

# **Math 141 Evaluation Report**

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prepared  
for

Professor Steven F. Bauman

by  
the LEAD Center Evaluation Team:  
Ramona Gunter, Phil Miller, and Susanna Priest

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## 1. INTRODUCTION

This report details the backgrounds and experiences of students in Professor Steven F. Bauman's section of Math 141 (offered spring semester 1997). 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).<sup>1</sup> 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 36 students enrolled in this section of Math 141. We also interviewed 3 students who dropped, having attended the course anywhere from two weeks to two months. The interviews were conducted by two LEAD researchers (Phil Miller and Ramona Gunter) during the period April 17 through May 5, 1997.

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 dialogue, "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. A row of asterisks indicates material from a different interview.

For certain issues it is not relevant to consider the viewpoints of those who have dropped the course. Therefore, when quantifying student viewpoints we distinguish between two groups: the group of 15 students including the 3 who dropped; and the subgroup of 12 students, all of whom stayed in the class. When describing the students who take Math 141, their expectations regarding the course, and their attitudes about math, we draw from

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<sup>1</sup> Several discipline-specific alternatives are available to fulfill the second half of the requirement (QR-B).

the larger group of fifteen. When talking about students' experiences in Math 141, we draw from the group of twelve. Qualifiers based on the group of 15 are noted with an asterisk and have the following meanings: few\*, 1-4; many\*, 5-11; and most\*, 12-15. Qualifiers based on the subgroup of 12 who did not drop the course have the following meanings: few, 1-3; many, 4-9; and most, 10-12.

## **2. THE STUDENTS**

All students enrolled in this Math 141 section have similar math backgrounds in that they have satisfied the minimum credit hours in high school math mandated for entrance to the university. Many\* reported that they did okay in their high school math classes but that they did not like math and/or noted it was not their strong point. And a few\* students said that they had done well in high school math classes and indicated that they did not see themselves as weak in the area of math. These student self-reports are not intended to suggest that they had sufficiently mastered the basic math skills needed to pass high school courses. Nor do we suggest that any subgroup of the students were homogeneous either in the particular math skills they have attained, or in the level at which they have attained them. The self-reports do 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. The self-reports also reveal students' attitudes regarding math and their perceptions of their own mathematical abilities.

### **2.1. Math Background and Interest Level**

Many\* students see themselves as weak in the area of math. Reasons given for their lack of developed skill or interest in math included: it is not personally interesting; it is not personally relevant; and for many\*, their skills and interests lay more in the humanities. However, a few\* students saw themselves as good at math, or as confident in their ability to do basic math.

While most\* hadn't taken a math class since high school, a few\* others had more recent experience as math students. One of the math students interviewed was majoring in mathematics and felt that the focus taken in Math 141 would help to broaden his/her base knowledge of mathematics. This student was also enrolled in a calculus course. A few\* had taken other math courses on campus. Among the recent math backgrounds of these students: one had taken, but dropped, Math 112; one had taken Math 113; and one had recently worked on basic math skills through taking Math 101. Many\* students came to Math 141 with different levels of confidence regarding their math skills. As well, they had varying opinions about what they liked and did not like as it pertained to how they learned math. In the following we present various categories which capture the type of math students enrolled in Math 141, as described by the students themselves.

### **2.2. Perceived Areas of Strength and Weakness**

Students talked about their math skills upon entering Math 141. A few\* described

themselves as successful in math in general. The following excerpts illustrate these students' views:

*[In high school] I took three and a half years of math. I took two courses in algebra and one on probability and statistics, and another on geometry, and that was basically it. I did fairly well; I was usually an "A" student and at the top of my class, especially in probability and statistics. I was at THE top of the class.*

\*\*\*\*\*

*I: In high school, did you like math?*

*R: Yeah, it's my major. And I took all four years in high school. I got up to second semester calculus in high school. (...) I haven't ever gotten a B [in a math class] yet.*

These few students described themselves as confident math students. They have always liked math and have done well in it. They did, however, identify some aspects of math that they are not good at. As it turns out, these particular areas, illustrated in the following quotes, are specifically targeted in Math 141:

*I: Tell me what you think about math as a whole. Have you always liked math or not?*

*R: Yeah, in high school I always did good in math, and I did good in Math 101. I did pretty good. I mean, I like working with numbers and stuff. It was just the critical thinking and stuff. I'm not very good with word problems.*

\*\*\*\*\*

*I basically took this class cause I wanted to expand my base. And I'm not very good at word problems so, I might as well take something that I'm not really good at.*

However, many\* students said they did not like math, and some of these students explicitly stated that math was a weak area for them.

Students were asked to talk more specifically about the things they did and did not like about math. In doing so, they articulated areas that they have done well in and liked. The following categories represent the areas of strength which students identified:

- **Word Problems**

A few\* students noted specifically that they liked word problems:

*I took 112 first semester and had to drop it because I was having a lot of difficulty with that. And at that point I had thought I was pretty good with algebra. Geometry is -- forget that. I'm not good at that at all. But, algebra I guess isn't too bad. Word problems, that's why I like this course. I do better with word problems.*

\*\*\*\*\*

*I: What kinds of problems are easiest for you to work, and what is the most difficult thing to do?*

*R: This will be hard to say. I almost like word problems, challenge type of things, [more] than*

*just plain number crunching. I guess I can do a sufficient job on number problems, but I more enjoy seeing how they're going to apply to things I might be interested in in the future. Like personal finance and that sort of thing. But, straight mathematics, where there's nothing involved besides numbers and variables and formulas, that bores me to tears.*

However, many\* students reported that word problems were difficult to solve. The following statements are representative:

*I find word problems difficult. Just because, in most math classes you take, they tell you basically what to do. You know -- you figure it out, you remember it and then you spit it back out when you have a test or you have homework. The word problems are a little bit different, just because you have to bring in different parts.*

\*\*\*\*\*

*I'm not really good at word problems. I'll sit and read them, then I'll go over it, and it just won't click inside my head.*

### • Equations

Given students' descriptions of word problems (those which are easy to solve and those which are not) it is not surprising that many\* expressed that they were better at solving basic algebra problems than the types of problems in Math 141. The following students expressed their preferences for "straight" algebra:

*I: So as opposed to word problems, what would you prefer to do?*

*R: Just like the xy variables are right there where you don't have to go digging through all the sentences trying to find them.*

*I: So just seeing a formula or an equation would be more comfortable for you then?*

*R: Yeah yeah.*

\*\*\*\*\*

*I: What kinds of problems in math are easier for you? What kinds of things do you like?*

*R: Algebraic stuff.*

*I: What do you like about that? What makes [algebraic stuff] easier for you?*

*R: Umm, I don't know. Because you have numbers to plug into the equation.*

### • Detailed Explanations

The following students said that they want detailed explanations:

*Sometimes with math I'm, like, I don't know how to do it. I've never done it before, and you need to tell me, you know. And then I can figure it out.*

\*\*\*\*\*

*[Math is] easier if someone explains it step by step. But usually teachers just go through it, you know, and I just never grasp it unless I'm told step by step. If somebody works with me one-on-one, I usually understand it a lot better. But as a group thing, I'm not very outspoken and I'm not going to ask questions, so it's harder for me to grasp it.*

The following student generalized about those in their class:

*I think a lot of the kids do not care about understanding math and being able to look at it in different ways. I think a lot them just want, you know, to know, okay give us equations, show us how to do the equation and we'll do it and that's fine.*

From whatever perspective these students talk about learning math, they all seem to echo the same message: math is easier and more likable when the problems are technical in nature, when relevant information is provided for easy application to an algorithm.

