REPORT OF THE PROVOST'S TASK FORCE ON QUANTITATIVE PEDAGOGY

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SUMMARY

We recommend shaping a wide variety of courses at Baruch around the principles of quantitative literacy, well described by Steen and others. The key skills include: reasoning with data; reading graphs; analyzing evidence; number sense (e.g., accurate intuition about the meaning of numbers, confidence in estimation, common sense in employing numbers as a measure of things); comfort expressing mathematics in words; comfort expressing mathematics in graphs; using mathematics to make decisions and solve problems in everyday life, the workplace, and within the wider society; using mathematical models to express ideas; reading a body of text and expressing it in a mathematical framework; and symbol sense (excerpted from Table 1 in report).

General principles for achieving quantitative literacy are:

- Integration and reinforcement across the curriculum
    - Numbers and quantitative reasoning integrated into courses that are not primarily quantitative
- Fewer topics but greater depth of mastery
- Assignments and tests that require students to apply skills in applications that are meaningful to the students
    - Examples involving familiar concepts are more effective than examples which require extra learning.
    - Examples which motivate and interest students are valuable
- A variety of *different* applications
    - Increasing student role in framing the problem and in abstracting
- Excel exercises integrated into course content throughout the curriculum
- Rule of Four: All applications and concepts presented as:
    - Words
    - Numbers
    - Graphs
    - Symbols
    - Translate from any one to the other
- Practice
    - Interpreting and writing about numbers
    - Explaining equations in words
    - Reading, interpreting and applying technical writing
- Textbooks and other materials based on best-practice guidelines described
- A learning environment that emphasizes malleability-- the idea that people get smarter incrementally by working

(Table 2 in report)

In order to facilitate implementation of these best practices, our recommendations are:

- Creation and/or purchase/adaptation of quantitative literacy best-practice materials with oversight committee to approve
- All quantitative courses, including but not limited to, mathematics courses should emphasize quantitative literacy.
- Homework graders to facilitate more assignments that involve in depth problem solving and writing on quantitative subjects
- Pre-business calculus requirement be substantially modified to reflect quantitative learning requirement. The University of Arizona math for business provides one possible model. Zicklin faculty should be substantially involved in this process and possibly involved in the teaching.
- Textbooks and other materials should be adopted based on a rubric incorporating the best practice we describe. The adoption process should consider the more widely used and well known books and materials.
- Far more applied exercises using Excel be incorporated into many courses
- Labs for Excel, statistical software and other technological tools for applying these tools in substantive applications
- Forums aimed at psychological influences of students, particularly attitudes towards malleability of smartness
- Faculty seminars for improving psychological aspects of learning environment
- Interview training
- Involving employers in course design
- Quantitative literacy exam development

OUR TASK

The Provost's Task Force on Quantitative Pedagogy was convened by Baruch College Provost Jim McCarthy in September 2007. The Provost asked the Task Force to determine how the college can ensure that all students graduate with the quantitative and analytical skill levels appropriate to their majors and that would enable them to move on in the workforce or the next level of education. We were told that no subject we found relevant was "off the table."

Such a broad task was, from the very beginning, both daunting and inspiring. Recognizing the magnitude of the undertaking and the fact that major changes can take some time, the Provost asked us to develop specific recommendations for action starting September 1, 2008. Given the broad agenda and need to be specific in the short run, we decided to simultaneously develop short-term proposals and create a road map for long-term goals. With the Provost's support, we also decided to recommend what we think should be accomplished, even in those cases where we can offer no clear practical path for getting there.

WHO WE ARE

The members of the task force have diverse backgrounds, all relevant to quantitative pedagogy. Our diverse composition was critical to what we did and therefore we will briefly describe our backgrounds before describing what we did.

> **Joe Collison**, Associate Professor, Mathematics, Weissman School of Arts and Sciences. Joe is a master teacher of calculus for over twenty years, established and oversaw for many years the math tutoring program of the Student Academic Consulting Center (SACC), and is highly knowledgeable about the literature and best practices in mathematics education.
>
> **Catherine Good**, Assistant Professor, Psychology, Weisman School of Arts and Sciences. Catherine started out in graduate school in mathematics and researches psychological influences on learning, including math phobias and gender stereotypes.
>
> **Sonali Hazarika**, Assistant Professor, Finance, Zicklin School of Business. Sonali is the course coordinator for Finance 3000 and has seven years experience teaching finance courses to undergraduate business students.
>
> **Matt Johnson**, Associate Professor, Statistics, Zicklin School of Business. Matt is a Zicklin School teaching award recipient and has extensive experience teaching a wide variety of statistics courses.

Jimmy Jung, Director of Enrollment Management (formerly Assistant Director of Institutional Research). Jimmy is very knowledgeable about student data, admissions practices, course performance and graduation.

Anita Mayo, Professor, Mathematics, Weissman School of Arts and Sciences. Anita has 20 years' experience in industry research in diverse areas of applied mathematics and currently researches financial mathematics.

Will Millhiser, Assistant Professor, Management, Zicklin School of Business. Will studied and practiced engineering. He taught high school math before graduate school and currently researches in operations research.

Dahlia Remler, Task Force chair, Associate Professor, School of Public Affairs. Dahlia is an economist and health care policy analyst with a prior doctorate in theoretical chemistry (computer modeling). She has 12 years' experience teaching economics and research methods to (often math phobic) masters in public health and masters in public administration students.

Until March, we were also helped by *Laurie Beck*, assistant to the task force, a student in the Higher Education Administration masters program at Baruch's School of Public Affairs, a lawyer who also had extensive experience in many different higher education settings. Unfortunately for us, Laurie had to leave in the middle of the Spring semester for an excellent job opportunity.

