# Math 141
# Evaluation Report

## Fall 1996

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prepared
for

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by
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TABLE OF CONTENTS

## 1. INTRODUCTION

This report details the backgrounds and experiences of students in Prof. Michael N. Bleicher'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 12 of the 37 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 6, 1996.

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.

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

## 2. THE STUDENTS

### 2.1. Competence in 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[2] did fine in their high school math classes, reporting that they often earned B's and C's. A few reported that they did very well in their high school math classes. We acknowledge that the meaning of grades varies among schools. These student self-reports are not intended to suggest that the students had sufficiently mastered the material in high school math courses. Nor do we suggest that they were homogeneous either in the particular math skills they have attained, or in the level at which they have attained them. However, the self-reports suggest, and these students' acceptance to UW-Madison confirms, that they were capable of developing skills and strategies needed to get through typical high school math courses.

This said, most also reported that math was a weak area for them. Although doing well in high school, one student noted that his/her skills were limited, saying: "I knew that as I got higher in math, the more complicated it got, the more lost I was." The following student noted his/her struggle with high school math and talked about his/her ability to get through math and math-based courses, sometimes doing well in them:

> *R: [High school] math has always been one of my weaker spots. In fact I almost got held back in the first grade because of my math ability. Eventually I brought it up to a level that was pretty much standard, [maybe] slightly above standard. But dealing with math, and with [numbers], always had been a problem for me. And it also sort of spilled onto my ability in dealing with sciences. But I was never at a disability level, or anything like that. It was something that I had to bang my head against the wall to understand sometimes.*
>
> *I: Did that deter you from actually taking courses that were related to math? (…) Did you get discouraged from taking anything?*
>
> *R: No. Because I was smart enough to know that I can't base stuff like that strictly on my ability, and these are classes I need to take. So ultimately what would happen is that I would wind up taking courses like Chemistry, and initially I'd have a hard time. But because those weren't strictly [math] classes, ultimately I was able to pick up [the material], and by the end of the year I was doing pretty well. And the same thing in a class like Physics. Initially I had a horrible time with Physics, but by the end of the year I was pulling, probably a B plus in the class.*

### 2.2. Diverse Level of Math Skills Represented

The differences in math ability in the students, as perceived by the students themselves, is, in the evaluators' view, a source of difficulty relating to how to pitch the course. On the one hand, many students referred to the Math 141 lectures as being over theirs and their classmates' heads. One student said of the class: "Everyone in there is looking for help." These students estimated that theirs and their peers' skill levels were lower than what seemed to be prerequisite for understanding the lectures. They also acknowledged that

[2] Qualifiers are used to give an indication of how many students expressed any given viewpoint: "few" indicating 1-3 students; "many" indicating 4-9; and "most" indicating 10-12.

the particular skills and levels possessed by students varied. The following student talked about this, noting the difficulty in designing a course for this particular group of students:

> *I just think that things would be better if things could be brought down a little bit. It's really hard because everybody does have different backgrounds. I mean, some people have more background than others, and so they are understanding more of what's going on. So it is really hard to decide what level to come down to. And I know that's why we're given a placement test, but this [kind of material] isn't really included in most placement tests yet. (…) I mean, I thought about this too, how could you teach this class? It's really difficult to come up with a set [of material to use with all the students.]*

On the other hand, a few students noted that, in their view, they were good math students. Some of these students mentioned they would have preferred to take Math 112, but that those sections had been closed when they registered. These Math 141 students reacted negatively to the professor's rationale for using non-traditional methods in this course:

> *Sometimes he treats us like, (pause) like he even told us one day that since we were in his class, he assumes that we didn't do well in math in high school. So now he wants to try a different method than we had in high school. And that's not true because I did well in math in high school. I know a lot of people did also. And that's the teaching thing that I didn't really like.*

### 2.3. High School Math Experiences

Many students highlighted particular teaching styles and particular learning strategies in high school math classes which were associated with positive and negative experiences. Almost all had to do with the way in which math problems were explained.

- **Slow pace and detailed explanation**

> *I had [good teachers] freshman and sophomore year for algebra and then geometry. I don't know why they were so good. I think they went slow and took the time to explain stuff. And the teachers that I had junior and senior year kind of assumed you knew everything and sped through it.*

- **Varied explanations on a problem**

> *I: What did you like about [your high school math teacher]? What made you think he was good?*
>
> *R: If you had a question you could ask him and he would explain it and not treat you like you were stupid. It wasn't one of those things where he just kept doing it the same way over and over, he would try new ways to teach you and you could understand it. If you did have a problem you could come and talk to him.*

- **Supportive, structured learning routine**

*R: [My favorite math teacher] was tough, but when he knew you had a problem, he would be lenient in that sense. But he was very tough, you know, get your assignments done, study for your test and quizzes. But if you were having trouble, he would help you personally. He would put it off until you were confident in what you were doing. He wanted you to have confidence in what you were doing. And that's a big help.*

*I: That's great. And then what was his teaching style?*

*R: I remember there was a board at the front of the room, and a board at the side, and he would have problems written at the top of the board, and then he would work the first problem. If no-one got it, he'd say, "ok, we'll try the second one." And they were all the same, just different numbers, and we'd just keep on getting them. And we could not do our assignments until all those problems were done.*

*I: Now are you telling me that he was up there doing them, or were students up there doing them?*

*R: He was up there, and he would question us as we were going along. He would call [on a student and ask] "what do we do next, and what do we do next?" And everyone had to answer once. Some people could answer five times, but everyone had to be involved once. He never wanted to embarrass anyone though! He just wanted to see. If they were having trouble he helped them along until they came up with the right answer on their own.*

*I: How did he provide help?*

*R: He was very understanding. If they're having trouble with something in the problem [he would] ask them to go back: "what do we do, what do we do?," and go with very basic math skills. "You add here, now what do we do with your next equation?"*

- **Examples graduated in difficulty; use of repetition**

  *My high school math teacher would start with basic problems and keep building it up and building it up until we got to a more complicated formula and then you'd memorize how to do it. And you'd do it a hundred times, and then take the test on it.*

- **Plugging in numbers; memorization**

  *I always think of getting formulas. That's [how I remember learning math]. A teacher giving you a formula and plug the numbers in and memorize that one and then getting a different one and memorizing it.*

The following student describes a course design that didn't work for him/her:

- **Finding connections between course elements**

*It was a lot the teaching style, but it was also a lot the material. I don't know if it was that I didn't have a good enough grasp of it when I was in my Algebra I class in junior high. I don't know, I just really didn't do well in that class! The teacher, his assignments compared to his tests, were just completely different. What we did for daily work had almost absolutely nothing to do with what was on the test. Because he expected, since we knew how to do this, we also knew how to do that. He expected it of us. And it just wasn't the case.*

### 2.4. Students' Attitudes About Math

Students had in common that no one particularly loved math, or had any desire to study it or any math-related field. But their particular attitudes regarding math and its importance varied. Rather than points on the same continuum, the opinions expressed covered three discrete points: math is important; math is "okay"; and math is unappealing or uninteresting.

