not a part of a sequence. The subject matter would likely be easier or, at least, more relevant to students taking the course as it was not preparing them to enter higher level math courses. Students talked about their expectations based on their understanding of what Math 141 would be like. They expressed views falling under several of the following categories.

- **Math 141 would offer a review of the math students had studied in high school.**

  I: *Did you have any other expectations about how the math class would be?*

  R: *Um, I sort of thought it would be easier. Um, that it would be reviewing what I already learned. Which is true to some extent.*

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  I: *OK. So what did you think you were going to learn when you took the class?*

  R: *Um, at the start I thought it was just going to be kind of like a simple review of geometry and algebra and then just some story problems that I had pretty much seen before.*

- **Math 141 would be more interesting than students' previous math courses.**

  R: Well [the SOAR advisor] said it was -- how did she say it -- it was just a, like, collection of all kinds of

different things that you would have learned in your different math classes throughout the years, so things that were more related to-- you know, because there's some geometry in there and some figuring out of things. And I think she did say that there were a lot of story problems, and those never bothered me, like in my math classes anyway, so it just sounded more interesting than taking algebra over again since I had already taken it once.

I: So you were hoping it would be more interesting.

R: Yes.

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It was either take the math 112 or she presented the option of 141 too and said it was more story problems and stuff, and I just thought it sounded more interesting than, say, algebra.

- **Math 141 would be a different experience from other math classes.**

I: Okay, and you signed up for Math 141 because?

R: I don't know, just the way [SOAR advisors] explained it to me. It just seemed like a more different course than just the average math course. Just not so much of the (pause) different maybe more like reading. (…) I didn't expect, I can't really say so much math, but I thought it would be more to do with other things as well. Incorporating reasoning. Why we do these things, why math is important, sort of like a general view of math and how it affects people everyday. Something like that, kind of like economics in a way.

- **Math 141 would present real-world problems**.

So I didn't really know too much about it, just what [the advisor] told me about it. AND I thought that you know, it wasn't a prerequisite to anything, so I thought, well, that would be - I would want stuff that applied to the world more, since I'm not going on in math.

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Basically, the advisor at the SOAR program had a little piece of paper with what you tested into and said you could take this or this. It was explained to me that it would be math dealing with more everyday kinds of going to the store to get a discount or whatever, which we did do.

- **Math 141 would help students achieve a better understanding of math.**

I don't think that there was anything major I was hoping to get out of it. I was kind of hoping to grasp a better understanding of math, better than I have now. Or than I did before I started. That's what I was looking for.

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I guess I expected to be able to learn and completely understand what I was doing. This was supposed to be kind of like a review of what you have already learned anyway.

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I [thought] "well, it would be important to learn the concepts behind [math], than actually doing it." So I signed up for it.

- **Math 141 is for students who don't like math.**

[T]his is a class geared for those of us that for some reason don't understand math, (...) [The students] obviously are there because they hate math and or dislike it in some way that they don't ever want to take it again.

3.3. A few students stated that they had no specific expectations except to earn the required credits.

A few students specifically stated that they had no expectation or desire to learn or otherwise gain anything from taking math 141. The goal for these students was to "get through" a math requirement, and to never take math again. In the words of one student: "[I took the class] just to get through it. Just to be able to say I am done, completed and never have to take it again".

Those students who placed into a remedial math course would have been required to take two or more semesters of math to satisfy the QR-A requirement. Some of these students registered for Math 141 because it offered an opportunity to satisfy the QR-A in one semester. The following student placed into a remedial course:

I: So 141 was sort of a one shot deal for you, then. You thought "Wow, I'll get it out of the way."

R: Yep. (…) That's the major thing is that it was one time and that was it.

(…)

I: [You have] no desire to learn about real-world applications, which is what you were told [by the advisor], right? So when I ask you is there anything in particular that you were hoping to learn?

R: Just to get it over, you know.

4. STUDENT PERCEPTIONS OF THE PROFESSOR'S GOALS FOR THE COURSE

Students were asked if they knew what the professor's goals or expectations were for the course. Responses were consistent. Students reported that the professor's goal was to make them confident problem-solvers and independent thinkers. As one student put it:

In the beginning [the professor] said, you know, we just want to get you guys to be problem solvers, not necessarily using formulas to solve problems, but just be confident enough to, like, try and solve them on your own.

Gaining practical "life skills" in mathematics and learning some basic math functions (which apply to practical problems) were other objectives some students identified:

He really wants us to take some life skills out of this class, you know, things that we can really use. The whole first semester has been spotted with a lot of things having to do with stock markets and economic type things: banking, checking, savings. And that really works … I mean there are other things along the way. There are similar equations like the equations for savings, the interest that is compounded and the equation for the half-life of elements is practically the same … So I mean they'll give us problems like that, and we aren't going to be archaeologists wanting to figure out how old, you know, a fossil is but with that same equation we are going to

be, you know, everyday people wanting to start a savings account and so, if it doesn't relate to one area, it might relate in another area.