WHAT WE DID

Reverse engineering: What should our graduating students be able to do?
Conceptually, our first task was to decide where we, as a college, wanted to be and then work backwards to figure out how to get there. We first had to decide and articulate what our students should know and be able to do. We used two main methods.

First, we looked to the workplace. For all students, and particularly the roughly 80% who of the students who are trying to get a business degree (source: Phyllis Zadra), the tools needed to get a good job, contribute in the workplace and advance in the workplace are central concerns. This is particularly true for students who are relatively low income and/or are the first in their family to attend college.

To determine what quantitative abilities the workplace required, relatively elite local employers in banking, financial services and management consulting were interviewed by Will Millhiser. Baruch College alumni who had been out in the workplace for several years were also interviewed. (The complete methods and results are in Appendix I.) We also interviewed the head of the career placement service, Pat Imbimbo, and reviewed materials provided by her, including job listings.

Second, we examined the extensive literature on what quantitative skills broadly educated students need. This literature has examined and articulated what skills are needed. “The Case for Quantitative Literacy” by Lynn Arthur Steen (http://www.maa.org/ql/001-22.pdf; hereafter Steen’s case) was probably the most influential document for us. Other sources used are given in the references.

Where Baruch is now

We spoke with a variety of individuals familiar with quantitative and mathematical education at Baruch College. As a group, we met with Warren Gordon, math department chair, Carol Morgan, director of SACC, and Jill Rosenberg, director of academic support for SEEK.

Individual members or small groups met with the Zicklin curriculum committee, individual faculty members and administrators of Zicklin, Weissman and the School of Public Affairs (SPA), BCTC staff and again with the director of academic support for SEEK. We examined syllabi and assignments from relevant courses in math, statistics, finance, management and public affairs. Data from institutional research about performance in math courses, on math tests and so on was presented to us. We learned about on-line resources available to students. Finally, we spent a great deal of time talking amongst ourselves, bringing in our own teaching experiences and observations of others’ teaching.

Determining how to change

In deriving our proposals for what to change and how to change it, we relied on several of the sources already described and some other sources. The existing literature on quantitative literacy provides a wealth of specific suggestions. (See references.) Joe Collison was already knowledgeable about much of this literature and able to educate the rest of us. The literature on psychological influences on learning, such as factors contributing to math phobias, was brought to us by member Catherine Good, who is an expert in that subject. Finally, again, our own experiences teaching and as members of the academic community at Baruch and other institutions provided valuable insight into both how to succeed and in the barriers to success.

We also examined what other colleges have done and learned from a number of outside experts brought to Baruch as part of the Provost’s Master Teachers Lecture Series. Presentations by and individual meetings with Mike Burke, Deborah Hughes-Hallett and Donald Saari were particularly valuable. They provided examples of assignments and other materials that facilitate effective quantitative literacy education. Laurie Beck searched the web for examples of what other colleges did and these are described in Appendix II.

We discussed admissions requirements, and possible alterations to them, as a means of improving the quantitative skills of our students. However, the college has limited flexibility in making such changes. Moreover, it was our assigned task to look at how Baruch could improve our own pedagogy—how we teach our students—and so we focused on that issue. Therefore, we decided to focus on what we could do at Baruch given the skills that our students arrive with. We are not against changing admissions requirements; we simply felt that the subject was not our assigned task and that such changes carry broad ramifications beyond our expertise.

THE GOAL: QUANTITATIVE LITERACY

> *… [U]ses of quantitative thinking in the workplace, in education and in nearly every field of human endeavor [are increasing]. Farmers use computers to find markets, analyze soil, and deliver controlled amounts of seed and nutrients; nurses use unit conversions to verity accuracy of drug dosages; sociologists draw inferences from data to understand human behavior; biologists develop computer algorithms to map the human genome; factory supervisors use "six-sigma" strategies to ensure quality control; entrepreneurs project markets and costs using computer spreadsheets; lawyers use statistical evidence and arguments involving probabilities to convince jurors. The roles played by numbers and data in contemporary society are virtually endless. …*
>
> *Unfortunately… many educated adults remain functionally innumerate… Common responses to this well-known problem are either to demand more years of … mathematics or more rigorous standards for graduation. Yet even individuals who have studied trigonometry and calculus often remain largely ignorant of common abuses of data and all too often find themselves unable to comprehend (much less articulate) the nuances of quantitative inferences. As it turns out, it is not calculus but numeracy that is the key to understanding our data drenched society.*
>
> *Quantitatively literate citizens need to know more than formulas and equations. They need a predisposition to look at the world through mathematical eyes, to see the benefits (and risks) of thinking quantitatively about commonplace issues, and to approach complex problems with confidence in the value of careful reasoning. Quantitative literacy empowers people by giving them tools to think for themselves, to ask intelligent questions of experts, and to confront authority confidently. These are the skills required to thrive in the modern world.*
>
> Excerpted from Lynn Arthur Steen, *The Case for Quantitative Literacy*

It is easy to say that our students need quantitative literacy, but what precisely does that consist of? What mathematical and quantitative abilities do students need in order to have valuable careers and be engaged citizens and individuals? What subjects should be covered? What sorts of tasks are needed for our students to learn and to demonstrate that they have learned?

Luckily, a great deal of analysis and writing addresses these questions for all levels of education, including higher education. While many terms are possible for the wide variety of quantitative and analytical skills needed, the term *quantitative literacy* has taken hold and we will use it. Quantitative literacy's definition and importance have been set forth by Lynn Arthur Steen and others. Those emphasizing its importance include the Mathematical Association of America (www.maa.org). Again, we made particular use of Steen's case.