### 2.3. How Students Feel About Learning Math

Students were asked to respond to two questions: “What do you like about math?” and “What don’t you like about math?” While few\* students offered responses to what they liked about math, many\* noted, for a variety of reasons, that they did not like math.

A few\* students said that they like math only when they are successful in it. As they put it, the accomplishment is satisfying. But what they like about math is inseparable from what they don’t like – not understanding is frustrating. The following students talked about this:

*I kind of enjoy math when I understand the problem that’s going on. I feel really good about myself when I understand, when I figure out a problem – more so than when I understand a history reading, because the math is more of an accomplishment for me. (...) But I generally don’t like [math] because I’ve always had trouble with it. (...) If I [had a choice] I would not take math. The fact that I have to bothers me a lot.*

\*\*\*\*\*

*I only like [math] when I get it. When I understand it. I don’t know if I like it or not – I think maybe I’m just too afraid of it. I’m not sure. Maybe it’s really not that interesting to me, maybe that’s why I’m not very good at it. It’s just not interesting.*

As well as noting the potential for frustration or satisfaction (depending on whether s/he understands the math), the following student also said s/he likes math because you know if you’re “either right or wrong”:

*It’s kind of hard to say [what I like about math]. I guess I like it because you can truly arrive at a correct concrete answer as opposed to a lot of other classes I take where it’s sort of like anything could be right. But I kind of like it in math - especially when you are right. It’s frustrating when you are definitely wrong, but when you are definitely right, it’s kind of satisfying I guess.*

A few\* students related their affinity towards a particular subject to their interest or aptitude in that subject. Because of their lack of interest or aptitude in math, the following students said they do not like it:

*I’ve never really enjoyed math. I’m probably a B plus student in high school math. Not spectacular, but I do have some grasp of what’s going on. So, it’s not my strength, but I guess I can hold my own to a certain degree in math. (...) Some of the topics in pre-calculus I didn’t*

*really see how they applied to anything. So, I mean, I really didn't bust my hump to learn them seeing I didn't think I'd have any real use for them in the future. (...) [I don't really enjoy math.] I enjoy reading more than anything else. (...) The humanities is my strong and more preferred course.*

\*\*\*\*\*

*I had trig in my junior year. I took it again because I failed it. I took it again so I could get my math credit for the year, my senior year. I did all right the second time I took it. But math has never been a strong point for me. (...) I like English because I'm good at it. But math just isn't a strong area, so, I mean, if you're good at something obviously you're going to like it. But when you're not, it's just going to be something that you're not going to care much about.*

A few\* students related their dislike of math to the teachers they have had:

*[I think] my disenchantment with [math] had to do with how [it was taught in high school].*

\*\*\*\*\*

*I used to like math, but during high school I really got stuck with bad teachers. (...) I didn't like math, and it had a lot to do with the teachers that I had.*

Although the following student is first and foremost inclined to relate his/her performance level in math to the teachers who've taught it, s/he also notes that the particular subject area could have been a factor:

*R: [Math is] by far my worst subject. I don't know. I did okay in high school. I guess it depends on what teacher I had. There was a different teacher every year.*

*I: You said it depended on the teachers. Were there certain teaching styles that you found worked for you or certain kinds of textbooks?*

*R: Maybe it was just geometry, I guess. Because I had algebra and then I had geometry and then I had algebra II with trig. And in both algebra classes I got low grades and in geometry I got A's and B's. And, I don't know, I know I had a really good [geometry] teacher, though, too. (...) I had three years of high school math, and I hate math.*

### **Evaluators' Viewpoint:**

Students did not describe their experiences at a level of detail that revealed how they did math or how they learned it. Instead, they discussed broader categories. Many\* related their experiences to the teachers they've had, and a few\* considered specific topic areas. We realize that students' judgments about who was or was not a good teacher are subjective. We think this would be an interesting area to explore further, but we do not have information from these interviews that would allow us to explore the deeper meanings of these students' comments. We suggest that the above comments reflect the level at which these students think about math, and engage in doing math. These students have not typically been engaged in exploring mathematical concepts, and arriving at applications through the understanding of concepts. Instead, they have been engaged only at the level of application.

### **2.4. The Value of Math**

Students related their ideas on the value of math, prior to entering Math 141. Most\* responded that it was a valuable subject in and of itself, and most of these students also

stated that it was valuable to them personally. A few\* students noted its value in science fields. As well, a few\* stated that there was value simply in “doing” math.

- **Perform practical functions**

Many\* made the point that, while math itself is of value to them personally, their high school and college math classes were not relevant or valuable to them. These students described personally relevant (and therefore personally valuable) math as that which deals with the stuff of everyday life, most often mentioning financial math and percentages. The following categories represent those that the students find valuable with respect to math. The following quotes are representative:

*Yeah, I [think math is valuable to me personally]. I think it's important to be able to perform certain little functions, like doing your taxes and knowing basic math. I don't think any sort of higher math is really worth it for me.*

\*\*\*\*\*

*R: I see how math has purpose. I just don't see it as part of my role in society, I guess.*

*I: When you think about mathematics, what comes to mind?*

*R: I guess, I mean besides the fact that there're certain math courses everybody has to take and certain things that everybody has to learn, I think of it more in [terms of] practical things every day. Trying to figure out my checkbook, wondering if I'm going to have enough money, and that type of thing. So more, I think along the lines of really basic mathematics that are going to come into play every day rather than big concepts in finite mathematics and what have you. So, it's more like the small stuff that I'm concerned with.*

\*\*\*\*\*

*[Math is valuable because] you use it in buying stuff, and we're gonna have to pay taxes--I don't pay taxes now, but you're gonna pay taxes and handle house payments. I think that's valuable.*

Another student said that math has a practical value, but also noted a relationship between the degree of its importance and his/her affinity towards the subject:

*I find [math] valuable to an extent. English, to me, is more important just because that's something that I like and I'm better at. But, I think math is important. I think it's very important just for everyday things like going shopping or trying to figure out percentages.*

A few\* stated that they already knew the math they needed and implied that personally valuable math consists of very basic math skills (i.e. the skills over which these students already have command).

- **Valuable in science fields**

A few\* students said that the value of math lay in its applications to the field of science:

*I: I'm a little bit curious about how you feel about math generally. So, can you tell me if you*

*think math has any value outside what you have to use it for?*

*R: For me personally, I'd say no. But I guess in terms of science, I'm taking a physics course right now, too, (...) we study a lot of the theories but not the actual [math]. A lot of mathematics are left out. If somebody else is inclined to figure out these really complex formulas to explain what's going on, yeah, that type of thing I can see. But as long as I don't have to do it, as long as I can just accept [their work] and trust them—*

\*\*\*\*\*

*R: I'm not very familiar with the mathematics field, but it seems to me that most major theories have been discovered. I mean, we already know how gravity works, and the different numbers you can put into that, and you know, the application of that. Mathematicians right now seem almost, like they don't really have much of a job left anymore {laughs}*

*I: So you think that most of the major discoveries have been made and [scientists or mathematicians are] re-working things that have already been discovered?*

*R: Yeah, yeah, basically. Either that, or they could probably find things about stuff we don't know about space yet, or something like that. I guess that would be handy, but. I don't know, I think we basically have a pretty good understanding of the way our earth works, to a certain extent.*

The following student noted specifically that the ability to perform better in math and sciences is a benefit to any student:

*For those who do well in math, life's a little bit easier. I mean, I look at my parents and they're not necessarily using algebra and other things that we learn in math. But for those who understand it, it's usually just easier to get through school, I think. Things revolve around it -- science, and then the math courses that you're required to take.*

- **Mental exercise**

A few\* students said that there is value, for anyone, in the actual “doing” of math:

*I think [math] does have value definitely, and it's always good to engage different parts of your brain and do something logical. I mean, there's something satisfying about that logic and you're just playing with numbers instead of concepts in your head.*

\*\*\*\*\*

*R: I definitely think [math is] important to keep up that half of your brain and keep up being able to think logically and reason and, it's a good skill to have--*

*I: How will you use that skill in writing papers, do you see it transferring?*

*R: Not necessarily writing papers, but maybe just sort of general thought processing and being able to logically go through a bunch of ideas. (...) Because it really makes you think and it really makes you work your brain. It's very intensive, the problems very sharp, very logical.*

### 3. WHY STUDENTS TOOK MATH 141

While many\* identified that they were most comfortable doing math when the process was algorithmic, these same students purposely opted to take Math 141 (non-algorithmic)

instead of Math 112 or a lower-level algebra course. Why did these students choose to take Math 141? Many\* had the sense that Math 141 would be easier. They arrived at this conclusion in a number of ways: some received this information from academic advisors; some talked to students who had taken the course; some had looked through Math 141 books (although some had looked through books which were assigned Fall semester); and some had decided it would be easier given what they'd heard about Math 112 (the alternative). One student, whose academic advisor suggested Math 141 would be easier than Math 101, was asked if s/he thought it was in fact easier. S/he responded: "NO, just because I'm better at doing algebraic stuff, and that's what 101 was." The following sections illustrate the various categories of reasons why students enrolled in Math 141.

### 3.1. Did not want to take algebra

Students had various expectations when enrolling in Math 141. Many\* expressed that they took the course because they did not want to take the alternative – an algebra course. The following categories represent the various reasons why students chose to avoid the algebra alternative.

- **Math 112 is hard**

Many\* students said that they had heard through friends or through an academic advisor that math 112 was difficult. The following comments are representative:

*My advisor recommended [Math 141] because I hadn't heard good things about Algebra 112. (...) I heard it from my own peers not real great things about 112, just as far as, just in being at really difficult levels.*

\*\*\*\*\*

*My roommate took math 112 and [s/he] just had so much work to do and I [felt] I don't really want to take that. And so I [decided to] take 141.*

\*\*\*\*\*

*My academic advisor said that if I didn't like math too much I should try [Math 141] out because she heard it was easier than Math 112.*

\*\*\*\*\*

*I took 101 [last semester] because I was placed into it. And then the next step, I think, was either 112 or 113. And I'd heard that they were hard, and I was looking for something that would be easier. (...) I went and looked at the book, and the book looks pretty easy.*

And the following student had taken Math 112 but dropped:

*I: Tell me a little bit about why you chose Math 141. You said you took 112 and dropped it, so did you sign up for this course because it was the only other option?*

*R: Well, this fills the Quantitative A requirement. And I need to do that. And, basically, I had a lot of trouble with [Math 112]. (...) So, when [Math 112] didn't work [for me] and I dropped it, I spoke to my advisor and she recommended this course. She said it was new and, because I told her about my math difficulties, she said that this would probably be the best [choice].*

- **Students did not see themselves as the "algebra type"**

*I went and seen my advisor well after I had already signed up for classes and he said [taking Math 141] would probably [be a good idea] because I'm kind of more of a poly-sci kind of person. And he said [Math 141 is] probably a good math class to take.*

- **Already had algebra skills**

A few\* stated that the prospect of taking Math 112 to satisfy the Quantitative Reasoning requirement was unattractive in that they felt it would be a review of math they already knew and in which they have done well. The following quotes represent this view:

*From what I've heard about 112, it's basically a review for everybody. It's all algebra, and moving on to calculus, and I think I would be studying a lot of things I've already studied and did fairly well in, in the past. It's not anything new to me at all. It'd just be a review. "Let's catch you up," you know? And I don't think I really have any catching up to do. I mean, it's not fresh in my mind, but it's still there. Just re-learning it would be almost a waste of time.*

\*\*\*\*\*

*I: You said you thought it was [more a review for you].*

*R: I probably should have taken 112 or 113, but I'm not regretting it because I think that I'd be severely bored with either one of those.*

### 3.2. Math 141 would be different

A few\* students enrolled in Math 141 because they thought it would be more interesting than an algebra course. As one stated, "I figured that it would cover different areas as opposed to Algebra 112 where it's all algebra. I wanted some different areas, too." And the following student stated further that s/he felt s/he was already comfortable with the skills taught in Math 112:

*My advisor was explaining [the options] and 141 sounded a lot more interesting than just basic math skills and I felt that I was already comfortable with just the basic math skills that were taught in 112, and that 141 seemed a little different.*

### 3.3. Improve Math Skills

Many\* students expected to learn new skills, or brush up on or learn applications for skills they already had. Students wanted to learn or improve in the following categories discussed below: general skills, applications, word problems, and comfort with math.

- **General skills**

*I did want to learn or brush up on things that I have learned before. Because I have a pretty decent math background. I mean, I didn't have pre-calculus or calculus or anything like that, but I think I had pretty much a lot of the rest. So I brush up on a lot of stuff.*

\*\*\*\*\*

*I guess [I just wanted] a basic brush-up of some of the stuff that I learned in high school. I hope that by the end of the semester I'll have somewhat of a solid base and some of the basic mathematics and what have you.*

\*\*\*\*\*

*I hope that I can, like I said before, just get a little bit more of a foundation and a review of some of the stuff that I stopped caring about a couple years ago.*

- **Applications**

A few\* students expected that, in Math 141, they would be applying math skills. One

student said that his/her academic advisor described the course as “being able to apply what you already know about math in certain situations.” The following students also expressed that they wanted to learn applications:

*The counseling person told me about 141, and she said she heard there was more of [an emphasis on] application, for people who were not continuing on with math, going on to calculus, things like that. (...) I really wanted an application [focused math course], that's something I felt was really missing in high school. You study the theories and the set ways to reason out stuff, but you don't really put it into application for real-life, and I thought that would be more interesting. (...) [I want to] understand [how to apply] math, the real-life skills, things that will honestly help me out, you know, as far as financial things.*

\*\*\*\*\*

*What I want to get out of math is what I will need to be able to use in life. You know, with taxes, shopping or whatever. (...) What I'm not a real big fan of is ridiculous numbers and problems and solutions that you won't really have to apply in life.*

And the following student specified that s/he wanted to learn to use logic to solve real-world problems:

*I thought it would more logic -- like you have to like think about the problems. That's what I was looking for. Because it's more real-life stuff.*

- **Word problems**

*My roommate had taken it last semester, and I guess he had a different professor. I would look over some of his assignments and see if a couple of them were challenging word problems or, you know, logical thinking stuff. I thought that that would be pretty interesting. Because, like I said before, the straight mathematics didn't interest me. (...) I wanted to deal more with word problems.*

\*\*\*\*\*

*I'm not very good at word problems so, I might as well take something that I'm not really good at.*

- **Be comfortable with math**

*I just want to be comfortable with math, really. To have some confidence in it.*

### 3.4. Satisfy the QR-A Requirement

Many\* students said that they had no expectations from Math 141 other than to satisfy the Quantitative Reasoning requirement. “I just wanted the credits” is how one student put it. The following quotes are representative:

*[Math is] not something I would ever do unless it was required of me, you know. That's the only reason I'm taking the math is to get the requirement out of the way.*

\*\*\*\*\*

*I: All right. What do you hope to get out of Math 141?*

*R: (Pause) Quite honestly, my priority at this point is just to get a good grade. I'm sure I have learned things and one day they will be useful. We just learned about IRA's. But, at this point I*

*just really need the grade and I need to get this requirement done, unfortunately.*

- **Condense two courses to one semester**

A few\* students noted that their only other option for satisfying the requirement would have been to take both Math 101 and Math 112. These students said they wanted to get the requirement out of the way with only one class:

*I tested into Math 101, and my major is [a social science] and [a language]. So, having a double major, I don't know, it's a little bit stressful as far as getting all the credits going and stuff. And since I tested into 101 I was going to have take 101 and 112. By taking 141, I get rid of both of those requirements in one semester.*

\*\*\*\*\*

*[I took Math 141] because I didn't test into 112, and I know that if I had to take 101, then I would have to take 112 or 141. So I just wanted to take 141, because I only wanted the one semester.*

#### **4. THE PROFESSOR'S TEACHING STRATEGIES**

The professor combined various strategies to create the learning environment. First and foremost, the medium for problem-solving was challenging word problems with applications to various real-life situations. He guided the students to carefully think about each problem; leading them through the process of interpreting problems, pulling out relevant information, and using that information to solve the problem.