#### 2.4.1. Useful and Important

Many students noted that math is important. As one put it: "I don't really like math, but I know I need it. Because math is connected to everything. You need it." The following students also noted the importance of math, but argued that it was not personally relevant:

*The first thing that comes to mind is anything like Physics or Engineering [when I think of learning math]. Essentially, stuff that I don't plan on using that much. I mean I know that's probably unfair, because there's a lot more to math than that. But the stuff that I've typically had to deal with has been pretty much that. So I don't want to say that learning math seems useless to me, because I mean, I know it's not. But learning math to the level that most people are expected to learn math, at least in this country, doesn't seem to have much of a bearing on what I want to do.*

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*I: [What is the role of math in] your life?*

*R: Everyday math? I definitely think math is important, I mean there is no doubt about that. It is used everyday. There are basic principles of course that you need to know, but I have always felt, especially when I started learning geometry and on, that it was just useless. I would sit in math class wondering "why do I need to know this?" Why do I need to know how to find an area of a circle, stuff like that. And then it got even worse, in algebra trig. Sine and cosine, I don't think I am ever going to use that kind of stuff. Which is another reason why I don't think I ever enjoyed it because I don't think it is going to be useful to me in any sort of way.*

*I: So if someone explained to you why certain aspects of math would be useful to you, would that help?*

*R: Perhaps. If I were in that class and I was learning something and I knew why I was learning it and I saw that I was going to need it and I saw how I was going to use it, that would make a big difference. If I saw how it was going to be useful to me.*

#### 2.4.2. "Okay"

A few students conveyed that they neither hated nor loved math. One student said: "I didn't love it like I loved other subjects. But it was there – it was math – it didn't really

bother me." And another said s/he wouldn't mind taking another math course "as long as [s/he] didn't get stressed out." S/he went on to say:

> *I'm a freshman and just hearing them talk about their calculus, they're in agony and I wouldn't do that to myself, but I don't mind learning math.*

### 2.4.3. Not Appealing or Interesting

Many students said they never liked math. For some, the negative feelings associated with math classes seem connected to their self-described weakness in math as a subject. The following students describe their feelings about math:

> *R: I hated pre-calc. I finished pre-calc and decided that I don't want anything ever to do with math. (…) I hated math. I didn't want to have to take a math class.*
>
> *I: And even now you hate it?*
>
> *R: Yes, I just want to get out of this because for my major it is my only math requirement except for physics or stuff, you know my science or whatever. I just want to get out of it, I hate it. (…) After having pre-calc, I don't know, now I feel dumb when it comes math, and I hate it and I don't want to be in it. When it comes to math I feel very stupid now.*
>
> ***************
>
> *Math was always my weakest subject in high school. It was my least favorite. I didn't really do too well in it. I never enjoyed it. (…) I mean I know learning math is something that's important. I know it is something that is hard to do because I have had trouble with it. It's complicated, personally I don't find learning math interesting. I think learning math has to be something that you want to do. I know every time I go to class I don't even want to go. And if you don't want to be there maybe it is harder to learn.*
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> ***************
>
> *I enjoyed [math] up until, I guess, some levels of high school algebra and geometry, and more abstract things. I never really caught on to all the geometry proofs -- I mean I always did alright. I did fair in math, but it was never something that I loved to go to class or anything. And then by senior year, I really just wanted to finish -- you know, meet my requirements, wrap it up.*

## 3. STUDENT EXPECTATIONS OF MATH 141

Many students had expectations regarding what they would learn in Math 141 that were both specific and based on what they had learned about the course from advisors at the SOAR summer advising session. Students felt that class would be easier than the algebra course they would otherwise have to take. While some thought the focus would be on solving real-life problems, others thought it would focus on a discussion *about* math (as opposed to actually *doing* math).

- **Easier than other options**

One of the most common expectations mentioned was that the course would be easier (than Math 112), and in some ways, not really like a math class. As one student said: "[I took math 141] because [the advisor] said it would satisfy the requirement and it would probably be an easier class and not just an algebra class."

- **Discussion based, concept oriented**

The following students expressed that they expected very little actual problem solving, and more discussion about math and math concepts:

> *I told my [SOAR] advisor I don't want a math class that is really hard. After last year I was so afraid that if I come to college, math courses would go too fast. So I want a course that is not going to be very hard. She told me about this class and she said that it was about concepts and stuff so that's why I wanted to take this one. It sounded a little easier. I wanted a little more explaining and not as many formulas to remember. She said it was more concepts and just talking about where things came from and so she goes, "it's not really a lot of math, it's just concepts". She said that we would probably have to write papers on where things came from and so, she said we would actually get the real history of it.*
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> ***************

> *At SOAR they said I needed this math course, and they said it was quantitative reasoning, but I didn't know what that meant. They said it was kind of a different course where they go over the math fundamentals and basically what math is more about than just working on problems.*

- **Designed to improve math skills**

Many students also specifically expressed that they had hoped to improve and strengthen their math skills:

> *I [was expecting to learn] more skills to be able to take math equations apart, to not be confused when I see percentages -- I guess to be less intimidated by math.*
>
> ***************

> *I guess [I was expecting to learn more about] story problems. I never really understood them and I thought that maybe this would help me to understand.*
>
> ***************

> *I was hoping to get a review of the math I had learned in the past and just feel stronger with that. I think I have gotten that so far. I just built on my skills I guess.*

- **Emphasis on practical math**

A few students said they expected to learn practical math. They expected to solve math problems that had real-life applications. The following statements express this:

> *I was basically going in [to Math 141] thinking "OK, this might be a little bit easier than 112 would have been and I'll have a better time in this class than I would have had in 112." I was actually like looking forward to it, cause I'm [thinking] "this isn't bad, I won't have to take any math after this and I hope that I can come out with a good grade and an understanding of [math]." It was explained to me that the course was going to be more real-life applications and so I'm [thinking] "OK, maybe I'll actually be able to use some of the stuff that we learn." (…) I thought it was going to be more real-life applications, stuff that we'd actually be able to use. Which it sort of is but the stuff that we're doing is so over everybody's head in there right now,...*
>
> ***************