Quantitative literacy is much more than mathematics—and sometimes it is also less. Numeracy is critical, as is logical thinking. Quantitative literacy includes the ability to create a mathematical framework to address a particular problem, at least as much as it includes the ability to solve a mathematical problem once it has been formulated. In an intrinsically quantitative field like finance, quantitative literacy requires facility in estimation and the ability to create an appropriate analytical framework to analyze a problem. Quantitative literacy is also critical in fields not traditionally thought of as quantitative. For example, school principals deal with accountability programs like No Child Left Behind, while those in public relations report on and compare rates relevant to their organizations. All citizens need to understand and apply political, medical and personal financial data relevant to their lives.

The key element throughout is that our students must learn to figure things out in a variety of quantitative contexts. Memorization or rote calculation in an already structured framework is not sufficient, although they may be necessary steps along the way. Working from Steen's case, other existing literature and our own experiences, we created our definition of quantitative literacy that is relevant for Baruch's students. It is primarily a revised version of that in Steen's case with some additions and deletions and is given in Table 1.

In Appendix III, we give examples of problems in several subjects that would demonstrate quantitative literacy.

TABLE 1: Definition of *Quantitative Literacy*

Interpreting Data
- Reasoning with data
- Reading graphs
- Drawing inferences
- Recognizing sources of error

Logical Thinking
- Analyzing evidence
- Reasoning carefully
- Understanding arguments
- Questioning assumptions
- Detecting fallacies
- Evaluating risks
- Drawing logical conclusions, predictions or inferences
- Determining when it is valid to infer that one thing causes another

Number Sense
- Accurate intuition about the meaning of numbers
- Confidence in estimation
- Common sense in employing numbers as a measure of things

Confidence with Mathematics
- Comfortable with quantitative ideas
- Comfortable applying quantitative methods
- Comfortable expressing mathematics in words
- Comfortable expressing mathematics in graphs

Making Decisions
- Using mathematics to make decisions and solve problems in everyday life, the workplace, and within the wider society

Mathematics in Context
- Using mathematical models to express ideas
- Reading a body of text and expressing it in a mathematical framework
- Reading, understanding, interpreting and applying written technical material

Symbol Sense
- Comfortable using algebraic symbols and equations
- Comfortable reading and interpreting symbols and equations
- Exhibiting good sense about the syntax and grammar of mathematical symbols

Prerequisite Knowledge
- Having the ability to use a wide range of algebraic, statistical and other mathematical tools that are required in an individual's field of study or professional work

Adapted from "The Case for Quantitative Literacy" by Lynn Arthur Steen

FROM THE LITERATURE ON HOW TO ACHIEVE QUANTITATIVE LITERACY

Fewer topics, greater depth

The National Mathematics Advisory Panel advises that the math curriculum should include fewer topics, and then spend enough time on each so it is learned in depth and need not be revisited in later grades. Similar feelings were expressed by many others: "Curricular expectations in high-performing countries focus on fewer topics, but also communicate the expectation that those topics will be taught in a deeper, more profound way. This is not happenstance, it means making real choices about what to teach, and, of equal importance, articulating those choices in a consistent manner in key instructional supports like standards, textbooks, and assessments" (Newmann et al., 2001). Although these reports were addressing problems encountered in middle and high schools, we, like much of the existing literature, feel that the same principles apply to higher education.

Quantitative skills across the curriculum

In order for students to become quantitatively literate, it is not enough to have individual courses which "cover" each of the areas. Rather, each of these areas must be incorporated into many courses. For example, symbol sense is a skill that is developed by repeated practice in many contexts getting practice interpreting symbols in a meaningful way and manipulating symbols to accomplish meaningful tasks. Symbol sense cannot be acquired in a few math courses, particularly for students who did not develop it in high school. Rather, it is a skill that will be practiced and developed in many courses—for example, mathematics, statistics, accounting, finance and so on. All of those courses should help students learn symbol sense by getting students to practice explaining in words the meaning of symbols and equations.

Faculty must realize that along with teaching finance, accounting, statistics, mathematics and so on, they are also teaching symbol sense and other quantitative literacy skills. That recognition should shape their teaching.

The role of applications

Classroom teaching, readings and assignments should provide many contexts that help students learn to apply the concepts. Simply teaching abstract concepts will not help students learn to apply the concepts. Students taught to manipulate symbols or solve problems in a particular application may not be able to apply the same methods to a different application. For example, they may not know what to do if a problem is worded differently, different symbols are used, or a graph takes a different form. Highly involved applications provide depth, but if they limit the number of applications, students may just learn those specific applications and will not learn how to abstract and how to apply abstract ideas. The key is the ability to go from the particular application to the abstract and from the abstract to the particular application. Many different applications, with students playing an increasingly active role in the application and the abstraction are critical.

The choice of applications
Applications help students make abstract ideas concrete. Therefore, applications whose contexts are already familiar to students are most valuable. Applications which require students to learn a whole new set of facts do not allow the students to focus on the particular skill. For example, in teaching introductory calculus to students who have not yet learned finance, financial modeling applications would erect further barriers. In contrast, applications based on shortest travel routes may better support learning of the quantitative material.

Of course, applications that intrigue and motivate students are also critical. Geometric shapes may be familiar to all students but may not be motivating to students who aspire to a career in finance. Ideal applications, which are simultaneously familiar and captivating, may be hard to come by.

Rule of Four
The *Rule of Four* refers to the idea that any application or concept should be presented four ways:

- Words
- Numbers (data)
- Graphs
- Symbols

Students should be able to understand the application or concept in any of these forms and be able to translate from one another. The Rule of Four was developed by Deborah Hughes-Hallett (Hughes-Hallett, Gleason, McCallum et al. 2004) for the teaching of calculus, but it applies to virtually any quantitative subject. Instructors can enhance their teaching by going from one form to another when teaching. Since students vary in which form is most easily accessible, teaching them all together allows students to build from their initial strength. Assignments should ask students to do things in all forms or to translate from one to another. If students are taught the Rule of Four, they themselves can prompt their own understanding.