Another aspect of the course which seemed to provide a supportive structure for at least a few students was the text book. The text provided a sense of organization to the various problem-types students were solving. It also was a secondary source for examples and explanations on how to solve problems.

#### **5. STUDENTS' EXPERIENCES IN AND THOUGHTS ABOUT MATH 141**

##### **5.1. The Problem-Solving Process**

In Math 141 word problems are the medium for learning the skills of mathematical thinking and problem-solving. The following quotes illustrate students' attempts to articulate a process for solving word problems. In one respect, these quotes represent a mixed category. That is, some spoke from the perspective of what they like about word problems, while others spoke from the perspective of what they do not like. What unifies these quotes is that they present conditions needed before students will admit to liking word problems (or at least to finding them "acceptable" or "do-able"). In all cases, necessary conditions include having all relevant information (such as equations), and having an algorithmic problem-solving process.

The following students liked having needed information stated explicitly:

*I like it when you can pick things out. Like, if you have a set formula and you have a problem,*

*you can apply things from the problem into the formula. It's easier that way if you have a set way of going about things. I don't like when it's not so obvious. When you have to take different concepts and kind of work them together, and use two different concepts in the same problem. It gets to be a little bit more confusing as to when you use which and where you use which and how to combine them to get the answer.*

\*\*\*\*\*

*Actually, I like when we're talking about something that has a formula. The formula is up on the board first, and then we plug in numbers. Use an example and plug in numbers.*

And the following student distinguished between algebra and word problems by saying that algebra is simply application while word problems require that one determines what application should be used:

*I: So you said [Math 141 is] easy if you like word problems.*

*R: Yeah. I mean, if you like to figure something out, a puzzle or whatever. But, I'd rather just do a problem and not have to figure out the problem. Like, maybe, factoring it.*

*I: Okay. So have the equation in front of you?*

*R: Equation right there, instead of trying to figure what it is and then figure out the factoring.*

Students' preference for an algorithmic approach to problem-solving was evident from their reactions to the basic pedagogical approach used in Math 141. This course focused on word problems, and more specifically on the use of mathematical concepts and logical reasoning to sort through and understand various information. In order to model this process, one would not explicitly present relevant information and outline an algorithmic problem-solving process. It is precisely this aspect of Math 141 that many\* students found difficult. In speaking of Math 112 in contrast to Math 141, the following student said s/he did not like the focus of Math 141:

*R: I had to take Math 101 first semester and then tried to get into Math 112 second semester, but it was closed already. So that's why I had to take 141.*

*I: Is [Math 112] what you really wanted to take?*

*R: Yeah. And then I tried Math 141 so I could get the Quantitative A requirement. But it isn't like set algebra, --not really the way Math 112 is, but it is more like theoretical thinking, and if you were given two options, which would you choose and why would you choose it, instead of set formulas and working with just numbers instead of situations.*

- **Understanding the problem-solving approach of the course**

When discussing their experiences, many students focused on the process of interpreting and solving word problems. Many of these students articulated well the problem-solving process which Math 141 students were expected to learn. Following are descriptions of the process, as these students understood it:

*I: So [Math 141] is basically all word problems, you would say? Does he use equations at all?*

*R: Yeah. I mean, there are equations, but they're turned into word problems. And also, when*

*we're going over the problems, he'll just pick numbers and put them into the equation, but he won't have an example of how it's gonna be used in a word problem. Because that's how the test is. [You'll have] a word problem, and you have to figure out which equation to use. Or which numbers [to use, and where to use them].*

\*\*\*\*\*

*In other math classes you learn a formula and how to use it. You're given some numbers and plug them in and you use the formula. But I think with this class you're not just given numbers, You're given a situation and you have to figure out from the situation which numbers are plugged in where in the formula.*

The above student considered it practical knowledge to know the problem-solving process:

*I: Do you [like that you have to figure out the situation]?*

*R: I do. It seems more practical.*

*I: OK. So you can see that these are the kinds of skills that you might use even as someone who's majoring in English?*

*R: Yeah, yeah. Yeah definitely.*

The following student described the problem-solving process as it applies to taking the exams:

*[In the tests you have] a complex word problem and from that you need to pull out bits of that word problem to answer different questions. And the word problems really do require a pretty good understanding of what we studied in class, because they deviate from what we've studied in class. It's not the same pattern. (...) And that's interesting cuz it makes you think a little bit harder. It's not, "so fill in A and," {laughs} you know, like, "insert this here, and it will all work out evenly." It doesn't work out evenly.*

- **Interpreting the Problems**

Many students emphasized the thought processes involved in solving Math 141 problems. Students referred to the process as logical, analytical, and complex, and noted that there could be different ways of interpreting the problems. As one student stated, "For some problems you can be confident [of what is wanted], but for some there are different ways of interpreting it." The following students described the professor's focus on overall understanding of a problem and the ability for students to articulate their understanding:

*He has stressed that you can't, especially in a lot of these problems that we're learning, you can't really jump right in and get going with formulas and numbers and variables. You can't do any of that until you completely understand the problem. He's really stressed that you [should] just read the problem and don't even think about the numbers until you know what you're going to be doing. (...) These problems are very complicated and if you overlook some of the problem*

*cause you're just going to rush right in and start plugging in numbers, you kind of end up assuming something that you can't assume in a certain tax problem or something. (...) If an exam question is more ambiguous, which most these questions are, as long as you explain yourself logically and it makes sense, he'll give you credit for it.*

\*\*\*\*\*

*I: It sounds like one focus is just to be able to look at tables or graphs or bar charts or whatever meaningfully.*

*R: Uh huh.*

*I: Does he ask you to talk about what this graph means on a test without actually solving equations?*

*R: Yeah, he does a lot of that stuff. And if you can explain [what you mean], you can write [about it]. If it's a word problem and you can extract the formula that you need to use from that, explain why and what the variables are and whatever. [If you] can interpret it and explain it well, he's not as concerned whether you can actually solve it.*

- **Emphasis on thinking**

Many emphasized the role of thinking in Math 141. One student said problems required a lot of thinking, and students had to make assumptions. As this student said, "It's not all straight forward all the time. You really have to think about what you're doing." And another student said, "A lot of it is you have to take the information [and] make an equation out of it." The following comments illustrate students' feelings that the problem-solving process is complex:

*R: It's slower, but it's also more analytical at the same time as far as looking at different problems in different ways. You know, you can work on the problem this way or you can work on it this way. Looking at it in a few different ways, you can work it out.*

*I: Did the students contribute to that direction in the class? Did they ask about different ways to do it?*

*R: Once in a while. I would say it's more steered, like he'll say, "Yeah, hey look at it this way." And then, you know, then, "We've also learned it this way." (...) He wants us to be able to describe it and to be able to look at it in different ways.*

\*\*\*\*\*

*The teacher tries to focus it more like, you know, don't worry so much about the algebra, just try and look at the graph. And try to extract the equation. And if you can't always solve it, the more important part is that you can interpret these problems.*

## 5.2. Applications

- **Math 141 is more applicable than other math courses**

Students described Math 141 as being different from other math courses. Many saw the major difference being that Math 141 teaches math applications for real-life problems. One student described the problems as representing "real-life situations, instead of equations in algebra." A few pointed out that they were learning to apply math skills they already had. As one stated: "I think he's encouraging us to use the knowledge that we already have and build on that knowledge."