> *My test scores were too low; I had to take [Quantitative Reasoning] A and B. The [SOAR advisor] said for A you could take this - they described one math course, I forget the number, and they noticed I was not particularly interested because I didn't like math. I didn't do well in math. And they said "Well, if you're not that interested, there's Math 141." This is what I was told - it teaches you practical things in mathematics: you'll learn how to do taxes, you'll learn about checking, mortgages, banking. And I thought "Well, that sounds very practical; I'd like to do that." And that's why I took it.*

## 4. STUDENTS' UNDERSTANDING OF THE PROFESSOR'S GOALS

While students' learning expectations were diverse going into Math 141, many expressed a consistent understanding of what the professor wanted them to learn. Students said the professor wanted them to be able to understand information presented in public formats, such as newspapers and magazines; and to be able to think through situations, using mathematical reasoning to shed some light. The following statement is representative:

> *He just basically has said all along that he's trying to teach us how you use math so you can understand everything that's around you. Like if you see an ad or whatever, you understand [the claims it makes]. It's kind of really practical; [knowing] what you should rely on and what you shouldn't. It's not getting ripped off.*

And the above student went on to say that s/he appreciated this aspect of the course:

> *It's good. Actually I like it because it makes more sense. He [explains things in] ways that we understand rather than [teaching] more math or whatever. So that's good and bad. (…) I guess it's bad when we have some problems and he will go through the longest way and explain how we can actually do this without giving us the formula. It gets to be a lot more confusing that way. But just explaining how math is used everyday, that's good.*

Another student added that the professor wanted them to gain a basic understanding of mathematics:

> *He wants us to come out of this course with a basic understanding of math. One of his big things is, and which makes sense to me, don't take everything at face value when people are saying [things], especially when they're quoting statistics.*

A few students reported that the professor's goal was to teach the "why" and "how" of math -- how to use math and how to analyze. The following student talked about the various strategies used to meet these Math 141 goals:

> *R: He'll give us a worksheet without first teaching it to us, I think to see where everybody is. We come back and no one can do it. I think his aim [is for us] to learn conceptual math and learn why it is.*
>
> *I: How did he frame that to you? When you guys began class, how did he tell you what the purpose of the class was?*
>
> *R: He articulated it mostly just like that. He said, "I'm going to teach you why two plus two is four, not just how do you know that two plus two is four."*

Just a few students experienced confusion about the course objectives:

*There's no goals, we don't really know what we're supposed to be doing. [He'll solve problems] five different ways too, and I don't know what way he wants me to do it, I get confused. He doesn't care at all what way we do it, which is hard too. Usually there's one way -- you learn one way.*

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*To be honest, I really didn't know what he expected from the course, I think almost until the first midterm. Because it seemed like he was meshing so many different things. Like reading articles and finding the fault in them, --talking about innumeracy and stuff like that. But also giving us [equations], like figure out the rate of inflation for such and such country, knowing all this information. And there was a lot of probability stuff. So, it really was hard to see what he was trying to get at. For a long, long time. (…) It's only like the week before [the test] that any of us really know what he's expecting from us, or what he expected us to pick up. Because it's just so random in there.*

## 5. TEACHING STRATEGIES AND LEARNING MATERIALS OF MATH 141

As stated in the introduction, the general goal of Math 141 is that students will learn to think "mathematically" and become independent problem solvers. This section of Math 141 incorporated diverse, non-traditional elements. The text, 200% of Nothing, consisted of a series of essays illustrating various ways in which math is used and offered an analysis of the information presented. Essay assignments were given whereby students were asked to model the types of analysis presented in the book. Students were also encouraged to write about their own thought processes when solving equations on homework and tests. (Note that students consistently refer to the homework sets as handouts.) Another feature of this course is the focus on discussing the "where" and "why" of formulas rather than presenting algorithms. Formulas were not presented in the traditional way. Homework did not consist of the traditional sets of similar problems designed for rote practice. In this section we address these aspects of Math 141.

### 5.1. Learning Materials

Many students focused on the various materials used in Math 141. Mentioned were the text book (200% of Nothing), the handouts, and articles. Student opinions regarding the value of these materials were diverse. But a common theme was the difficulty in identifying a connection between the materials and how the materials were intended to help students meet the course objectives.

#### 5.1.1. Varying Opinions of the Book

Although many students said the book was interesting, many of these students did not appreciate it in the context of the class. In particular, they expressed difficulty adjusting to a text so different from those used in all their previous math courses. (See also section 5.4.1 on students' felt need for problem solving models.) Some described it as having "no math in it at all." Others merely found it interesting. As this student described it: "It's this guy talking about how people screw up using math and stuff, and it is really interesting to read because it gives you a lot of things." A few related it to math in the sense that it has problems and answers, but these students' concern was that it did not show how to solve the problems. The following comment is representative:

*R: The book is called 200% of Nothing. It's just a regular book that you could buy in any book store and read for pleasure if you wanted to. [It hasn't been helpful for class] because it brings up things but it doesn't tell you how to do anything. I mean it will show you how you were being tricked in advertising and stuff like that but it doesn't show you [how to figure it out for yourself]. [The professor] will show you how to [figure it out] in class. The book has nothing to do with that, really.*

*I: So you see no connection with the book and how he is teaching you?*

*R: The book helps him bring up subjects, but the book for us didn't help us when we were trying to figure things out on our own. Like it brought up the question but it didn't answer the question.*

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*R: The book is very general. It tells you a problem and it gives you the answer. It doesn't tell you how you got the answer - it just gives you the problem and the answer.*

*I: What kind of problem?*

*R: {pause} Ah, some benzine was spilled into some French spring water and it was pulled off the shelves in the United States. Apparently scientists projected that such and such amount fell into the water. What's the probability of cancer? Everyone thinking the probability will be so high, but actually in reality it's low.*

*I: And so when it gives you an answer it gives you a number? Like .01?*

*R: It gives you words - it will explain it. But it doesn't show you the actual calculations, and you're kind of lost! (…) Some [sections] are logic problems. (…) But when we're reading along, we would be totally confused.*

*(…)*

*I: What's your overall opinion of this book?*

*R: It has some interesting anecdotes and some facts, but {pause} I don't think it's helped me understand how to get these answers any better.*

Students were assigned essays in reaction to or related to various chapters in the book. As well, students were encouraged to bring in articles for which the class might practice the type of mathematical analysis modeled by the book. Many students did not appear to see the value of these types of assignments. When talking about their experience of learning math in Math 141, students focused on the homework problem-sets. And for a few, the lack of connection between the reading assignments in the book and the homework problem-sets was disturbing:

*R: There are no math problems [in the book]. He gives us math problems but it is kind of confusing. You know, how do we put them together? And I think, most people are used to the old way math is taught and the new way is kind of …*