Reading, interpreting and writing quantitative material
The verbal component of the rule of four is particularly important. Reading, interpreting and applying technical material is a central skill. Writing, clearly and lucidly, about quantitative material, both in prose and by creating tables and graphs is also a critical skill.

Psychological influences
Both educators and psychologists are increasingly interested in understanding the factors that prevent students from attaining high achievement and fulfilling their potential, particularly in quantitative disciplines. Recent research in social psychology, for example, has dramatically demonstrated the pernicious effects that negative stereotypes about one’s abilities can have on achievement. This research suggests that stereotyped individuals often suffer negative performance outcomes, not necessarily because they lack ability, but because of their vulnerability to the effects of negative stereotypes. Indeed, the research shows that when stereotypes are not activated, stereotyped

individuals often perform as well on an intellectual task as do non-stereotyped individuals. However, when negative stereotypes are activated, they appear to trigger psychological processes that undermine the performance of individuals from a wide range of stereotyped groups, including females in quantitative fields such as mathematics and science and minority students in academics more broadly.

In addition, the achievement motivation literature can teach us a great deal about the effects of messages that imply fixed ability—as stereotypes do—on students' performance. This research shows that students who think of intellectual ability as a fixed trait rather than as a potential that can be developed are at greater risk of negative academic outcomes when faced with difficulties or setbacks. Due to the culture of talent that often accompanies quantitative disciplines, a majority of students are likely to hold the view that their quantitative abilities are fixed by nature. Research shows, consequently, that these students are at particular risk for underachievement in quantitative disciplines, particularly when content in those disciplines becomes challenging.

The good news is that students can overcome their vulnerability to both negative stereotypes and messages suggesting that quantitative abilities may be fixed by adopting a more malleable view of intelligence, in general, and of quantitative skills, in particular. In Appendix IV, we summarize research-based recommendations for improving students' quantitative literacy and review the literature that supports these recommendations. In the recommendations section, we provide specific recommendations for Baruch's students and faculty.

TABLE 2: General Principles for Achieving Quantitative Literacy

- Integration and reinforcement across the curriculum
  - Numbers and quantitative reasoning integrated into courses that are not primarily quantitative
- Fewer topics but greater depth of mastery
- Assignments and tests that require students to apply skills in applications that are meaningful to the students
  - Examples involving familiar concepts are more effective than examples which require extra learning.
  - Examples which motivate and interest students are valuable
- A variety of *different* applications
  - Increasing student role in framing the problem and in abstracting
- Excel exercises integrated into course content throughout the curriculum
- Rule of Four: All applications and concepts presented as:
  - Words
  - Numbers
  - Graphs
  - Symbols
  - Translate from any one to the other
- Practice
  - Interpreting and writing about numbers
  - Explaining equations in words
  - Reading, interpreting and applying technical writing
- Textbooks and other materials based on best-practice guidelines described
- A learning environment that emphasizes malleability-- the idea that people get smarter incrementally by working

PROFILE OF BARUCH COLLEGE UNDERGRADUATE STUDENTS

Baruch College is considered one of the most diverse institution of higher education in the US with 107 languages spoken and 156 countries represented. The ethnic makeup is 36% Asian, 34% White, 18% Hispanic, 13% Black, and under one percent American Indian. The gender breakdown is 48% male and 52% female. The undergraduate enrollment of Baruch College in the fall 2007 is 12,863 with approximately 76% attending full-time.

The 2006 CUNY Experience Survey found that 27% of undergraduate Baruch College students have a household income of under $20,000, 35% are the first in their family to attend college, and 38% work at a job for over 20 hours a week while attending school full-time. Thus, many of our students have few resources to draw on and have a substantial work burden. One might imagine that they also have significant family responsibilities.

Undergraduate students are admitted to Baruch College either as freshmen, students who have not matriculated at any higher education institutions prior to admissions, or as new transfer students, those who have matriculated at another higher education institution(s). During the 2007-2008 academic year 1,564 freshmen and 2,083 new transfer students were enrolled. In any typical academic year there is a greater number of new transfer students enrolled compared to freshmen. Hence, a majority of the undergraduate student body is composed of students who transferred into Baruch College.

The profile of freshmen and new transfer students differ drastically, mainly due to the different standards in which these students are admitted. The minimum admissions requirement for freshmen is a high school grade point average of 85 with a combined SAT score (Critical Reading and Math) of 1050. While the minimum admissions requirement for new transfer students is a college grade point average of 2.75 for those with an Associates Degree from a CUNY college or a college grade point average of 3.00 for all other applicants.

Regarding quantitative skills or preparation recorded as part of the admissions process, a typical fall 2007 freshmen has a SAT Math score of 599, a high school math average of 86.5, achieved a 86.1 on the New York State Math A Regents, and have taken 3.4 high school math units. For a typical fall 2007 new transfer student there are no indicators of math skills or preparation recorded during the admissions process. A transfer articulation study conducted on the fall 2007 cohort by the Office of Institutional Research and Program Assessment found that 31.4% of new transfer students had received credit for taking a calculus course at a prior institution.

All freshmen and most new transfer students are required to take the ACT Compass Math test. Mean ACT Compass Math test scores for freshmen and new transfers students in the fall 2007 cohort are shown in Table 3. Freshmen students outperformed both groups of new transfer students on all three subtests, while new transfer students from 4-year institutions outperformed new transfer students from 2-year institutions on subtests 2 and 3. New transfer students from 2-year institutions outperformed new transfer students from 4-year institutions by a slight margin, 60.4 versus 58.9, respectively, on subtest 3. This analysis suggests that freshmen enter Baruch College with a higher level of mathematical ability than both groups of new transfer students whereas new transfer students from 4-year institutions have a higher level of mathematical ability than new transfer students from 2-year institutions.