- **Some applications are useful, some are not**

The following students also spoke about Math 141's focus on application, but noted that some applications don't seem practical or relevant and therefore are not likely to engage his/her interest:

*R: Basically, there are certain things that I don't think are useful, but there are certain things like percentages or things that you're going to use all the time in life that I really like. (...) It's more relevant than anything I did in high school. You know -- algebra, geometry.*

*I: Give me some examples about the kind of material you'd rather not cover in this class?*

*R: (Pause) Half-lives and things that have a lot to do with science and things like that. Because, I mean, basically everybody in this class isn't going on to anything in the math or science field, I don't think. (...) And then, kind of what we're doing now. I mean, it's easy, so I like it. But we're learning how to decode bar codes and things like that. And, I don't know, unless I'm planning on working in the Post Office, I don't really care.*

\*\*\*\*\*

*There're some really useful things we've learned about finances, and I really like that. Stuff about IRA's and CD's and savings accounts and all that kind of stuff. I do like that, and I find it useful, and I know I'll remember that stuff. But the rest of the things is like, why should I care, you know, if a bullet is shot in this direction, how long does it take for the sound to come back? I'm not going to be a physicist, and I'm not going to be an engineer. Math for me throughout my whole school career is just kind of something you learn to satisfy the test and then forget. Unless I find it useful in some way.*

- **Learning to apply math skills**

Many students described the course in terms of the math they brought to the course. That is, they said the course was teaching them to apply the math they've already learned. When asked if the course is challenging, or emphasizes logic, one student has told friends, "No, basically it's just an emphasis of basic geometry and algebra and that type of thing. Just from another approach." The following quotes are representative:

*[In Math 141] most of the math that you actually do is algebra and geometry, pretty much stuff that everyone would have learned in high school. But it's just different ways of applying them and being able to use them in sort of real-life situations. Being able to [solve] word problems, [using] your past math knowledge to understand.*

\*\*\*\*\*

*I: You said that some of [what you're learning is a] brush-up on things that you had in high school. Do you see this course as a review of high school material?*

*R: Yeah. I wouldn't say to the point that it's remedial for me, or all review. I'd say most of the material I've used in the past, but it's the application of that that's a little bit different.*

\*\*\*\*\*

*I'm definitely learning what I can do with math. But I'm also learning some math, for example, like completing the square. We learned that a couple of weeks ago and I've never done that before. But there's a lot of stuff we've already seen and we're just expanding on it. [We're learning] what we can do with it or what it means.*

### 5.3. Sense That the Course Was Unstructured

Many students mentioned that the course had no syllabus. As students described it, the lack of a syllabus caused a kind of short-sightedness whereby students never knew the direction the course would take until a new topic was introduced in class. A few students indicated that, had they known the homework assignments further in advance, they would have worked ahead.

A few indicated they were uncomfortable with the course, saying that the presentation of material was unstructured and therefore confusing. Some expressed concern that there was no connection between the various problems worked on during lecture. According to these students, this inability to see connections made it difficult to study for exams. The following represent these students' viewpoints:

*I think the one thing I didn't like about the class was that it wasn't very structured. We would just be talking about this thing for a day and then the next day we would be talking about something totally different. And so I think there needs to be a structure where you talk about things that kind of relate and then you move on. It just is all mushed together and we're doing all these different kinds of problems. It's really hard to study for the exams because my notebook is filled with all these different kinds of examples that don't really relate.*

\*\*\*\*\*

*It doesn't have the organization that I think 101 and 112 would, where you do something and then you do the homework and you have the right formulas and everything. I would say it's a little bit confusing as a course. (...) When the exams are coming up, you kind of have to grab pieces from here and there that you think maybe the test will be on, but you don't really know.*

- **For some, the book provided structure**

It should be noted that many students commented favorably on the book, Why Math?, and a few specifically credited it for providing an organized structure to the learning material. (See section 5.6.)

### Evaluators' Viewpoint

The evaluators note that many students identified and discussed the math skills which were taught in Math 141: analyzing or interpreting information in problems and application of math skills to solve real-life problems. Sections 5.1 - 5.3 illustrate that many students understood that they were learning problem-solving processes, and that the skills were transferable to the various problems solved in Math 141. The interviews indicate that this course was successful in getting students to approach math from a different, unfamiliar perspective. This is especially notable given the difficulty of getting students who are accustomed to classes where math skills are often learned by rote, to use more analytical approaches to problem-solving.

Many of the students who understood the goals of the course, noted that a few of their classmates did not. The following student explained his/her feelings that some students wanted specific, detailed explanations:

*I know a lot of people are frustrated with [the class]. And I think partly it's because a lot of people want [something] concrete like, "This is the problem, this is how you do it." There are*

*some problems like that, but there're also a lot of problems where he can't really explain how you do it. You kind of have to get to it yourself.*

We suspect that the few students who felt there were no connections among the problems were actually reverting to their traditional ways of learning math and organizing their study. That is, they were focusing on the details of the problems rather than on the process for solving them or on the overall concepts. By the following student's account, s/he measures the amount of information gained (during lecture) by the number of problems solved. If five problems are solved, s/he's learned how to solve only five problems. S/he has not learned to generalize and apply what s/he's learned to other problems.

*His lectures help me, you know. I can pretty much understand his lectures. But I feel like so little of the material is covered in them. Like I say, if you have four problems or five problems in a lecture, you know, to me, that's not a whole lot. At least as far as what I had been doing in past [math classes]. So, I very much understand the lecture, I just don't feel like a whole lot is covered in them. You know, because you spend half your time maybe reviewing or going over homework, and the other half of the time going over new stuff. But, like I say, if you go over four or five problems, I don't feel like very much is covered.*

And the following student is more specific in terms of the information s/he feels is lacking. This student stated that different variations of problem types are not presented in class or on homework.

*I'm trying to think back to the first test. I think there were one or two problems I never had seen. It's like, we go over the problems, and then on the test it's a totally different problem that we've never learned; but we had learned somewhat of what it is. I don't know, it's kind of hard to explain. There were these ones where the airplane would travel so far, and the wind was 40 mph one way -- how long would it take for the airplane to get there? And then on the test there would be different words. Like, instead of finding how long it would take to get there, [you'd have to find out] how fast the wind's blowing. So we'd go over it one way and then we'd have it another way on the test. It was just hard to figure out how to do it.*

The above student does not fully understand the concept of a variable. A few others in the class also demonstrated a lack of understanding of this basic math concept, referring to variables as "letters." These students made it clear that equations with "letters" were confusing to them. But the equations made sense after the professor replaced the "letters" with numbers. One student specifically said that only after seeing the equation solved several different times with numbers, do the "letters" make sense. With respect to this, we make two points:

- 1) As stated earlier, a few students were trying to construct an understanding of the material in Math 141 by focusing on details. For instance, some were looking for the details of the algorithm for each problem type, and for each *variation* of a problem type.
- 2) Some Math 141 students were attempting to interpret and solve word problems without command of some basic math skills. (What seemed most debilitating was their lack of understanding of variables.) A few students made it clear that they understood that they

lacked some basic skills for solving the problems. However, one of these students pointed out that the focus of the class was on understanding the problems and being able to interpret and state assumptions about them. This student noted that one would still get a lot of credit for demonstrating an understanding of the problem, even without being able to solve it. Still, a few of the students seemed focused on being able to completely solve the problems (rather than on demonstrating their understanding of them) and were therefore frustrated by their inability to do so.