5. MATH 141 STUDENT EXPERIENCES

5.1. Students talked about course elements and teaching strategies of Math 141.

5.1.1. Board Work

Among noteworthy comments regarding teaching techniques, a number of students stated that working problems on the board was especially helpful to their efforts to learn the material. As noted in the following quote, outlining the *process* used in problem solving is valuable:

I guess he does a lot on the board, which I have always found helpful. Actually going through the process on the board, showing you step by step. That I find helpful. --going over and understanding the ways before moving on. Twisting the problem around a little to understand it that way also. But making sure that you have a good hold on each problem or how each one works. Just being able to go through and really working with them and understanding what you need to do to get this answer.

However, several students stated that although they were able to follow in-class explanations when the problem was thoroughly discussed, they could not make the transition to applying it to problems outside of class. The following student talked about this:

…He shows us the problems and when I see it on the board it makes sense to me. I see him doing it, but then when I take it home for some reason I don't know how to do it. 'Cause he makes it look really easy as far as setting up the problem and, I mean, he goes through and explains it, but it's just, he's a lot better [than I am] at setting up the problems, and that's pretty much half the battle right there, is once you've got it set up, you know, it's easy to solve.

5.1.2. Repetition

Many students had become comfortable with repetition as a strategy for learning mathematics at the high school level. That is, once given a process (an equation, how to use it, and when to use it) students would apply it to large sets of similar problems. This is not a strategy that easily transferred to Math 141. For the type of problem solving they were doing, the process was not neatly defined. Rather than applying a set of rules, students were asked to learn how to *think* about a problem, and subsequently take steps to solve it. Students described the homework sets as consisting of problems different enough (from examples done in class) that solving them required a deeper understanding of the math than students had achieved. They could not "map" the same steps used on in-class examples to the homework problems. Therefore, not only did they lack a precise set of

rules, but also they lacked a set of similar problems whereby they could practice a problem solving algorithm over and over.

5.1.3. Homework Problem Sets

Comments regarding the problem sets to be worked outside of class revealed students' desires to have an opportunity to experience "graduated reassurances." Attempting homework problems which seemed different from any they had seen was intimidating and frustrating. Students wanted something which would give them confidence that they were on the right track when solving these problems. A few explained it would be more beneficial for them to have the problem sets explained prior to having to work through them:

> *I guess maybe I am one of those people who really need to go through step by step, through every possible angle to a problem or a formula to really understand what I am doing. Then that helps me out with the harder ones. When it is told to me I really get the concept and when I am doing that type of problem later I can do it fine. But say the assignment was given before the explanation, I would have a lot of trouble reading the book. I think books in math just don't help a lot in my opinion because they are written by people who really understand the subject. So when they are writing it, they leave out a lot of stuff that would be helpful.*
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> *I don't like … the way we do our homework and THEN we discuss it. I think we should discuss it first and then do the homework, when we understand it already. (…) 'Cause we end up just skipping problems and not knowing what we're doing...*

Students wanted feedback on their problem solving attempts. At least a few were disconcerted that homework was either not fully discussed or did not seem related to the material covered in class. One such comment:

> *R: He is doing the problems in class. And he doesn't know the answers to the questions at all [because he doesn't have a teacher's edition to the book]. So that presents a problem when he assigns fifteen questions and they are all word problems and each will take some time to do especially if he is doing it step by step on the board and someone doesn't understand so he has to stop and we never ever, ever get going.*
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> *I: So there are a lot of them that you never do?*
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> *R: Right. There are a lot of them that we never work through and none of us know that we are working them right.*

One student concluded that the class really didn't need to know how to solve those problems which were not covered in class:

> *Well, at the beginning of the year -- well he did this all year, but -- he would assign problems and we were to do them and bring them back to class and sometimes he would have us hand in select problems and at the beginning of the year I did all of the problems all of the time, whether we had to hand them in or not, I just did them anyhow. But as the semester progressed, umm, I stopped doing all of the problems. I did a few here, I did a few there and actually right now I'm*

not doing much of anything. If he tells us to hand something in, you know, I will do them and I will hand it in, but we usually discuss only some of the problems in class and I really found that I was getting frustrated over some of the problems that we didn't discuss in the class and we didn't need to know it anyhow.

5.1.4. Instructional Materials

The text and supplemental handouts for this section received mixed reviews from the students. A few students commented that handouts were provided early in the semester and that they were useful, but that they were discontinued fairly early in the term. As students described them, the handouts were for the purpose of reviewing some basic math, and provided examples and problem sets on which students could practice. This student appreciated the handouts:

We just have one text book and (pause) that works pretty well. But it would be nice if we had handouts sometimes because handouts really help me a lot. There's like a worksheet or something that I can work on. We have had probably two of them and I think that those helped me but I think that we need more of those. And I don't know if that's my like kindergarten math style that helps me out a little bit better, but it's better than just going through the same book all the time. I like a little bit of variety. It helps, keeps away the monotony.