TABLE 3: Fall 2007 Cohort Mean Compass Math Scores by Admissions Type

Admissions Type	Subtest 1 (Pre-algebra) Mean (N)	Subtest 2 (Algebra) Mean (N)	Subtest 3 (Intermed. Algebra) Mean (N)
Freshmen	65.7 (107)	69.9 (1,459)	60.8 (1,431)
New Transfer Students (2-Year Institutions)	60.4 (136)	54.3 (569)	48.5 (510)
New Transfer Students (4-Year Institutions)	58.9 (132)	59.9 (641)	53.5 (577)

STUDENT, ALUMNI AND EMPLOYER PERSPECTIVES: WHAT QUANTITATIVE LITERACY SKILLS DO OUR STUDENTS NEED?

What quantitative skills do our students need according to students, young alumni and employers? In the fall 2007, we conducted 15 interviews asking two questions:[1]

1. What analytical, quantitative and/or mathematical skills do Baruch students need most?
2. How do firms assess quantitative literacy (e.g., in interviews)?

The full text of the interviews is available in Appendix I.

The employers represent members of the banking, financial services and management consulting communities of NYC, that is, world-class companies for whom Baruch students might aspire to work. The student respondents are those who have accepted full-time positions starting by summer 2008. Most alumni and students are BBA majors in the Zicklin School.

Summary of Findings

1. Quantitative literacy can play an important role in a student's ability to interview strongly. This was confirmed by employers, students and alumni.
2. Employers vary widely on how they screen for quantitative skills, if at all. While the most rigorous screening occurs at management consulting firms, we found that generally, most firms screen for the ability to think logically and estimate well under pressure.
3. Surprisingly, employers were silent when asked, "What quantitative literacy skills do Baruch students lack?"
4. When asked what quantitative skills do Baruch students need, alumni and current students unanimously commented on the need for better training in MS-Excel. After Excel, many mentioned the importance of being prepared for quantitative

[1] The interviews were conducted by Will Millhiser.

content knowledge and the "brain teaser" questions that have become ubiquitous in the interviewing process.

We first look more closely at what the employers told us.

Employer Perspectives

No employer explicitly stated a skill that Baruch students lack. Therefore, the focus of the responses was around how each firm assesses quantitative literacy.

Case interviews. Management consultants were the only employers to indicate that they use the "case interview method[2]" to assess candidate's quantitative ability. A partner at a leading consulting firm said that the purpose of the case interview is to "look for good problem solving skills" and "test one's ability to structure business problems into manageable, trackable components, then to take each one and apply analytical and quantitative rigor to determine solution for each component and then apply business judgment and good conceptual thinking to draw implications."

A financial services consultant agreed. "The primary way we assess the quantitative/ analytical/math skills of entry-level job candidates with a bachelor's degree is through two rounds of case interviews. … Yet we try not to get too technical on our interviewing to avoid favoring economists and engineers."

In 2002, McKinsey and Company gave written materials to job applicants to explicitly describe the importance of quantitative literacy. One of the four objectives of their case interview is to identify a person with good problem-solving skills, or in their words, one who "[r]easons logically, demonstrates curiosity, creativity, good business judgment, tolerance for ambiguity, and an intuitive feel for numbers." See the McKinsey statement in its entirety in Appendix I.

No formal screening?. At the other extreme, we discovered that several banking firms have minimal official screening for quantitative ability. For example, an operations division manager at a leading Wall Street investment bank told us, "In my side of the organization we tend not, in the US, to focus on quantitative assessment during interview—but that may change." (They do in Europe.) An investment banker said, "I found my interview experience similar to most investment banking interviews: no formal case-based interview questions, and no formal tests to assess my math skills. However, in every interview, I received a question like, 'Consider company X in industry Y. What metrics would you use to measure the value of the company?'"

Spreadsheet skills. Only one employer mentioned MS-Excel. In a division of Standard and Poor's, "[m]ost of the interviews aren't really that structured. Almost all of our work is done in Excel so we base a lot of our questions on that." She explained that they screen

[2] What is a case interview? You can read more at an authority on the subject, www.Vault.com (search "case interview").

for a candidate's working knowledge, asking for details about knowledge of specific Excel functions and shortcuts.

Alumni Perspectives

MS-Excel. One could argue Excel is a "tool" for quantitative analysis, and perhaps beyond the scope of the task force. However, the response about Excel was so strong and consistent that it motivated a study of what Excel training is available. See Appendix VIII, "MS-Excel at Baruch: Undergraduate Instructional Offerings and Recommendations for Improvement."

Many alumni and students mentioned the need for more intermediate and advanced Excel training. An operations management major from the class of 2008 said, "The quantitative skill we need most is MS-Excel—pivot tables, the WhatIf and SumIf statements, macros, vlookups, etc. I was tested on these skills in a recent interview for an asset management position. This is simple working knowledge, but I never got it in any Baruch class. The SimNet test and tutorial [for teaching MS-Excel] provided at Baruch is horrible."

Students suggest that Excel be integrated more deeply across the curriculum. For example, a finance major hired by Unilever said, "Baruch needs to make Excel more built into the classes we already take."

Brain teasers. Roughly half the students told us that their interviews involved questions commonly called "brain teasers." Examples include: How many gallons of white house paint are sold in the US every year? What is the size of the market for disposable diapers in China? Three alumni independently recommended a chapter in the *Vault Guide to Finance Interviews* (7^{th} ed., Vault, Inc., 2008, p. 133) on "brainteasers and guesstimates."

QUANTITATIVE EDUCATION AT BARUCH

We do not describe exhaustively all of Baruch's quantitative courses but rather focus on some important courses and their expectations. We also examine support outside of regular courses.