#### 5.4. Good Course Assessment

Many felt the tests connected to class work, while a few felt otherwise:

*I personally feel that he gave us examples that had nothing to do, very little to do with the actual exam. [Exam problems] were just kind of out of left field and shocking. That was upsetting about the exam.*

Many also spoke highly of the tests, saying that they were good assessments of whether course material was being learned. In other words, many students appeared to follow the course well, and to have no trouble understanding how to organize study in preparation for an exam. The following is representative:

*R: Yeah, the exams are pretty comprehensive. (...) It is a good overview.*

*I: Are [exam problems] representative of the kind of [homework] problems you work outside of class?*

*R: Definitely. (...) We always know it's going to be the general concepts that are going to be on [the test]. Occasionally he'll throw a little curve ball in there and word things differently than what you're used to seeing just to see if we can think it out. And there's also the fact, like I said before, we have to explain almost every step, what we're doing and justify whether or not we think our answer is realistic and make sure it works. So, I think they're pretty fair.*

#### 5.5. Teaching to the Students

##### 5.5.1. Students have Different Levels of Knowledge and Skills

Many students expressed that it must be challenging, if not difficult, to teach to this particular group. Most noted that their own backgrounds and those of their classmates were varied. One student described the challenge as follows:

*I think this class could work well for [the students with lower level math skills] if [the professor] would slow down. There's half the class where the professor could move really quickly and they could get a lot more done and we could go deeper into a lot of things. Take it to a different level. And then I think there're people where the professor really has to slow down, break every problem apart to show every step, and I think that would help them understand. I almost feel bad for the professor cause he just seems torn between where this class is at.*

The following student described Math 141 in terms of the skills students should bring to the class:

*I'd say it's a class that demands that you know, or that you should feel fairly comfortable with your math skills, your basic algebra and geometry skills. And that it's a lot of thinking, a lot of being able to reason and being able to understand concepts that may not have anything to do with math, but then being able to apply them to math.*

A few noted that the beginning of the course was used for remediation:

*I think that it was important to go over the elementary stuff that we did in the beginning, because in college you just don't know where students have come from in terms of their mathematical background. And even though I knew it, there were some people in the class who didn't know what we were talking about. And now, hopefully, we're all on the same level.*

Another student expressed a hope that the remediation had brought everyone to the same level:

*The problem with the class is that, I think the basic math skills of everyone in the class are so different. Some people have really advanced algebra skills and some people don't. I think it makes it hard for the teacher to [teach everybody]. And I think that's hard. Especially because that's not really what we're learning in this class. You're supposed to already know that, I think.*

A few students felt that the professor made assumptions about students' knowledge and abilities. As one said: "Sometimes I get frustrated because he makes assumptions a lot of times, I think." The following students also described the difficulties of teaching such a diverse group:

*I: Are there parts of the class that are working for you? Parts that could be better?*

*R: Just, if whenever he's teaching the class, if the professor can make sure that he's at the same level as the students and explain things. And then maybe go over the homework problems at the same time, you know. Or, do one at least, and then let us maybe work on it in class. Because sometimes we bring in our homework, you know, and we're like, "We don't understand it, and we have to turn it in right now. Can you at least do a problem for us, or a similar problem, and then let us work the homework out before we turn it in to you and maybe change our answer or whatever?" That would probably be helpful because, I mean, you really want to learn. It's not just the point to get your homework done and hand it in. It would be nice to remember, retain a little bit.*

*I: Having that example to draw from is really important for you in the way that you learn math.*

*R: Right.*

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*R: He's just at a higher [level] and has a hard time bringing himself back to our [level]. I think he has a pretty good idea of where we're all at. Sometimes however, he's not quite sure. I mean you have so many people from so many backgrounds of math. And some people are just way more advanced than others and some are really far back and you need to explain things a little bit more clearly to them.*

*I: How does that show up in class? How can you tell, is it based on the kinds of questions people*

*ask, or how can you tell there're so many different kinds of people in class?*

*R: It's basically the different questions. Some people, they're not picking up concepts that I find fairly easy. They need it explained a little bit more in-depth or, things that they don't have completely grasped, things that I learned in high school that I still have with me, and I don't know. Sometimes it's just hard for them, and I find I actually get kind bored.*

### **5.5.2. Meeting Students Where They Are**

A few students expressed that varied student backgrounds, combined with the fact that the material comes very easily to the professor, made it difficult to teach this course. As one student described:

*I think that because of his intelligence, and obviously any teacher is more intelligent than their students in the subject matter they're teaching, but it just really seems the stuff comes very easy to him. And it does, you know. And a lot of the problems don't come easy to me. I mean, I'm not saying that I could do well in the stuff with ease if he was teaching the right way and this isn't right and whatever else. I'm not saying that. But, I think it comes very easy for him, and so I don't know that, you know, he's able to teach to all the kids because I think there are a lot of kids at different levels in there.*

### **Evaluators' Viewpoint**

One way to understand the experiences of some students is to note that the professor's basic unit of understanding (the concept or the overall meaning of an equation) is different from that of some of the students' (the algorithm or "how to"). Therefore, some of the students are aiming to understand something very different than what the professor intends to teach. This leads to frustration, as one student explained when describing how other students sometimes feel:

*They feel frustrated. They tell him that they're frustrated. They don't get it, and he tries to go about it in maybe a little different way. But it still [doesn't work], it's just the general point of breaking it down, you know. He just basically gives you an answer and says, "Use this formula." But when we don't understand how to plug the numbers in the formula, you know, we don't get it.*

While only a few students seemed focused on learning algorithms, and many appeared to understand the broader goal of the course, even the latter expressed the need to go further into basics on some of the problems. As one said:

*He'll get it down to the basics where all you have to do after that is algebra, and so he'll stop. And that gets frustrating cuz sometimes I need a little reminder of algebra, especially if you're working with fractions. Fractions I'm a little bit fuzzy on still, so I'd prefer if he worked the problems the entire way through.*

We suggest that, often, students need to practice algorithms before they are able to understand how to apply very basic skills or knowledge. And understanding the application of basic skills is the precursor to "getting" the bigger picture. Perhaps these students need more algorithm.

## 5.6. Opinions on the Books

As previously noted, a few students credited the book for providing a structure to the course. Furthermore, many students liked the text, *Why Math?*, and found it helpful. One student described the text as “written in really simple language,” saying it “demonstrate[s] things really well.” Another found the text helpful in solving difficult homework problems, saying: “The examples and the definitions are pretty straightforward,” and “the chapter gives you a clear definition [and a good example] of whatever concept we’re discussing.”

Many also voiced appreciation that the text was organized in the way a traditional text would be. Some students noted it is organized in such a way that problem-types can be identified by chapters and subheadings. One student said: “It’s like a traditional math book. Like a chapter a topic and then problems.” Another added: “There’re main chapters, and then within that there’re subtitles where you can [find] types of mathematics in different fields.”