*I: Kind of clashing?*

> *R: Yeah, exactly because there is no transition. (…)I think that there could be [a correlation between the book and the homework problems] but I don't think we have realized it if there is one.*

A few students expressed that the book had some value with regard to its use in Math 141, but also suggested a traditional math book would be helpful:

> *Now we are into probability and choosing numbers. Now we need a text that we can refer back to for the problem part and we don't have one. We don't know where this stuff is coming from. We just have what he puts on the board. The book [we have] is okay for learning about what is out there. It is not a difficult book for a primary book. I guess in the other class they have their math book. I think both books would be beneficial, both of them together.*

A few students had suggestions for how the book could be better used in class. This student referred to the text as something which can be a reference and provide guidance:

> *[If I could change this course] I'd probably encourage writing on a more frequent level. I guess I'd start with the lectures, first and foremost. I mean, I'd keep them as structured as I possibly could, basically start with what the book says. That's just something that I've always had a problem with, is just keeping consistent with the textbook, or at least, keeping a consistent enough lecture that you can follow, that you can write down, that you can be able to refer to. With this class I'd start with the book. Start with what the book says. Try to decide how it would be relevant, then perhaps start working on the numerical aspects of it. I mean that personally would help me along, because then I'd be able to better synthesize what exactly is in this book, what we can learn from this book. And, you know, while math isn't totally unavoidable, here's how we could use it. And be clear on what the equations are, and what it is he's expecting you to know through these equations. And like I said, encourage more writing on the topics discussed in the book. And also perhaps to encourage more writing on the tests.*

The evaluators note that students' interviews revealed some "marked" and "unmarked"[3] Math 141 events. The text was a marked component of this course; many did not consider it a math book, some to the point of actually saying they did not *have* or *use* a text. Assignments having to do with the text were also marked events. Despite the reading and writing assignments which students described, the classroom discussions focused on the readings, and the professor's solving of problems presented in the book, a few students expressed that the book was not being used. The following viewpoint is representative:

> *R: Well our book hasn't meant a lot to me yet. You should see it, it is like a reading book. (…) It talks about dentist commercials, and how four out of five dentists like it and [the book makes an argument that the statement] is wrong. Then it moves onto some other topic and stuff.*
>
> *I: How do you feel about that?*
>
> *R: I don't know, interesting maybe. It is definitely a book that is fun to read. But then since we don't really use our book at all in class, he doesn't really ask questions from the book.*

[3] "Unmarked" refers to what is considered to be the norm. Homework sets consisting of problems (involving formulas and numbers) to be solved is an unmarked event in this class. Essay assignments are "marked" events, that is, events which are not considered to be the norm. The text and use of articles were also marked events in this class.

The above student went on to suggest that the book *could* be used in this class; but because it is not used, it is "pointless":

> *I am thinking, what's the point of having the book? I think if he asked questions from the book, like the dentist thing, why [the "four out of five" statement] is wrong, then I would think there is more of a point to that book. To me [the book] is kind of pointless. I don't want to say that but it is. I [feel like] I wasted money on this and I don't really need to read this because it doesn't pertain to anything.*

### 5.1.2. Varying Opinions on Homework Problems

A few students found the handouts helpful:

> *But the handouts that he gives us, those do [pertain to what we are doing in the class]. He will go over problems then we will do [the homework assignments]. Then when we turn them in, he will ask who had questions on them, and then we go over that. And that will be the kind of stuff that he will give us on the test. So those help because those are things that we use in class. We actually do problems in the class and go over it.*

This student described the handouts as not being helpful in and of themselves – but being helpful as part of a process which brings the students into a meaningful dialog about the problems:

> *I: If there was any one particular thing that jumps to your mind, that you feel most helps you to learn in this class, what would it be? One feature or one specific item, what would that be?*
>
> *R: It would probably just be the handouts that we receive, because oftentimes what happens is that he'll explain something, and he'll give us the handout which, he assumes, applies relevantly to what he has explained, and none of us are really quite sure what it is he's told us, and it sort of works backwards. We look at the handout and it's through the handout that we see the problems, we get confused, we bring it up. At the same time, it sort of forces him to synthesize what he has been trying to tell us, in a manner that we can understand and in a manner that's directly tangible. I mean where I have gotten the bulk of my information from is basically: "Ok, what are you saying, how can we put this into context."*

However, many students focused on how the handouts were significantly different from and more difficult than the examples worked out during lectures. The following student described the homework as confusing and difficult:

> *[The homework problems] are difficult. Some of the questioning is a little confusing sometimes. A bunch of us need to sit down. I think it is very difficult for one person to sit down and figure out all that by themselves. Just based on the notion that we don't have any concrete background of how to solve these problems. I think some of the examples that he has on the handout aren't what he talks about in class. So where do you even begin?*

And this student stated that there is no connection between lecture and homework assignments:

> *I know he does give us the homework, but sometimes it has nothing [to do with the lecture], he didn't bring up that example in class and I have no clue how to do it. (…) So we don't even hand it in on time. This one work-sheet he gave us, we had no clue why we were doing it. It asked us to find a deficit for the last six years. Like for voting population for voting counties, and then the regular population in those counties. And it had all these things that had nothing to do with math really. It was just looking up stuff and it took a lot of time. I spent a number of hours on the [internet] and couldn't find anything. And then a lot of people spent hours in the library and ended up having the librarian finding everything for them. So I don't understand what the point in this assignment even was.*

Many students expressed the feeling that lectures did not prepare them to do the homework. As one student put it, the professor simply gave a brief overview. This student suggested that more, shorter example problems would help, and added: "But make it challenging, you know, not make it a carbon copy [of the homework], but alter it differently. But still make it so that there is correlation between the two problems."

### 5.1.3. Some Mention of the Articles

Students were invited to bring articles that the class might discuss and mathematically analyze. A few students mentioned the use of, or attempt to use such articles in class and one student noted the difficulty of the task:

> *R: …I mean, one of his big things is, but nobody in the class has really done it yet, is bring in newspaper articles where the writer or whoever has kind of manipulated the statistics to make them like look like the writer wants them to, and have us analyze it and think, "OK, well actually this is really what's going on, you know, this is what they say is going on, but this is really what's going on".*
>
> *I: And nobody's done that yet?*
>
> *R: No, I mean it's hard to find those kind of things too. Because they do [exist] but it's [hard], especially because we're not used to it. He's trying to get us used to doing it, but we're not, and so it's hard for us to pick it out. Even if we do see something that has statistics in it and stuff, I mean, everything basically is going to still look OK. So it's hard to pick those things out.*

## 5.2. Discomfort With Lack of Formulas

In expressing their discomfort with the non-traditional approach, many students talked about the role formulas played during lectures. As students described it, formulas were not presented as a starting point for the problem-solving process. One student described the process of problem solving used in Math 141 as follows:

> *R: Sometimes I wish he'd have formulas I guess instead of, I don't know, he writes them all out the long way.*
>
> *I: What do you mean by "the long way?"*
>
> *R: Well, I know that [there are] formulas, [and if he would] give us the formula we could figure it out. But he takes it step by step and [shows] how to get the formula. Which I guess is good, but sometimes I get impatient. I just want the formula right there so that I can get to it. (…) I guess in my mind I like to have the formula first before he starts working the problem so I can try and figure out how it fits in there. But he ends up with the formula and then, when he tries to explain it, it seems different from when I have learned it before.*

Another student talked about the need for formulas and stated that the majority of the class wanted formulas up-front:

> *Everyone expects to use the equations and then he won't give them to us until the end. (…) We say "We don't understand. Why don't you just show us the equation?" and then he'll say no.*

We observed that students tended to hang on to familiar learning strategies when face with strategies and goals they did not understand.

A few students appreciated the different approach, but acknowledged that it was difficult for their peers to change mind-sets with regard to learning math. The following student talked about this:

> *I think he is a really good professor and I think if [students] just get used to taking the course, it will progress and it will be a good course. Especially for students like me whose math skills are not that outstanding.*

In the evaluators' view many students did not actually grasp the goal of Math 141, but continued to operate with the math class goals they had learned in their high school courses: to use algorithms and to arrive at answers. Thus they were unable to adjust to pedagogical methods that serve a goal focused more on the conceptual process of dealing with a problem.

### 5.3. Appreciation for the Writing Assignments

One feature of the course that many highlighted was the use of writing. Most talked about writing with respect to the essay assignments. A few mentioned that they were encouraged to write explanations of why they solved problems in particular ways, incorporating into their explanations the assumptions they make or the reasons they don't understand the problem.

A few liked the idea of having writing assignments in the class, with at least one saying s/he would have liked more writing assignments. The following student, who noted that writing in Math 141 was helpful, is typical of these few:

> *We have to write explanations a lot, on the handouts, and on what we think about the chapter in the book. It surprised me. It was more writing than math than I thought it would be. It helps a lot. Either you have to do a paragraph on something you read or he gives us handouts with problems on it and then we do that. And if we don't get it we can write an explanation about why we don't get it or, why we don't understand the problems or something, but we usually understand them.*

The following student expressed value in doing those assignments in which s/he could tie in math:

> *I think it is good that we are writing. The one about being a mathematician made me think of a few different ways in which you do use math. So that one was good. (…) Because it made me think of a lot of different things and go back into how many different ways you do use math. There is actually a lot of things that you do use. That one was good because it had to do with understanding how you used math.*

Yet this student felt frustrated when she could not see how to incorporate math into the writing assignment:

> *[The essays are] one of the things that I don't understand. I guess I don't see what [the assignment on the lottery] had to do with math. And my whole problem with doing the essay was trying to tie math into it. Because I didn't think it would be right if it wasn't and I don't really know how you do tie math into it. He doesn't give good instructions on what he wants. I was a little bit confused on what [the lottery essay] was exactly supposed to be about. And he said, whether the lottery is moral or not and I said that I don't understand. Because I didn't. I didn't understand how we are supposed to tie that in and stuff.*

There were many students who found the essay assignments frustrating, largely because they didn't know what the professor wanted, and that they needed guidelines.

> *I liked the handouts where you get an answer, you know, like the set answer. But then he'll give assignments saying analyze this part of the book, and then, you don't know what specifically he wants -- I mean, I analyzed it to the best of my abilities, and I got an 8 out of 10 or something. I think it just depends on the grader. So many times you have no idea what he's looking for. There was a chapter in the book called "I am a Mathematician," about how everyone uses math. And he said write a paper, either your criticism of the chapter, or what you think of the chapter, or if you think you're a mathematician. I mean, it's just so broad, there was no specific criteria for grading it, so I really have no idea what I'm going to get on it.*

A few students explained that the writing does not seem like a math assignment:

> *R: We're writing papers too, which I think is great for people like us because we're a lot better at writing than we are at doing math, but in that respect too I don't think we're learning math.*
>
> *(…)*
>
> *I: How do you benefit from doing the writing assignment?*
>
> *R: I don't. I think the people in our class are good writers, well most of us are better at our verbal skills - like, it's one of those cheesy things, you know, get an A, it's not really a hard class.*

**********

> *The papers that we've already done, we didn't really have to do a lot of math and all. I mean the first one was about lotteries and how lotteries affect different states and where lotteries came from, stuff like that. And the other one was on a chapter in our book called "Everybody's a Mathematician" and we had to write a write a paper about why we are mathematicians. It's not like math homework you know.*

### 5.4. Varying Opinions About the Lecture Presentations

Many students expressed that the pace of the class, as a whole, was too slow. These students felt that too much time was spent on the same topic. As one student said: "A lot of the time we don't do anything different than what we did the previous day." This student saw this redundancy as a "waste of time." A few students related the pace of the class to the students' diverse levels of prepartion. The following makes the point:

> *It is detrimental when you yourself are getting a grasp of what's going on, but then everybody else in the class is just like, "well, you know, what's going on, how did you get this?" So the same thing is being gone over more, over and over and over again. It gets frustrating and so you tend to tune things out then, and just feel like it's a waste of time.*
>
> ***************
>
> *I think [the other students are] impatient, and kind of frustrated, too. I think it's a mix of everyone that just wants to get out of math. [The professor] does his best to answer every question. But, someone has a question that a third of the people might know the answer to so they space out, and doze off, and then, when they wake up again -- he's on something different and they ask, "Wait, what did I miss there?" And it just seems that it's good that he focuses on individual questions, but at the same time, it's kind of dragging down the group as a whole.*

A few students said that the pace at which examples were solved in class was too fast. The sense that the professor sped through examples is most likely related to many students' feelings that basic steps are left out of the problem-solving process, leaving them unsure of what is happening. The following is representative:

> *I: How does he model problem solving? I take it that he poses a problem in class and then solves it on the board?*
>
> *R: Ok, he will try to solve it on the board, and we know it will come up later so we try writing it down, and following him, to see where he's coming from. But he'll just steamroll through it, do the calculations, the estimations, in his <u>head</u>, and then put down step one, and then put down three on the board, but step two is missing! And therefore we're lost! He's doing all these little short cuts that we know <u>nothing</u> about, and therefore, he's already done with the problem, and I'm only halfway! And I'm like, well how did you get here? I don't know!*

And a few students felt the professor jumped around in such a way they did not feel the lectures were making a particular point:

> *I think he could plan the day out better. [The way he teaches is] like "well, why don't we try this." Or "oh that makes me think of this." So maybe if he planned it out better and what it is he is going to talk about so if questions came out, you could still keep going with that kind of problem and you know it's going to work out the way you wanted it to.*

The following student also described lectures as having points that students could not connect:

> *I think I would seriously be lost if I didn't [attend everyday]. Just because he jumps from one thing to another. He really does. Once you have questions on something, like most of the class, like the first week, with the coin thing, nobody really understood what he was saying. So that is why we spent so many class periods on it. So in class time, he will just jump. We will talk about probability and talk about, I don't even know, the lottery or whatever. Those are two totally different things. So if don't go, and I don't see how he is doing it, I would be lost.*

This student (above) also felt s/he needed to capture what the professor is doing and exactly how he does it:

> *On our grades, on our papers and stuff, he is really strict, you have do it the way he does it. Even though there are other ways to do it, you do it the way he does it in class. Like on your test, we had a question about the coins and we had to draw it out like he did in class. So for people who didn't go, you aren't going to know. You are going to do it the really easy way, with the formula. And you don't get full credit for that. I think if I didn't go to class I would be lost.*

It appears that these students did not understand the goals behind certain lecture strategies. For example, while the expectation for students to draw a diagram demonstrating possibilities for coin tosses was most likely to assess their understanding of the math concept, this student saw it as only one possible way to arrive at the answer.

The evaluators note that many students expressed a lot of negative emotion in connection with their Math 141 experience. In virtually all cases, these emotions (frustration, strong dislike, and withdrawal) were directly linked with students' inability to see the connections between the components of a lecture, as well as between the steps within a problem. It seems these emotional barriers were a factor in students' overall receptivity to this new type of math class. In the next section students describe what they feel is needed in order to help them comprehend the material presented in class.

### 5.4.1. Felt Need for More Algorithm and Step-By-Step Process

Many students wanted a clear process to follow, one which could guide them through homework assignments. The following illustrates this point:

> *If we're supposed to analyze, it would be nice if we had a process of analyzation. Some sort of steps to follow. I know that every problem is going to be different. But there should be some way you can approach a problem to begin with. And it's just chaos every time we approach something.*

The following students suggest that a traditional text would provide the guidelines they want:

> *There was one homework assignment that he had us try to do about four times. I just couldn't do it. And I didn't have the text book to look at to show me how to do it. You don't know how to do it and you are at home, you are stuck.*
>
> ***************
>
> *I think the least helpful was maybe the book. It doesn't seem like a math book to me. I mean we have problems for homework and we don't have examples of how to do them. I think maybe math is something you learn by practicing. You know, like having an example problem and then*

> *having all these other problems then doing them and doing them and doing them. You learn how to do it and that is not in the book at all.*

A similar sentiment was expressed by many students who also wanted guidelines for the essay assignments:

> *We weren't exactly sure what he wanted in the papers, or [what we were supposed] to get out of them. That was unclear, and he said to just write about this. There was a billion things that you could write about, but then when we get our papers back it was like "well you told us to write about this," but why did we get a seven out of ten? (…) It was not clear what he wanted and then we would get something back and be wondering why did we get this [grade]. There is no concrete form to lean on.*

The above student suggested that guidelines in the form of detailed feedback would be of help.

### 5.4.2. Felt Need for Teacher to Model Problem-Solving

Student responses regarding whether the professor successfully modeled the problem-solving process were bi-model; lectures were described as either helpful, or not.

A few students said the professor did a good job explaining problems. The following student talks about how the professor explained details:

> *With each problem type that we do, he breaks it down a lot and I think that is really important because it helps me see where stuff comes from in the problem. I think if I understand that it would be easier to understand the problem as a whole. You can kind of see how math works a little better. I think he really pounds some problems to death, and that is good because it helps me.*

A few students mentioned that examples types are important to the learning process. The following student stated that a variety of problems and real-life applications were useful:

> *Professor Bleicher tries to make [the examples] things that we do every day. Things we will do, things you are actually going to use and a situation that comes up on you that you don't even think about, and that helps. It makes me think that I should probably really understand how to do this because it might come up. Where other [less applicable problems], you think you are really not going to use this. You get something and its like "how are you going to use this."*

This student (above) also appreciated the professor's explanations:

> *Doing the examples more than once [helps]. Going over a problem more than once and doing it differently. Not just giving you one way to do it, but giving you a few different ways so that if you don't understand one way, you can find another method to use. (…)*

However, a common feeling among many students was that the lectures did not illustrate guidelines for problem solving. Many had the following suggestions: the professor should use examples more like those in the homework; examples should be more simple and therefore easier to follow; and the professor should take care to point out all basic steps in the problem-solving process.

*I: If you were teaching the course, would there be anything that you would change to help students to learn the material better?*

*R: Yeah, just more homework, -- more homework. Maybe giving more chances to do examples.*

***************

*R: The brief overview, especially if you are going to do problems, [is not very helpful].*

*I: So you would like more?*

*R: More, not so long problems, but shorter example problems. Not so lengthy that by the time the problem is done we are still confused.*

And the following comments illustrate students' feelings that explanations are not basic enough:

*[When doing homework], you are supposed to be able to go back to your notes [you took from lecture] and look but if you never understood what he was doing to begin with well you can't do that either.*

***************

*I think he is kind of beyond this class because like I said before, when he does a problem, he will kind of do it so fast and it makes sense to him because he knows what he is doing. Sometimes he will leave out steps. He just kinds of skips right over them and doesn't use those steps. I think he would be a great professor for an advanced class, there is no doubt about that. He knows what he is doing. I think he is just a little too fast for us.*

## 6. STRATEGIES STUDENTS BELIEVE WILL WORK BETTER

Many students commented that the various strategies used in Math 141 did not come together to make a coherent course. However, reflecting on what did and did not work with respect to their Math 141 experience, students talked about various strategies that worked, and strategies they felt would improve the course.

- **More active involvement**

A few students indicated that the learning experience in Math 141 would have been more successful if there had been more involvement, on the part of students, in the process of problem-solving. These students suggested variations on the way the class is structured which would facilitate more student involvement:

*If you set up problems and have kids go up and do them. [If he asked students to go to the board] then [they're] sort of forced to go through and see how his mind works and how [their] mind works. There's just none of that. There's people saying, "I don't understand, I don't understand," every five minutes, but we're not getting anywhere with that.*

***************

*I noticed that there is not a lot of, "okay, lets hear the problem and see if you can do it and then we will talk about it later." He usually just gives the problem and here is how you do it. There is not a lot of doing it on our own in class and I think I would change that. [I think you should] have to try a problem and then ask questions about it.*

A few students mentioned that they were encouraged to write explanations of why and how they solved problems on homework and tests. As one student said: "A lot of the problems ask you to explain why you did a certain process, so you have to know the processes of why you did stuff. When learning how to do a problem, I have to look at why [I did it in a certain way.]"