Weismann School of Arts and Sciences

Mathematics courses. CSTM 0120 focuses essentially exclusively on elementary algebra needed for future courses and not on graphs or other quantitative literacy skills. Students who take CSTM 0120 either do not succeed in later math courses or have already learned the material that CSTM is supposed to cover. MATH 1030 is focuses on algebra and is intended to prepare students for all courses at Baruch that use algebra. MATH 2003-2205 is a two-part pre-calculus and calculus sequence. MATH 2207 is a calculus course for students who meet pre-calculus requirements in other ways, including transfer students. None of the courses has much focus on broader quantitative literacy skills. Appendix V has much further detail on these mathematics courses and student performance in them.

Pre-calculus and calculus courses are carefully organized and largely follow standard formats. We learned about student and faculty perspectives on these courses from surveys and focus groups of students done by SEEK, discussions with SEEK representatives, and brief discussions with a convenient sample of math faculty. Many failing students feel pre-calculus and calculus courses cover too many topics. These students feel that when they are presented with too much material they can not learn any of it particularly well. They also feel that not enough class time can be devoted to review. Many students, at many levels, are frustrated by the math courses.

Some faculty felt that courses are so tightly organized that if all the required items in the syllabi are covered, little time is left to go over topics that have been presented previously, present any other topics of interest, or study any topic in depth. In order to prepare their students in classes with uniform finals, instructors sometimes rush through the necessary material, covering a new topic every class. Consequently, those instructors feel unable to take time to give more challenging examples or show how the material is applicable to problems that students will encounter in other courses. Time constraints sometimes limit the number of student questions that can be addressed during classes. Problems arise if the instructor is unavoidably absent and his class can't be covered by another professor. Responding to these perspectives, several more elementary (pre-calculus) math classes have already been streamlined: material that some consider important has been eliminated from the curriculum but the sense of covering too many topics persists.

Other quantitative courses in Weismann. We spoke to several members of the Natural Sciences Department to learn what is needed in quantitative courses. Genetics requires algebra and basic probability and statistics. Physics requires fluency in manipulating fractions, algebra and trigonometric functions. In order to balance equations in chemistry, students need familiarity with basic algebra. Several faculty felt that students had significant “math anxiety” and a lack of comfort with the quantitative skills needed, even among students who had the basic knowledge. Social science classes, particularly psychology, also require reading of graphs and basic descriptive statistics.

School of Public Affairs

The School of Public Affairs (SPA) has a very small undergraduate program at present, although both the college and SPA plan to increase it. The undergraduate program was redone and the transition to the new requirements began in 2007-2008. The course PAF 3401 (Quantitative Methods for Policy and Practice) uses cases and substantive Excel exercises and was taught for the first time in Spring 2008. The new course does a good job of teaching quantitative literacy but students generally come in with little preparation. The economics for policy analysis course provides training in graphs and analytical thinking. STA 2000 is a requirement.

Zicklin School of Business

We asked a convenient sample of instructors across as many disciplines as possible what mathematical concepts the students should know.

Introductory statistics. One of the first quantitative courses students will encounter from the Zicklin School is Statistics 2000, Business Statistics I. To succeed in this course, students need the following skills: high-school-level algebra; proficiency with a hand-held calculator to perform multi-step calculations, and an understanding of the order of operations; the ability to graph functions; recognition of subscript and summation notation; and the ability to work with different units of measurement. While not required, comfort with basic set operations (e.g., unions, intersections, Venn diagrams, etc.) and basic counting rules (permutations and combinations) aid students. Instructors also expect basic data entry and spreadsheet skills (such as basic functions and cell-referencing methods). The *de facto* prerequisites for the course are MTH 2003 and the SimNet computer-based Excel exam, described briefly in the Excel section.

According to its course description, STA 2000 covers the following topics: descriptive statistics, the normal distribution, sampling distribution of the mean, estimation (confidence intervals) for means and proportions, hypothesis testing for one and two groups, regression and correlation, and control charts. In reality, instructors are unable to cover all of these topics in one semester. Control charts are often dropped. Many instructors only cover simple linear regression (one predictor) and only for a few classes. Those instructors who cover multiple regression (multiple predictors) do so only briefly.

Probability is not part of the official course description, but most instructors cover the basics of probability (e.g., basic probability rules, expected values, and variances). Some discuss the binomial distribution.

Finance 3000. The Principles of Finance (FIN 3000) is part of the core curriculum at the Zicklin School and is required for all BBA students. Further, it is a prerequisite for all further finance courses and provides students with a rigorous introduction to the fundamental principles of finance. The primary concepts covered include the time value of money, principles of valuation and risk, and the nature and characteristics of domestic and international financial securities and markets. Specific applications include the valuation of debt and equity securities and capital budgeting analysis. Prerequisites are ECO 1001, ECO 1002, STA 2000, and ACC 2101. To succeed in this course, students need to be very comfortable with mathematical concepts such as probability, solving equations, and understanding and plotting functions.

Expectations in upper-level business courses. For admission to Zicklin, students must pass at least one calculus course (MTH 2205, 2207, or 2610). Therefore, instructors in the 3000-level business courses assume that their students know how to differentiate, integrate, optimize simple univariate functions analytically and calculate the area under a curve defined by a function.

Similarly, those instructors expect statistics skills covered in introductory statistics. However, they also expect students to know the basics of probability including the definition of random events, basic probability rules, conditional probability, expected values, and variation, even though those topics are not in the official STA 2000 description. These faculty members would also like students to know probability distributions, in addition to the normal distribution, that are commonly used for modeling business phenomenon; including the Poisson distribution, the binomial distribution, and the exponential distribution. Faculty members would like to discuss simulation, an important tool in business, but it is not taught in any official course. Multiple regression is an important tool for business. Only students who major in finance, economics and accountancy are required to take courses that include multiple regression. Thus, there are many skills that faculty at the upper level expect students to have or would like students to have, but often there is no clear point in the program at which students would gain such skills.