A few students found the text useful. This student found it especially so when it modeled the type of problem-solving done in class:

I: *…do you use the text book much?*

R: *Umm, yeah, actually I do.*

I: *And how do you use it?*

R: *Umm, well depending upon how we -- sometimes he changes, like in the lecture, he changes, like, how we do the problems -- like, I'll read the text first. And then if he, like, does an easier way in class and says we can use it that way, then I won't look at the text a lot, but if we're, like, going by the text exactly then I study it and everything.*

This student was sometimes able to use the text to find alternative explanations:

[I study by doing] the problems that he assigns and I usually can't do most of them, so I have to just pace and just look at his [notes] and keep applying and look at the book. Because I've learned a lot through the book as opposed to him. Sometimes he makes no sense and I read the book and it almost sounds different from what he says. (…) But now it's getting really confusing – the book is too – so now I'm learning more from him. Just at the beginning, because the beginning started off like geometry stuff that's supposed to be pretty basic, so he didn't really explain it as much, so I had to use the book.

5.1.5. Working With Peers

Many students reported that attempts to utilize groups were made both inside and outside of class. For the most part, it was apparent from students' comments that group activities related to this class were not viewed as successful for many reasons. Speculations included students' not

knowing each other, other class members' perceived reticence to form groups, and commuter students' logistical problems in getting together with other students. All interviewed students were asked about group work during class. There were varied responses: some said group work was used often; some said group work was used infrequently; and some said group work was not used at all. The varied responses seem to be due to the particular context of each student's experience and their varying application of the term "group work." When asked to describe how they worked when solving problems during class, a few described actual discussion between the peers in their group, a few described using their neighbor's results to check their own, and a few described a "fruitless" and then aborted attempt to discuss the problem which resulted in waiting for the professor to solve it on the board.

It is informative to consider those experiences in which students benefited. The following student describes a successful peer collaboration (although it did not occur in Math 141) and suggests that some students need a structured situation to facilitate peer group work:

> *I'm in physics 109, which we have lab partners and my lab partner and I have got together quite a bit to study outside of just doing labs and it's been really good because we've helped each other learn and understand and we've gotten better grades on the tests than we did before -- but in math 141 it's just not even feasible. He tried several times to encourage that and he's tried several different ways of getting people together and doing that so he's done a good job. But … [the other students] don't want to get together with somebody else or if they have a friend already they look at you like, "who are you?" That's why I say if there were some sort of discussion section, because it sort of forces you to do that, because here there's student input, but it's more just lecture whereas if there's a discussion section you're actually forced to do it.*

Collaborative work with peers was viewed by several students as a potentially positive and useful learning tool for this and other courses. A few students described successful paired or small study group activities composed of classmates who lived on the same floor or in the same dormitory. The following describe successful small group processes:

> I: *What do you do in your group, when you study with your group, either inside or outside of class?*
>
> R: *Umm, mostly we all look over the problem and then sometimes say it out loud and then if I don't understand something I will say "do you guys know what's going on with this one" and they help me out. Or if someone doesn't kind of understand we kind of try to break it down where someplace it doesn't look like one big problem.*
>
> ***************
>
> *R: He goes through a lot of examples and shows us a lot of different scenarios, but it's just a matter of us doing it by ourselves, so perhaps [it would be helpful to] show a problem on the board and then do a problem in the class in group work. Cause it narrows the entire class trying to generate the thought process down to a small group, and then once it's homework time, it narrows down just a little bit more so you're by yourself or you know with a partner in some cases, and it slowly narrows it down instead of taking it from the whole class having to understand, to yourself.*
>
> *I: OK, so what is it about group work that you think would help you learn that process?*

R: Well, it's just the fact that some people are better in some areas, and having people throwing ideas, especially in a class like this where you don't really know people and you don't know the strengths and weaknesses of other people, so you aren't saying to yourself, OK, I'm going to pair up with this person because he really knows his algebra, or I'm going to pair up with this person because he knows geometry – it's kind of finding out you have to work together and that's what [my study partner] and I do. S/he's good in some areas and I'm good in the others, so we kind of both benefit.

5.2. Students described various strategies and styles of learning.

For most of the Math 141 students we interviewed, mathematics is not something of great interest. Students have persisted in math and many have performed well in previous math courses by developing learning strategies or, in some cases, coping skills. As we found diversity among student backgrounds, interests, and abilities, we found divergent strategies for succeeding (in some cases, surviving) in math classes.