- **More repetitive problem-solving**

A common theme emerging from the interviews was that of repetition. Many students identified repetition as a familiar learning strategy in math, and one which has been successful. While students described repetition as a strategy they would choose to use, they also described Math 141 as a course which did not lend itself to that strategy. Students gave reasons for this, having to do with the homework and with the lack of a traditional text book. According to students there was not a lot of homework. They described the problems as notably different from those done in class, and from each other. Thus the homework sheets did not constitute problem sets whereby students could practice a problem type until they felt comfortable with it. The following comment is representative:

> *I actually would like more homework because then I think I feel more comfortable doing problems. If I can work through several of them, then I can have confidence. (…) Yeah, just more homework, more homework. Maybe just giving more chances to do examples.*

Students also mentioned the lack of a traditional text which would provide examples and problem sets.

- **More work with classmates**

Many students mentioned that they worked on homework assignments with their classmates. For some of these students, working with others was a survival strategy they adopted primarily because they felt the homework was too difficult for them to do on their own. The following comment presents this experience:

> *The [homework assignments] are difficult. Some of the questioning is a little confusing sometimes. A bunch of us need to sit down. I think it is very difficult for one person to sit down and figure out all that by themselves. Just based on the notion that we don't have any concrete background of how to solve these problems. I think some of the examples that he has on the handout aren't what he talks about in class. So it is like where do you even begin?*

Students most commonly mentioned that working with peers provides alternative approaches to solving problems. Students also mentioned that interaction among peers, when discussing problems, helps in understanding. The following quotes are representative:

> *[With group work] we each have different approaches to the problem because we all have different back grounds of math and of how we were taught. It just seems that we each have different ways of thinking and we can correlate them together.*

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*Sometimes [group work] is good because, even sometimes in class, there are students who understand it and will explain it to you better then the professor.*

***************

*I like [working in groups] better, because, sometimes if you don't get something, somebody else has a better idea of how to get the answer and how to solve it and then you can get insight from other people.*

***************

*I: Do you think you learn from groups?*

*R: In this other class, we go into groups and I think we get a lot accomplished. But we all give our different interpretations of how you could read the poem. And that helps and I learn a lot from that, from seeing how other people look at it. So in that way I think it does.*

*I: How about groups in the math hour?*

*R: I think it does. In high school when we would do it, we would have problems and get into groups and if you didn't understand, then someone else did. They could tell you how they did it. Sometimes you can understand better from the student than the teacher. When you ask a student they give you little hints of how they do it, so it is easier to understand. When I didn't understand something, [my friend] would give me little directions, then I would figure it out.*

***************

*[When you work in groups] you get to see other people's perspectives on how they do the questions. Because there was a question on Thursday's class where he worked it out on the board using one method. Then another girl raised her hand and said how she did it, and it was a completely different way of doing it, but got the exact same answer, so. In that sense I think group work helps.*

***********

*Any time you get together in a group and have your peers explain it, having an interaction that way, I mean, no matter what subject matter it is, you always come out with a better understanding of what you're doing, you know?*

One student pointed out that group work is only successful when members have some understanding of the problems, and when they are willing to talk and share. S/he went on to talk about his/her Math 141 group:

*I don't think [I'm learning from working in a group] because, maybe it's not all of them, but most people just want someone else to give them the answers. And if they don't have to do it, then they don't want to.*

Students described the supportive nature of working together:

*When you have that many people who have the common bond that none of them understand what's going on, they do tend to group together, and that's where I've noticed that most of the results happen. I've understood more just getting together in groups and studying with some people, because we're all mutually confused, than I have sometimes sitting in the classroom--*

*trying to have him answer it for us.*

**********

*R: I like the groups better because I think we all work better together than just one who is trying to figure [the problem out on their own]. We don't get it and just give up.*

*I: Do you think you are learning when you work with people?*

*R: Oh yeah, definitely, especially in this class.*

**********

*I: What about that process [of working in groups] helps you to learn more than if you were doing it on your own?*

*R: If I'm on my own I'd probably get frustrated and mad because I couldn't figure out a way to do it, but, I guess if you have more ideas floating around you'd probably understand it better.*

One student summed up the experience of working with peers by saying: "It's a good feeling when we work through it ourselves -- like some of us at the library -- that's a good feeling."

## 7. FINDINGS

The most common experience reported by students was that Math 141 was *not* what they expected when they signed up for the course. Most students learned about the course from a SOAR advisor. Many reported that they expected *less* problem-solving and *more* discussion about math. One student said: "When I got [to class], its was totally different. We didn't talk about concepts or where things come from. We do problems everyday."

In addition to this experience, students reported a variety of learning outcomes.

- **Changes in knowledge of math**

Many students reported that they experienced at least some change in their understanding of math. For these students, the change was not so much in their competency, but in their overall understanding of how they can use math. When asked whether s/he was using math concepts, one student responded: "It depends what you define as a "math concept." Yeah I guess so, if basic logic is a math concept." The following quotes are representative:

*I: What does the phrase learning math mean to you?*

*R: Learning math-- Umm, it used to mean to me learning formulas, and proofs, and procedures, and how to work problems. But now I think math teaches more logical thinking than anything. (…) I consider learning math, actually using it or seeing a practical application of it. That's why I never liked geometry or anything like that, because I never saw, at the time, the practical use of proving congruent angles, for example.*

**********

*I realize that math is an everyday part of our lives, if you think about it, it's logic.*

**********

*I: Has your experience in math 141 changed the way you think about math?*

*R: Yeah. Because math is involved in a lot [of things] that I never thought it was. Like in the beginning, I encountered math all of the time and it made me think more about where you use math and how you use it, things like that.*

The following student stated that s/he wanted to learn what was being taught in Math 141:

*I think [the professor] wants us to learn that math is used everyday. That it is not algebraic equations. (…) I would like to learn the same thing that he is trying to teach.*

- **Improved confidence**

Many students stated that they were (at least partially) successful at learning in Math 141:

*I'm doing much better in this class than I did in any of my high school courses.*

***************

*This [material in Math 141] I understand and I can do. I remember most of it. A lot of it is stuff that I went over in high school. So most things I remember and understand. There is some that I need to be refreshed, some that I need again. But I know that if I had a different math, I wouldn't understand it.*