Only a few students appreciated the second text (which was a math book on quantitative reasoning). Many said that it was not used in the class. One student described it as a word problem book, saying it was “very vague and not really targeted at anything. It’s just a bunch of real-life things.” Most students apparently did not use it as a reference when studying. In fact, while students gave the name and author of the one text, they referred to the second as only “the larger book,” “the blue book,” and “the really expensive book.” The following comment is representative:

*We’ve got three weeks left, and I’ve never opened that blue book. And it was really expensive, so I wonder why we ever had to buy it in the first place.*

## 5.7. Homework and the Grader

Most students commented on the grader. Of significance to these students was that the grader had never been to a class. Many felt that it was for this reason that the homework grades were generally low; that is, the grader wasn’t aware of the particular guidelines set by the professor. As one student explained:

*There’re a lot of different things than just the correct answer, you know. You look at different ways of [interpreting the problem]. I’m sure that kids would get a lot better grades on the homework if [the professor] were to grade it. Because he said that he would grade it on how well you think you understand a particular problem. [The grader] grades it on if you have the right answer and if you show it correctly.<sup>2</sup>*

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<sup>2</sup> We point out that the above student said something problematic, that is, that the professor would grade

In short, students felt the grader was too picky. The following student describes, with some detail, the problems associated with the Math 141 grader:

*You have to explain the most obvious things, which I've never had to do in another math class. And we had this one question about the bottle and the cork, and you had to figure out how much the bottle cost if the cork was this much. So I wrote, "B equals C equals," and I got graded down because the grader wrote, "What does B represent?" Well, look, obviously the bottle. You know? I mean, some things like that are really picky. Other kids in the class have talked about this, that we all feel like we have to explain to the utmost detail in words everything you're doing about math. And I understand that he wants to know your thought process and know that you're figuring this out in the right way. But it's just redundant to have to write down all that stuff when it's obvious what you're talking about.*

### **Evaluators' Viewpoint**

We note that one possible way to understand the students' experiences regarding the grader is that the students and the grader may not have been communicating. For instance, when the student (above) set up an equation with variables representing the prices of the cork and the bottle, it is possible that the equation itself was wrong. A question about the meanings of the different variables may have been meant to clarify a point for the student. Or, perhaps the grader meant to clarify something for him/herself. That is, the meanings of the variables may not have been obvious. This is merely a suggestion as to another way to understand students' experiences with the graded homework. We do not have adequate information from the student interviews to suggest a strong interpretation one way or the other. But it is necessary for students to understand expectations (including guidelines on homework, and what must be included to get full credit), and that the feedback facilitate a clear communication between the grader and the student.

## **6. STUDENT PERSPECTIVES ON THE VALUE OF MATH 141**

### **6.1. Better at Solving Word Problems**

Many students said that Math 141 helped them learn to deal better with word problems, some noting that word problems have been a particular source of difficulty for them in the past. More specifically, students commonly reported that they thought more carefully through problems; they now think more logically or use analytical skills they hadn't used before. As one said: "I probably do just stop and think more logically about problems." The following students described how they've learned to deal with word problems:

- **Breaking down the problem**

*I: You're learning what to take [out of the problem] -- what did you mean, "what to take out of*

---

homework on the basis of how well the student thinks s/he understands the problem. It is possible that the student actually meant how well the professor thinks the student understands.

it"?

*R: Like how to break down a problem and solve for what it's asking for. [Math 141 has] changed my perspective on [problem-solving], how to go about it. [I'm learning] how to do everyday problems that you might come across. Just how to break things down, so that it's more understandable. (...) I've learned to look at what it's really asking. Instead of trying to figure out an equation right away.*

- **Considering more options**

*I think about more solutions now. Like, I think "Okay, it could go this way. But what if the circumstances were this and it could be this way?" I never had done that [before] with any problems. I just looked for the one answer.*

- **Becoming a more successful and independent problem-solver**

*Now when I have problems, I can do the work. I think I'm better at getting my homework done and, you know, figuring it out for myself. Because I had worked a lot out of the book by myself this year. And there are certain things that I did in high school that I didn't really get the first time around, and that I'm getting now.*

## 6.2. Increased Appreciation for Math Applications

Many students identified that they appreciated the use of math applications, especially as they relate to everyday life (as mentioned in section 4.2.). Some pointed out that the application to everyday life helped them understand and learn the mathematics. One student described his/her improved math skills as those involving "more common sense math"; that is, math which applies to things used every day. This student said that it was the "practical things" covered in Math 141 which helped. The following comments represent students' views regarding math applications:

*It is applications of math that I can see useful. And I think that [those are] the most effective. That's the way that a math teacher can be most effective in getting somebody [who's not a big math fanatic] to use it, and to really appreciate math. Not necessarily like it, but see the usefulness. So I think all in all, it was a good decision to take that class.*

\*\*\*\*\*

*I am enjoying the fact that we are learning things that apply to life. I think that's very very very helpful.*

\*\*\*\*\*

*[The reason that I like math 141 is because] it is math as application, and that it does apply more to real-life. There are a few things we had studied [that were not] incredibly useful in my life -- maybe more useful to perhaps a construction worker or an engineering kind of person, someone who's setting up buildings, or dropping things from great heights, or {laughs} shooting off rockets, or whatever. I found it more interesting because of that -- that it's an interesting course in that you are applying it to life.*

\*\*\*\*\*

*I'd say that 141 in and of itself is a really, really good idea. I would recommend to the Math*

*Department that they have more courses taught in that style where the mathematics is more applied at different levels. One at maybe a plain algebra level, one at a pre-calculus level, and I don't know necessarily if those things are as easy to apply to everyday situations. But I'd say that I would think a lot of math lay-people, as it is, would be able to pick up on some of the stuff and understand it more if it was [taught in] the type of context that 141 is. Where it's not just dry numbers and dry concepts.*

\*\*\*\*\*

*[Math 141 is] all word problems. I mean, you do get appreciation for what all you can apply stuff to and [how mathematics applies in life]. So I guess that's good in that aspect. It's not all just numbers and problems. I've gained a little bit of understanding of how to apply it in life and stuff, which is a pretty good thing, you know.*

A few students specifically noted that they've learned to apply mathematics that they already knew. One student was encouraged that s/he had learned "how to use (...) the math skills I have." In other words, many of these students' previous experiences with math was without context, or meaning, in that what they had learned made no sense in a bigger picture. Math 141, to them, foregrounded the application of and demonstrated various contexts for math equations.

A few students stated that only the personally relevant applications were useful. The following quote illustrates how important application can be as a learning tool:

*I: So you really feel like what you're learning is something you probably won't retain?*

*R: There's some really useful things we've learned about finances, and I really like that. Stuff about IRA's and CD's and savings accounts and all that kind of stuff. I do like that, and I find it useful, and I know I'll remember that stuff. But the rest of the things – it's like, why should I care if a bullet is shot in this direction, how long does it take for the sound to come back? I'm not going to be a physicist, and I'm not going to be an engineer. It's like, math for me throughout my whole school career is something you learn to satisfy the test and then forget. Unless I find it useful in some way.*

While many students still do not like math, they appreciated having Math 141 as an option for satisfying the QR-A requirement. While saying that the class did not affect his/her opinion of math in general, the following student voiced appreciation for the way in which Math 141 was taught:

*I: Would you take any more math in the future because you took this course?*

*R: Not because I took this course, but because I'm going to have to, probably {laughs}. All in all, I'd say this course was a good experience. I think that I've learned from it. But it's math -- it's never been incredibly interesting to me. I appreciate the fact that this course has been much more interesting than I expect 112 would have been. And again the fact that it relates to life.*

### **6.3. Improved Critical Thinking Skills**

Many students mentioned that they had better critical thinking skills. One student was glad the class "forced" him/her "to do certain things, (...) like critical thinking when it comes to math." Other students, as illustrated below, also believe the class developed critical thinking in specific ways, such as: recognizing important information, revealing assumptions, setting parameters, thinking about meaning, and developing understanding.