5.2.1. Use of Equations

Many students described their approach to doing math as what could be characterized as the mechanical use of formulas. One student stated that s/he would rather have formulas given in class and went on to say, "I have heard a lot of people say that. They're just like, give me the formula and I can figure it out, you know." Another student said:

Learning math… (pause). I guess I had always figured it was memorizing formulas, you know. Just memorize a formula and you'll be able to do math, you know. It's pretty simple. Sometimes every now and then you'll get a question that's, like, you've really got to think. Um, I don't know. Now [in this class] it's like you have to, I don't know, I guess think about it. I don't like to, but I do. …I don't really learn math. I memorize formulas, and then once the semester's over I'll forget `em.

For some, the use of formulas within a context provided relevance. The following student talks about applying math skills to chemistry:

Oh, in chemistry [we calculated "how fast"] a lot, as far as units of measure go. Um, that was where I first really applied my geometry, when measuring out liquids or when measuring particular masses, or you know, amounts that it was, and then equating the mass and the volume of, whether it be a beaker or that sort of thing. You know, I used that, once… geometry and chemistry really taught me like units of measure and that. I hear every day: liters, quarts, feet, inches, you know. (…) If it's a unit of measure [in a problem], then it's probably an object that I can relate to.

5.2.2. Use of Concepts and Alternative Examples

A few found that understanding the concepts behind the formulas and being shown alternative approaches and variations helped them to more fully understand a problem. This student describes how learning math is much more than a rote process:

[Learning is] having somebody present it to you, and being able to understand it fully, not just, um, plugging numbers into an equation, but understanding what it means, and where the equation comes from (…) And why you're doing it.

The following student describes a particularly good Math 141 lecture:

> *R: Well also, he gave us little tips, like "look at it this way." Also, "this always helps me," then you can look at it that way and go "wow" that really makes a lot of sense. I think we have a lot of class interaction as well. It causes you to look up from your notes as well and say that really makes sense. Then you can see it. It is visually there to see on the board how what you are supposed to do. That you add these or multiply these. Sort of like pounding it into your head. This is what you need when.*
>
> I: *And that worked for you?*
>
> R: *Yeah. Really being very thorough and causing you to react to what you are seeing.*

But many students found that being shown more than one way to solve a problem was confusing, as illustrated by this comment:

> *…he'll explain one problem one way. And I get it. And then he'll try to explain it a different way, and then I completely lose him. And everybody else will look at him like, "What the heck did you just say?" And then, you know, I feel kind of stupid because he, I mean, it's the same problem, but he explained it like a couple different ways. So then it's like: "So which way do I use?"*

5.2.3. Use of Word Problems and Context

An element of the course which addressed students' preferences for context and relevance was the heavy use of "word problems" or "story problems." Many students wanted the context to be relevant to their personal interests or needs. This student talks about "thinking math" within the context of his/her life and says it is different from "learning math" in class, even when story problems are used:

> *Learning math is math class. Versus <u>thinking</u> in math. Of course I'm learning, but I'm learning about life when I think in mathematics. I'm not necessarily JUST learning math. I try not to separate math from the rest of my life. And when I can incorporate math with science and history, like physics, then it's great, but when you're thickly plopped in the middle of a math course, and say here's a formula, even when life is applied to it, when it's not part of my personal life, when it's not something I'm excited about or want to integrate with my life, then that's just learning math. (…) [Math 141 does] seem, it does seem relevant, in the essence that it teaches us how to do our investments, or how to um, figure out a shopping bill and coupons. Um, that sort of consumer ideas. But there are lots of things, like the quadratic, that just don't apply.*

Even though students liked solving problems in context, some were intimidated by this type of focus. A few students stated that they always "screwed up" word problems, or that word problems scared them. The following student explained that there is some value to the process of solving word problems, but that s/he still has difficulty with them:

> *I really don't care for story problems a lot, and that's basically what it is. So it took me a while to adjust, I mean, now I almost, sometimes I wish I would have taken 112, because 112 is Algebra/Geometry, which is… somebody gives you an equation and you plug in the numbers. {laugh} And it makes it a lot easier. I know that this is a lot more helpful, where you actually have to think about things. [But] there's words in there that will confuse - it's like I can deal with words by themselves and I can deal with numbers by themselves, but when they integrate them it really messes me up sometimes! So I'm still having trouble.*

Although students talked about the value of context (and its relevance to their interests) they also noted that they didn't quite know how to go about solving the problems. They wanted some structure to the process, something to guide them through the "steps." This need was illustrated in section 5.1.3 which discusses students' desire for more detailed explanation prior to attempting homework problem sets.