***************

*I would change the description [of Math 141]. But otherwise I think it is a good class. (…) I think it is a good class for people who don't understand math, like really don't understand it. For someone who doesn't want to take the math and get the credit, this is a good course. I think you do get a lot out of it. I mean you do learn a lot, and you learn a lot of stuff that you can use every day. Because it has like real-world situations. So I think you do get a lot out of it that way, and that is good for people who aren't really good in math.*

***************

*I: Has taking this course changed how you feel about math as a subject area?*

*R: Yeah, I guess it doesn't scare me as much. You know when I'd hear we were having a math quiz I'd get all worried, and I guess now it's like you can take your time and look at it. You can think of different ways to solve it.*

- **Professor provided a positive learning experience**

A few specifically noted that the professor had done a good job in teaching:

*I think [the professor] is a really good math teacher. I think he knows a lot of stuff and I think he can teach it really well. He really is an open guy, he is not intimidating. Kind of smiles a lot, a good person so I like him a lot.*

***************

*I like that it's easy to talk to [the professor] and he does a lot of stuff in class. It helps me understand it more.*

- **Appreciation for the method**

A few students also expressed that they appreciated the methods of the course. These students found the non-traditional approach to learning math enjoyable and a welcome change. The following quotes are representative:

> *I like his philosophy of teaching -- as far as asking questions and seeing the method behind how you get the answers.*
>
> ***************
>
> *When I go to class, I am kind of excited because you get to ask questions or if we bring in newspaper articles or stuff about something with math that we think is used wrong and stuff. So when I go I am kind of glad. Its not like "oh I am going to math class."*

- **Changed attitude toward math**

A few students talked about a change in attitude towards math. These students describe that they are less intimidated, and that they now approach problems with a feeling that they can figure out a solution:

> *I: Has taking this course changed the way you feel about math as a subject area? Not about a particular course or what you do with it, but about math?*
>
> *R: Yeah, I guess it shows how easy math can be if you think about it and think about it on a higher level and just see it as something easy to do. Instead of being intimidated by it. If you just think about it a little bit, most of the time it is actually easy. You are subject to learn if you are up to it.*

The following student discussed the impact Math 141 had on his/her attitude:

> *I guess it just changed the way I looked at math and, like, I don't know, it seems more friendly. (…) Like now, if I think about it, math is pretty much in everything. I guess it's easier now, I guess I look at it differently because he made me look at math in a different way so I'm more interested in math than I was. (…) I went into it thinking I wasn't going to like it and, probably did not make as much of an effort as I should have. I'm, more into it now and I'm understanding it.*

- **Appreciation for collaborative learning**

As described in section 6, a significant outcome was the student-initiated strategy of working with peers. Many students mentioned that they worked with classmates on assignments, as well as used classmates, during class, to provide explanations. Students pointed out that peers often provide more easy-to-grasp explanations and alternative approaches to problem solving. As well, some pointed out that the interaction itself helps students learn. (See section 6.4.) Based on these students' reports, we suggest that building some form of group-work into the structure of this course would help to improve students' experiences.

## 8. CONCLUSIONS

Many students described some significant successes related to their participation in Math 141. Some of these students began to see math as not just an algorithm for solving equations, but as a way of thinking or reasoning. Others noted that math was useful and applicable to many aspects of their lives. Many gained appreciation for the value of

working collaboratively with peers. A few students gained confidence in their ability to approach mathematical problems.

At the same time, many students also reported that they experienced frustration. As these students described it, their frustration stemmed from their inability to see how various course components connected. Many did not understand the role of the text in this course, what they should get out of it, or how it related to other aspects of the course. Many were uncomfortable with the essay assignments, expressing that they did not understand the guidelines or expectations. Also, many of these students did not feel the essay assignments were related to math in any way. Many expressed frustration with the homework problems, stating that they didn't know how to do them, and that the lectures did not seem to prepare them for these assignments. And many described the lectures as confusing.

The sense of fragmentation, described above, seemed a function of how course goals and strategies were presented by the professor and perceived by the students. With respect to course goals, the evaluators note that although many students could recite the professor's goals, they did not seem to understand them. This viewpoint is based on the fact students insisted that they didn't understand the purpose of some of the non-traditional approaches being used. If these students had understood the goal, they should have had some understanding of why the approach to this class was different. In fact, many students consistently stated that they wanted and needed formulas, that they wanted problem sets for rote practice, and that they wanted the professor to use a pedagogy like that used in high school classes. Students quite literally asked that the class become aligned with their expectation of a normal math class, that is, that the components of the class become "unmarked". Many of the students did not talk about process, except in the very simple sense of a "mechanical" process for getting answers to problems. Many students did not understand the purpose of the text or the value of the writing assignments. It appears that students' inability to perceive connections among course components caused frustration and emotional barriers, and was a factor in their desire to have a more traditional approach to the course.

The intensity of the experience, described by many students, is especially likely to be felt by the types of students targeted by Math 141. Most students likely to enroll in Math 141 are homogeneous in the sense that they are not interested in taking a math class, yet they are diverse in their math backgrounds and skill levels. While these students had developed strategies for getting through high school math classes, many had not developed confidence. The most prominent theme which emerged from the interviews was that students wanted structure and guidelines. Again, they wanted to rely on the "unmarked" strategies that in their experience that had worked for them fairly well. Their inability to perceive a coherent structure for the course, and lack of guidelines by which to do assignments, contributed to the frustration they experienced. A prominent finding is that students developed a strategy (peer collaboration) *to stand in for* the familiar strategies they wanted, and to replace the unfamiliar strategies they seemed not to understand. Perhaps the general finding, applying to many of the students, is that they could not make

the connections the faculty member had in mind because they were implicitly playing the learning "game" by different "rules".

While the students took the course *because* it was different and targeted toward those who do not like math, it should be noted that they only knew one way of learning math. Therefore, it seems, the challenge of a course like Math 141 is how to change the whole "game" and get the students to relate to the new game. For the course to achieve greater success, the evaluators suggest that the rules of the game should not be completely unfamiliar to the students. Many of these students are self-described weak math students. In order for them to gain the confidence to approach math in an unfamiliar way, a structure which provides for graduated successes might help. Perhaps some mix of the familiar and unfamiliar would provide a "ladder" by which students can move, with some success, into the more conceptual work of Math 141. The following student talks about the need for a connection between how the students learn and how the professor teaches:

> *I: And what does he think when you don't connect the relationship?*
>
> *R: Well, last Thursday, one of the girls was saying how we couldn't do this. This is probably different from what we are used to. I do agree with her, …*
>
> *I: She was saying something about how this is totally different?*
>
> *R: Right, there needs to be a transition between his teaching and our learning. Because we are used to the math book, the math problem. Then he just goes on about this other stuff.*