Further quantitative requirements. Zicklin recommends (but does not require for all students) either MGT 3000 or OPR 3450—operations research courses and even further courses. The Baruch handbook notes for those seeking to become accountants that "to satisfy New York State CPA licensing requirements, public accountancy students must include LAW 3102, OPR 3300, and an advanced finance elective in their programs as free electives."

Comparison with other business school requirements. Quantitative prerequisites to enter Zicklin are introductory statistics and calculus, as noted before. To compare Baruch with other programs, we examined a systematic sample of 13 schools ranked ahead of Baruch on the *US News & World Report* rankings of BBA programs. One school's requirements matched those of Baruch. Three schools had the same two courses but more intensive versions. The remaining schools had more quantitative requirements. All programs require at least one calculus course and at least one statistics course. Some schools require a second calculus course, some require more coursework in statistics, some require a probability course taught by mathematics departments, and some require coursework in operations research.

Pre-business calculus requirement. The calculus prerequisite for Zicklin is controversial and condemned by some. We addressed this issue with many of those that we interviewed, with some we spoke with individually outside the committee, and amongst ourselves.

Some regard the failure and withdrawal rates in the calculus courses and other math courses as too high. Pass and withdrawal rates of freshmen and new transfer students in their first math course taken at Baruch College during fall 2007 are shown in Table 4. Freshmen had a higher pass rate and a lower withdrawal rate in their first math course at Baruch College than both groups of new transfer students. New transfer students from 4-year institutions had a higher pass rate and a lower withdrawal rate than new transfer students for 2-year institutions. This analysis suggests that freshmen may be more prepared than new transfer students for math courses at Baruch College and that among new transfer students those from 4-year institutions are more prepared than those from 2-year institutions. Thus, some of the problems students have with Baruch's math courses can be attributed to weak mathematical preparation prior to attending Baruch.

TABLE 4: Fall 2007 Cohort Pass and Withdrawal Rates of First Math Course by Admissions Type

Admissions Type	**N**	**Pass Rate**	**Withdrawal Rate**
Freshmen	1,304	69.6%	16.6%
New Transfer Students (2-Year Institutions)	434	53.0%	20.0%
New Transfer Students (4-Year Institutions)	307	60.9%	17.3%

Even for freshmen, who have the relatively high math scores described earlier, only about 70% of students pass their first math course. The high failure and withdrawal rates of the calculus courses fuels the controversy about the calculus prerequisite.

Those who object to the calculus prerequisite contend that calculus is not important for all Zicklin majors and that students could become fully qualified in subjects such as accounting or marketing without calculus. They stress that other, less technical and advanced quantitative skills are what most business majors require. To some extent, this perspective is vindicated by our findings about what employers want and by the academic literature.

However, others counter with several arguments supporting the calculus prerequisite. First, the notion of optimization is central to all areas of business. Task force members from Zicklin, and other Zicklin faculty, felt that optimization (a significant portion of calculus) should be mastered by all business students. Second, the calculus prerequisite is critical to the prestige of Zicklin. A systematic sample of 13 schools ranked ahead of Baruch in the US News & World Report rankings of BBA programs found that all of them had a calculus requirement. Third, Zicklin needs some way to screen candidates for quantitative ability and deny admission to those not meeting their standard. A rigorous math course is the only currently available option for that purpose. Finally, most MBA programs have calculus as a prerequisite and our undergraduate degree should prepare students for graduate study.

Further Support for Quantitative Education: SACC, SEEK and On-line Resources

Baruch has some excellent outside-the-classroom resources for students.

SACC. The Student Academic Consulting Center (SACC) provides a variety of teaching support services to undergraduates. In particular, they have an extensive program of tutoring and workshops, the majority focused on pre-calculus and calculus courses. More advanced undergraduates, with careful training and supervision, provide tutoring and a variety of workshops. Professor Judy Broadwin provides workshops every two weeks for all tutors coordinated with what the math classes are presently covering and is available in person once a week and always by e-mail to assist tutors. The tutors not only provide good instruction, their mathematical skills are extended and reinforced while their teaching skills are developed. We were tremendously impressed with how well run SACC is and the superb job done.

SEEK. The Search for Education Elevation and Knowledge (SEEK) program provides a variety of support services for students from economically disadvantaged backgrounds. SEEK offers its students private tutoring and supplemental instruction in math (group tutoring associated with Algebra, Precalculus and Calculus in which students can ask questions and review material covered in class). It has been effective and has become an innovator in working with students. At this point in time, SEEK students pass math at higher rates than non-SEEK students—a huge feat since they enter Baruch with weaker skills. The SEEK program and its recent innovations are described more extensively by its director of academic support, Jill Rosenberg, in Appendix VI. As with SACC, we were very impressed with SEEK.

On-line resources at Baruch. SACC provides videos of math instruction for the main calculus and pre-calculus courses, available at www.baruch.cuny.edu/sacc. The library has also assembled several instructional videos, including one for reading financial statements (www.baruch.cuny.edu/tutorials/statements). There is a pilot program in various information technology skills from BCTC (www.baruch.cuny.edu/bctc/training/etraining.htm).

RECOMMENDATIONS

As we have seen, while Baruch College provides strong quantitative education for our undergraduate students in many ways, we also fall far short of the best-practice in quantitative literacy. In this section, we describe our recommendations to improve quantitative education at Baruch.

Coming up with these recommendations has not been easy. We could describe where we wanted to be in the long term. But for every suggestion our committee came up with, we immediately saw many barriers, including many we had seen or experienced ourselves. Time—both faculty time and student time—was always the biggest barrier. Because the barriers are so critical to our choice of recommendations, we have no separate section on barriers but integrate that discussion into the recommendations.