5.2.4. Use of Peer Collaboration

A number of other strategies were identified, relating to how people study effectively, how they prepare for assignments and exams, and how they conduct themselves in study groups. Many of the effective study strategies involved working with one or more peers. A few students explained that it was beneficial to explain a problem to others in order to better understand it themselves. Some also felt their peers often did a better job making an "intellectual connection" with regards to explaining a math problem. This emerged primarily within the context of collaborative or "group" activities. One student identified another structure which would facilitate this type of learning. S/he offered the following suggestion when asked how the course might be improved:

> *…I'd have when you give presentations of problems, like, in front of the class if you understand a certain problem. Like if someone asked a question, and you know how to do it and you raise your hand and you show how to do it--everyone should be required to do that.*

5.3. Students described an intellectual "disconnect" between the professor and themselves.

Most students described the professor as very intelligent, or brilliant. They perceived that he loved math and really wanted them to learn. Yet, in terms of being able to relate to them as students, they felt the math was too easy for him, and that he'd forgotten what it was like to learn math (at the level of Math 141). As one student said:

> *It's easy to him. But I mean, it's almost [like] he doesn't know it. I mean we can't do that, we can't add and multiply in our head that fast, that quick. You know, we're not going to think abstractly like that all the time. I mean, he loves math. I mean, you can tell that. And, we don't. We're just there to learn what we need to learn, pass the class, and we don't have that love like he seems to.*

The following statements illustrate students' feelings that there is an intellectual disconnect between themselves and the professor:

> *Sometimes a question will be asked and he will talk about it and answer the question but will talk way past what you really need to know. So in that manner, everybody just sort of sighs.*
>
> ***************

I think the teaching style is a big problem. I wish he would, sometimes I don't know what I expect from him because he is the head of the math department and it just blows my mind how he really doesn't, I mean he is a brilliant man and written all these books, and yet he can't show us another way. They are word problems so I am pretty sure that there is another way to do things. Or his explanation of things is what makes it harder to understand. We have spent, sometimes we have spent the entire hour and fifteen minutes working on this one problem because he is trying, he knows it is going to be on the exam, and he knows he is going to give it to us and he wants us to understand.

****

I: *I get the sense that going over the same thing again isn't what you need.*

R: *Yeah, it seems like what he's doing is repetition. If you repeat it enough, it will bang into their heads, sort of idea. Whereas we're just banging our heads against the wall!*

Because of the inability to reach an intellectual connection – where students are able to communicate their questions, and the professor is able to give explanation, respond to questions, and impart understanding – students describe an added emotional dimension to the classroom. The inability to communicate has left a feeling of frustration among the students. A few students perceive that the professor is frustrated as well. A few say that this feeling of frustration (on the part of both the students and the professor) within the classroom causes students to retreat into themselves; to not respond and to stop listening. One student talked about why s/he thinks the professor becomes frustrated:

I think he has good intentions and that sometimes he comes to class ready, you know, and he wants to show us something. But as the hour progresses, he sees how we don't understand, or I am hoping that he sees that. And, I think he gets frustrated in the fact that, I mean he is a professor and head of the math department and he still can't [get us to understand]. And I think that tends to frustrate him. And like I said, I think he does have good intentions and he does come wanting to teach, and is willing to help us, but I think that a lot of us, we honestly don't think that he knows, that he will be able to help us. He has been doing this for such a long time that I think he has forgotten that this is, you know, elementary math used in regular or word problems. And he expects a lot. And I don't think that his expectations are too high, I think that they are too high for the way he is teaching. I don't know if teachers usually get a refresher course [addressing how we students don't know the subject, so that they don't] assume that we all know. There is a reason that we are all taking this class, usually the reason is that none of us ever want to take math again. I think that he is just frustrated with us and thinks that we are never going to know anything anyway.

Although a lot of formal group work did not occur in the class, a few students did talk about studying with their classmates. (The effectiveness of this strategy was described in section 5.2.4.) These students described situations in which talking about problems with their peers allowed them to grasp concepts, take the first steps in solving problems, and move forward. A description of what happens in these informal groups is offered here as an example of the kind of communication which helped facilitate an intellectual connection, within the context of a problem-solving discussion, for some students:

R: I think that having another person there is a help, you know, if I get part of it but don't get another part, she might have that part. I feel like group work really helps. Um, sometimes we do that in class too, like figuring out problems and um, yeah, having another person there and telling you, "Well you know, what if we did THIS," that can make you realize - yeah.

I: So when you get together in groups in class, you find that beneficial?

R: Yes.

(…)

I: What is it about the group work, that you think is so effective?

R: Um, like I said before, having another person there to you know, if you feel you're really stumped, you know, they can maybe introduce you to a new thing that you never thought of before. And, I don't know, I just remember things better that way. Some people have hints on how to remember things and stuff.

5.4. Students described feeling as if they were receiving the material through a large lecture format.

Students were aware that the class was supposed to be different from large lecture sections, and that the class size was small, at least in part, to facilitate discussion. But, due to the fact that students usually did not understand the material at a sufficient level, classroom discussions rarely, if ever, occurred. A few students suggested that the format was more like a lecture section than a discussion section, with the professor lecturing on how to solve problems, the students taking notes, and a small number of students asking "mechanical" questions regarding the steps the professor takes to solve problems on the board.