*[I now work through problems] a little bit differently; now I underline different parts of the problems that I see that are important, and I might jot down a few notes to myself. And I keep more of an eye out now for things like -- you have to assume certain things. He's been telling us that when you have a word problem and it doesn't say you can assume linear relationship or something like that, and you realize that you can't do the problem unless you use some linear relationship. You have to write down, "I am now assuming a linear relationship," and I never did that in the past, and I find that that's helpful; that you can restrict the problem because you need to.*

\*\*\*\*\*

*I think a lot more about the problems that I'm doing instead of numbers, numbers, numbers. I think about what the numbers mean. So I think that's kind of what the course is trying to make you see.*

\*\*\*\*\*

*I'm glad I took [Math 141] because it's helped me understand things clearly. Slow down and actually start out by understanding the problem and then going from there. Just a lot of practice with things like that.*

\*\*\*\*\*

*I think the course has made me slow down a little bit more and not to get ahead of myself. Because [when we solve problems] we have to explain what's going on. (...) I'm working to try to get the right answer now and really understand it rather than just work through it and hope that I came up with the right thing. (...) I think I'm more organized than I was and more focused on taking it one thing at a time and not getting ahead of myself. Because on a tests I tend to be a very quick thinker and really race through things. Just the fact that I'm more inclined to slow down and really see what I'm being asked, see what's being asked of me and be able to reason with myself why I'm confident of my answer.*

#### **6.4. Better Understanding of Concepts**

A few students said they now had a better understanding of concepts. As students described what they've learned in Math 141, it is clear that they had become more cognitively engaged in the math problems they solve. They are not thinking at a rote level. The following excerpts illustrate how these students have become more engaged in learning math concepts:

*I: So, really, what you're saying is that the kind of word problems you're doing in this class are a more realistic kind of math than the kind of equations and the kinds of formulas that you would learn in a more traditional course.*

*R: Yeah, because I can see them, you know, I can see what they're actually asking. I think in a class like 141 I'd be more inclined not to follow -- we talked before about patterns -- not to follow patterns, but actually to think about what I was doing rather than just going through the routine.*

\*\*\*\*\*

*I: What parts of the class are helping you learn things? Like, is it helpful when the instructor explains things? Is it clear to you what's being explained?*

*R: Yeah. Now he's in the section that [my calculus class] did a few weeks; something like interest and all that. And now I understand it a lot more and actually know why this equation looks like this. (...) He's a good teacher.*

*I: A little bit earlier you said that you look at things differently now. You look at things in*

*context more and you think it's changed the way you solve problems.*

*R: Somewhat. Yeah. Because I see everything now and it's like everything's connected some way in math. It seems like everything is. It's helped me think things out more clearly, because I've never been good at word problems. But I've always been good at the concrete things.*

It is interesting to note that while students report these positive outcomes, many also maintain that math is still frustrating and unenjoyable. For example, one student when asked, "Are you getting anything out of Math 141?" responded, "Yeah. I mean, I'm learning what to take out of a problem more so, but I'm not enjoying it."

### **6.5. Increased Appreciation for Math**

A few students reported that beyond developing an increased appreciation for math applications, they also are gaining an appreciation for math. These same students' attitudes regarding taking further math courses have changed for the positive – some to greater degrees than others. The following quotes represent these views:

*I: Tell me a little bit about what you're getting out of the course. What are you taking away from it?*

*R: I guess maybe more of an appreciation for math. I'm almost motivated now to take [another math class.] Well, depending on what I do next year, I guess I probably will have to take another math course. But I don't think I'll go into it saying, "Well, this is totally useless to me. I'll never use this stuff in my lifetime."*

*I: Did you think that before?*

*R: Yeah, I was usually pretty pessimistic and I always tried to downplay math because, like I said, I'm not geared towards math so much. So I think that if anything else, there's a general attitude [about] math, that it does hold some significance even for somebody who doesn't want to study math or pursue a career that has mathematics in it.*

\*\*\*\*\*

*R: I'd take another class like this. I don't think I could ever go back to a calculus class or whatever. But if it was something more like this I think I'd take it.*

*I: So you really like this class?*

*R: I do.*

\*\*\*\*\*

*I: Would you say that you have a greater interest in expanding your math knowledge now as a result of the course?*

*R: I guess it would more be like, I wouldn't be upset if I needed to take a math course or needed to do something mathematical. I don't think I'd complain as much as I used to. I still know that I'm not the kind of person who can go out of my way to do something in mathematics if it wasn't absolutely necessary for me.*

## 7. CONCLUSION

This section of Math 141 was very successful for many. These [many] students described the several problem-solving skills they learned in the class. They learned to think more carefully about problems, breaking them down and finding and using the information within. They learned to think more logically and analytically.

*[I'm learning] strategies to solving problems, [although I've] always had somewhat of a sense of my own, how I would best solve problems. They make us write out explanations as to what we're doing (...) [and] I guess maybe that makes me a little bit more clear minded when I'm taking an exam or doing the homework, to be able to defend what I got or question where I went wrong.*

And they learned various applications for equations that, in previous math courses, they had applied in contexts which were not meaningful.

*[I liked Math 141] because it's more relevant than anything I did in high school. You know, algebra, geometry. This [class] covers a lot. So when it covers algebra or geometry problems, I kind of lose focus a little bit. Yeah, I like the things that are practical, that's what I like about the class.*

\*\*\*\*\*

*I'd say this course was a good experience. [But math has] never been incredibly interesting to me. I appreciate the fact that this course has been much more interesting than I expect 112 would have been. And again the fact that it relates to life.*

They reported that they liked the course, and greatly appreciated that it was an option for satisfying the QR-A requirement.

*I just feel like I've had four math classes like [Math 112] and it's just kind of nice, or kind of different [to have Math 141].*

\*\*\*\*\*

*I: Do you have any other comments or questions or anything you'd like to say about the course?*

*R: I think they should keep it. I think the University should keep it because it's helped me fill the requirement and doing some of that without jeopardizing my GPA.*

*I: This course helped you to feel somewhat more successful in math?*

*R: Oh, absolutely. Absolutely. I was hysterical when I had to drop 112 because I felt like such a failure. I felt like I would never get this requirement done with, and I had to call my parents and my advisor and all these people. I was just terrified. It actually made me scared to think I might not ever fill this requirement, but because of this course, it makes it a lot easier. And I can also concentrate on my other courses. I don't have to put all of my time into math.*

\*\*\*\*\*

*I'm glad, -- maybe I'm not really glad -- but if it wasn't a requirement, I wouldn't have taken it. And I think that I should [take it], but I wouldn't have made myself take the class.*

It is our opinion that challenging problems with real-life applications, and the professor's continual guidance in the problem-solving process were key factors in the success of this course. A few students also noted their appreciation for a traditional text. It may be that some traditional elements in the course provided familiar learning tools which students could turn to, as well as a sense of security.

A few students found the course to be unsuccessful in that they did not see the “connections.” These [few] students experienced frustration and confusion. Their experience was magnified by the fact that they did not know how to prepare for quizzes and exams.

*[The class is] good if you are able to work on your own and kind of figure things out for yourself. (...) Sometimes he's really hard about not giving you any clues. And I find that frustrating, because sometimes with math, I don't know how to do it. I've never done it before, and you need to tell me, you know. And then I can figure it out.*

Our interpretation is that these students focused on learning the details of how each problem was solved; in other words, they were trying to identify algorithms. They did not see the overall connections, which might have enabled them to identify the problem-solving process that their classmates were learning and that the professor was teaching.