In discussing class lectures, many students suggested that thorough, detailed, inclusive descriptions and demonstrations were helpful or necessary. However, lengthy, detailed descriptions in class could also be a distraction for others. Students described three scenarios during which the lecture became difficult for them to follow: 1) remediation of material that (some) students already understood; 2) giving too much detail (which students felt was irrelevant or unnecessary) in response to a question; 3) and repeating an explanation of which the students are not "getting", instead of giving alternative explanations.

5.5. Students described feeling lost and unmotivated.

Many students described the students in class (in general) as being unmotivated because they don't like math and because some of them feel lost. Not only do they have trouble with specific content, but they have trouble identifying overall connections between lectures. As well, they have trouble identifying the most relevant points made in lecture. The following quotes express these viewpoints:

Generally [when walking into math class] I really don't know what to expect. I mean, it's so hard to be able to tell where he's going, where he's gonna go with the course, or with what he's going to try to teach, or what he'll decide to begin the class with. I don't really know if we've had a consistent, like two or three sessions like studying a single topic.

****

Does he want us to think logically, and think theoretically about math, and if so, I hate to say it but that's just the wrong approach for people who aren't going to be taking math ever again!

…For the exams, very specifically he'll give us a review sheet, and that always fits, but you spend the four or five weeks in between exams going, "Hmm, I wonder if this is going to be on the exam," or "I wonder if we really need to know this?"

These viewpoints suggest students would feel more secure in their study of Math 141 if they had explicit instructions regarding what they will be doing in class and how it relates to the exams. The professor might improve the class by using more "sign-posting" about what they will be doing.

6. MATH 141 STUDENT OUTCOMES

While it is true most students indicated they experienced frustration and benefited from only selected teaching materials and strategies, we note these results can be expected for this group of self-selected "math avoiders." We feel the outcomes are all the more impressive given the backgrounds and inclinations toward mathematics of the students who took this course.

6.1. Students liked how the professor modeled problem-solving.

Many students reported that they actually were becoming better problem solvers. A few students talked about the way in which the professor solved problems in class. The following students described a teaching strategy which they found very helpful:

I: *If you had to specify one aspect of this class that was helping you to learn math this semester, what would that be?*

R: *The why of how to solve it. Why did [he do it] that way. Why did you have to solve it this way and not the other way? Um, sometimes he doesn't do that though, but whenever he did do that, that was helpful. `Cause then I could use that, when he said "Why?" for this one problem, I could use it for other problems.*

****

R: The approach that he has taken in this class is more like problem solving where these are the things that you need to accomplish in this problem. Take a look at a problem and think about it as opposed to trying to memorize what should be done with it. More of a common sense approach.

I: Does that appeal to you in terms of what you were talking about earlier at all, in terms of needing math in terms of a practical sense?

R: Greatly. That seems to be all I can think about. If I can't look at it in a real-world or common sense way, it won't make sense for me.

6.2. Students valued the concept of Math 141.

While the class had mixed results with regard to impact on students' attitudes toward math and confidence in math skills, many students reported that they understood and valued the *concept* of the course. The following student talks about the professor's pedagogy with respect to the goal of Math 141, saying s/he is benefiting from it:

R: He always says, "That's why sometimes it takes longer - I'm showing you how we came to, in previous equations, how we came to get this equation." He just doesn't want us to, you know, plug in numbers. He wants us to be able to think things out, you know, he's always emphasizing that this is a quantitative

reasoning course, and that that's what you're supposed to be learning. You know, saying that you may not use all this math later in life, but it's the process of coming to get the answer that's important.

I: And do you think you're developing that?

R: Yeah!

This same student reflects on how math was taught in high school:

I: What is the philosophy being used in teaching Math 141, as compared to [that in your high school math classes]?

R: My teachers in high school (…) just presented the answer, kind of like, this is what you're doing here's your homework. Yeah, they wouldn't always work out - tell you where equations came from. They said this is the equation to figure out this. And I mean, yeah, it made it easier to do homework and get good grades on tests, but here it's kind of like well, this is why we're doing it, and sometimes it's more important to understand why than it is to get the right answer. Know what you're doing.

I: Know what you're doing. Yeah. Do you agree with that philosophy, or do you think you're benefiting from that?

R: For as much as I'm going to need math, outside, yeah, I think this is probably better for me than knowing how to do calculus or something, that would really mean nothing to me.

Another student articulated the value of the course in terms of its goal to teach practical applications of mathematics:

The practical application of this class is far better than what 112 would be. If it were my call to make, I would like to see more math classes turned to practical math. Well more courses in general on campus for that matter-- The abilities to use formulas and mathematical equations is meaningless if you don't know how to translate that into what you are trying to do in your daily life. If you are not in engineering or chemistry and you are not dealing with that kind of thing, I would believe that your time would be better off spent with a class that is a little more practical.

While many students said they valued the concept of Math 141, most of these students also stated that it wasn't working for them. They reported feeling frustrated and lost. These students suggested that there were still changes to be made to course structure and content in order that it better meet its goals.

6.3. Students became better problem solvers.

Several important statements were made regarding what students are taking away from their Math 141 experiences. Among the most significant is that many students now see themselves as more thorough and thoughtful in their approaches to problems. However, while these students described that they now approach problems differently, many also indicated that they were not good at it, and still lacked confidence. A few described that they now have a different approach to problem solving and increased confidence and ability. The following quotes represent a range of student outcomes in this area:

R: *[We're learning] to be confident problem solvers.*

I: *Confident problem solvers.*

R: *Yeah. Because I know usually a problem isn't exactly the same, like on a test. If it's not exactly the same as the review problems we did, I can't do it. But I'm trying to learn how to do things, like, if it's a variation of the problem, learn how to do it -- how to, like, change what I'm doing, think of a new way to solve it, because usually I can't do that.*

****

[Math 141 has impacted me in that] I might think about taking other math classes in the future and if I needed to it wouldn't be a problem because it has kind of brought together everything I have ever learned before and advanced it a little bit more. It makes me look at different problems in different ways.

****

I: Do you feel like you have developed skills?

R: Yeah, I do. Some of the things we're learning now that were things we did in the past, in high school – the way we did them was much more simplified than the way we do them now. It's more complicated now, and so the fact that it kind of makes you think harder, and everything - it's definitely making me think harder!

I: Which way would you rather do the problem?

R: Well, I'd like to take the easy way out, but I guess in the future I'd probably say that I'd like to have these skills, of working problems out, more than I'm doing now.

****

I: Are you learning math in this class?

R: I think so. I wouldn't say, necessarily, like math as in learning calculus, but more learning like he says, learning how to problem solve things. Different ways of going about it. Because even in our tests he says, well if you have to guess and you just do process of elimination, well that's better than not trying to do it at all. I don't know, I guess that's what comes to mind.

I: Okay, you compared it, you said, "not necessarily learning math like learning calculus," what about learning math like learning algebra? Is it very different from learning that too?

R: I would say so.

I: So it's different from other math classes, but it's still learning math.

R: Yes.

I: Okay, so you're learning math in your algebra class and you're learning math here. What's the difference between what you're learning?

R: I think just, like I said before, how in all of the other different math classes it's like the traditional, "I'll give you a problem and you practice this one," and here it's more problem solving, like figuring out the problems almost for yourself, but not really.

I: Okay, yeah, I think I hear you saying that you're more involved with the thought process of …

R: Yeah, right, right.

6.4. Many students viewed math differently and experienced a change in attitude.

Many students valued the problem solving processes they learned (even some of those students who felt they hadn't become very proficient). Many valued the material that was addressed in Math 141, as it helped them see math as relevant to their lives. This student saw the usefulness of new skills s/he learned through the course:

> R: *You know actually, I was kind of surprised -- it's not like a bad surprise. I learned a lot more than -- I was anticipating not really learning anything.*
>
> I: *Oh, really?*
>
> R: *In this class, yeah. It was just I needed a math class, and I said I want something that I can get through, but I actually learned a lot of practical applications, especially in the in the area of compounding interest and that sort of thing. A lot of, I guess you might say, business math. Um, kind of like the basic things I need to, you know, balance my checkbook and start a banking account and things like that. And that's stuff I know I'll definitely use in my life.*

Many students said they viewed math differently, as more interesting and useful than they had previously thought. A few said they had actually come to like math more. We observed that while many students experienced a shift in their attitude about and confidence in math, the shift was by degree. That is, students we identified as more mature or independent learners[2] experienced a greater degree of attitude change. The following comments reveal this shift in attitude:

> *I: Has your experience in Math 141 changed the way you think about math?*
>
> R: *Yes. I have almost come to enjoy it. It is a helluva good feeling walking out of a math exam and feeling good about it.*
>
> *(…)*
>
> I: *In what ways has it changed how you feel about [math]?*
>
> R: *I have never, at least in my recent college history, haven't felt comfortable with the material, haven't felt like I really learned anything. But in this course, some of the material is things I am working with already or can at least relate to my life and it is a good feeling to be able to do a problem correctly.*
>
> ***************
>
> *I: Do you feel more comfortable with math now, as a result of taking math 141?*
>
> *R: I do. There is more than one way, you know, to arrive at an answer now. I've followed through this course, where previously it's always been this way or that's it. It's just kind of changed the way I look at math. It used to be, you know, I'm bored in class where half the class is speaking. And the instructor up there just sits and talks to the wind. You know, and now it's changed that a lot for me. I mean just the way I view math. It used to be a yawner and now, dare I say, it could be fun if you look at it right?*

[2] We identified "independent learners" through subjective information, such as their discussions about how they study and learn, and through objective criteria such as being a nontraditional student, or having placed in math 113.

Many students, like this one, described a positive experience in this course, but still state emphatically that they do not like math as a subject:

> I: *So you still feel the same way about math?*
>
> R: *Well, I feel better about this math class, but I won't take any more. …I like it better than any math class I could have taken, I think. Does that make sense?*
>
> I: *Yeah it does.*
>
> R: *I mean I know that I would like this class better than if I would have taken algebra.*
>
> I: *Well, that's really good.*
>
> R: *But I still don't like math.*

In spite of the accomplishment of some of Math 141's goals for students to become improved problem-solvers and to face quantitative reasoning challenges with greater confidence, it is apparent that most of these students will continue to avoid math in their futures wherever possible.

7. CONCLUDING COMMENTS

Generally speaking, LEAD's role is to provide feedback rather than specific recommendations for improvement. However, it seems in this case worthy of noting that some conflict existed between the stated objectives of this course, as reported by both the instructor and the students (increasing student self-confidence, learning practical life skills, etc.) and the practice of remedial instruction (returning to proofs and derivations the students had often seen or heard before, whether or not they fully mastered them at the time). Where students were initially excited about this course, they were excited because of the chance to learn "practical" math in a new way; where they reported learning something valuable, it was along these same lines. Where the students reported being bored, lost, or confused, it was often because they were being asked to study the same type of material that did not appeal to them in the past. While many students did not specifically object to trying to relearn material (after all, many stated they expected to relearn material when signing up for Math 141) they did experience frustration at trying to relearn it in the same way, and experiencing failure. Given this pattern, we are inclined to advise future instructors in this class to continue to emphasize new approaches involving applications and mathematical reasoning.

In all likelihood, there will continue to be a great divergence in Math 141 students' previous math backgrounds and in what they have retained coming into the course. There remains a problem, then, in dealing with those students who need remediation to do even the most basic mathematical calculations, even though their placement scores indicate they are equipped to do the work. Perhaps arrangements could be made for those students to seek help from tutors who support Math 95 and/or Math 101. Additionally, students who sought tutoring through GUTS on campus

were told that Math 141 was a new course and, thus, was not supported. As Math 141 eventually becomes a more "standard" course offering as a permanent option in the satisfaction of the QR requirement, the Math Department may wish to consider advising GUTS on how this course might best be supported.

What united the students in this section was a disinclination to pursue math-related majors and careers. This is something a one-semester course is unlikely to impact. Students were also united by some interest in learning "real-world" math applications. Future versions of this course may be most successful by more consistently recognizing that these students are not likely to go on in math and are unlikely to be enthusiastic about either traditional freshman-level mathematics or remedial work. On the other hand, students will be more likely to become engaged in this course when it teaches them math they feel they can actually use. It is significant that so many of the students in this section commented favorably about the impact this course had in the realm of practical application and how this impact influenced their overall impressions of the importance and usefulness of math as a subject area. It should also be noted that several students commented on the value of the reasoning processes modeled by the professor during board work.

While "group work" as implemented in this version of the course did not appear to be a significant success, we believe that peer collaboration more generally may be a very appropriate technique for teaching nontraditional, issue- or topic-oriented material to students who vary a great deal in background and ability. Faculty may need to consider how to facilitate group work to make the diversity of the class an advantage. The number of students who reported success with group work and/or "explaining things to others" in this course (and in other courses) suggests that this might be another commonality on which this course could build.[3]

Finally, there are some valuable messages in the students' observations about what was most beneficial to them and what was perceived as an impediment to their learning Math 141. No structure or teaching strategy will prove effective with all students in a given setting. The added complexity of a wide range of student backgrounds, preparations, abilities and interest levels makes identifying the potentially most successful strategies more difficult. However, we believe that the instructor of this course has a unique opportunity to experiment with and develop some effective ways of introducing useful and interesting approaches to quantitative reasoning and problem-solving to such a diverse mix of students.

Overall, this pilot course of Math 141 experienced some significant successes. It is true that students had diverse experiences: a few reported a significant shift in attitude, ability, and confidence while many reported *some* shift in these areas; and most reported a shift in that they now had a better understanding of how math is applicable. While individual students described a variety of outcomes related to their Math 141 experience, the following quote is representative of an outcome experienced by most of the students:

[3] The College Level 1 Team of the National Institute for Science Education (NISE) has a website for cooperative learning resources for college instructors. (//144.92.236.220/main.html.)

Well, I like it a little bit better. I still don't like the class, but I do like math a little a bit better. I mean, I'm able to see why we need it. I mean I'm more open-minded about math. That like, I mean why we need it, why it's used. And I can even see why people like it a lot. But, it's just something that's not for me.