Creation and/or purchase/adaptation of materials with oversight committee. Improving quantitative literacy amongst Baruch students would require emphasis on teaching in ways that would encourage students to think analytically. That is, not just learn the material to pass the course, but understand the fundamentals. To facilitate this would require a change in teaching materials and methods. More intensive assignments that require writing must be created and graded. The principles for the materials are described in Table 2; they include word problems, reading and interpreting technical material, writing about quantitative material, fewer topics with greater depth, applying same techniques to different applications, and Excel applications.

All these tasks are extremely time-consuming for faculty, who are already very busy. If we expect faculty to adopt these practices, they must be supported in order to make such practices somewhat less time-consuming. Offering faculty lectures, assignments, tests, classroom activities and “lesson plans” at least partially reduces the burden, making adoption of these practices more likely. Such materials are particularly important to adjunct faculty, who receive little pay for each course. Further, training workshops need to be organized with good teachers leading the discussions to show examples of how the lecture can be conducted to make the students think and understand more of the material.

Therefore, we propose allocating funds for the creation or purchase and adaptation of materials consistent with the best practice that we describe. In some cases, off-the-shelf materials developed commercially or at other universities are available and there is no need to reinvent the wheel. However, in those cases, faculty time would be needed for selection, adaptation and training. Adjunct faculty would need to be paid for training. Some release time would be needed for full-time faculty. In other cases, new materials would have to be developed, obviously requiring faculty release time.

However this is done, it will be important to conduct the process so that faculty “buy-in.” Faculty buy-in is particularly enhanced when those faculty with greater status (e.g., due to research prestige or other attributes) take a leading role and express clear interest in the process.

On the one hand, we want to provide departments maximum flexibility in choosing which courses to focus on, how to approach this and so on. On the other hand, it is critical that all materials truly fit with the best-practices described. We propose offering each department a budget of funds, available for any mix of release time and direct funding. However, each department’s plans, initial choices and end products are subject to approval by a college-level quantitative literacy oversight committee. Obviously, this means that we also recommend the creation of such an oversight committee.

Addressing all courses and all programs will obviously take many years. Even after all course content has been worked on, revisions and improvements should continue into the indefinite future.

Homework graders. The kinds of assignments and tests that we propose are much harder to grade than more mechanical kinds of problems. To make it possible for all faculty, including adjunct faculty, to give these kinds of tests and assignments, we propose funding for homework graders. These graders could often be more advanced undergraduates or masters students. Teaching more advanced students how to grade substantive questions would be valuable learning for those students. The training that SACC currently provides to its tutors provides an excellent model for training graders.

Pre-business mathematics courses*:* calculus. Those arguing for and against the calculus prerequisite for all Zicklin majors have valid points. We recommend retaining a calculus prerequisite for Zicklin but strongly recommend changing its form. It should cover far fewer topics, with a greater emphasis on applications. Optimization would be central and the basics of differentiation, as well as some integration would be included, but many standard parts of a calculus curriculum could be replaced by applications, including difficult word problems that require students to formulate the calculation themselves. The Arizona Mathematics for Business program (business.math.arizona.edu/MBD/mbd.html), described in Appendix V, provides one example of the kind of curriculum that could replace the current calculus course. Appendix V describes further how the calculus courses could be modified and discusses the Arizona program further.

The central role that calculus plays as a business school prerequisite suggests that Zicklin faculty must be involved in every aspect of the course reform. Both Zicklin and mathematics faculty, together, should reform the pre-calculus and calculus curricula and select and/or create materials. Indeed, it may make sense to have some courses taught by Zicklin faculty or taught collaboratively by Zicklin faculty and mathematics faculty. (Obviously, the Zicklin faculty qualified to do this will be those in the more mathematically oriented subjects, such as finance, statistics, economics, operations research and so on.) Inviting the finance professor, Christopher Lamoureux, who was the co-developer of the University of Arizona math for business program might be a good way of interesting and involving Zicklin faculty. Having all or most of those who select or create the materials also teach the courses creates particularly well aligned incentives and opportunities for each part of the process to inform another.

Care must be taken not to introduce too dramatic a change too suddenly. All faculty cannot suddenly learn to teach different material in a different way. Change should be introduced gradually. Perhaps two new sections could pilot the new program, with more and more sections transitioning over a few years. Such gradual transition allows opportunities to improve the new courses. We recognize that changing the focus on the basic calculus course will have ramifications for more advanced courses and that some majors might need to require an additional mathematics course.

Precalculus and other elementary mathematics courses. Our general recommendations for quantitative literacy apply, of course, to mathematics courses that precede calculus. More specifically, and as described further in Appendix V, we recommend adding material on graphs and interpretation of data, while cutting out more technical applications at earlier stages. For example, CSTM 1030 could omit working with rational expressions, Math 1030 could be examined to determine which algebra topics are not required for more advanced courses.

While we recommend that all mathematics courses incorporate our recommendations for broader quantitative literacy, one or two mathematics courses cannot do everything. They certainly cannot alone make up for earlier education problems. Moreover, even the best prepared students would need quantitative skills taught and reinforced across the curriculum, not just in one or two mathematics courses. Quantitative literacy is far broader than mathematics and cannot be taught solely in mathematics courses.

Textbooks and other materials. Textbooks and other materials should be selected based on the principles described above. Every course should have a let of learning goals. A rubric for evaluating textbooks should be created based on those learning goals and the best-practice principles we describe (such as the Rule of Four). Departments and individual faculty should create lists of all the widely used textbooks (and any others of interest). All the potential books on the list should be evaluated using the rubric.

Excel. First, Excel training**—**training in the narrow skill itself**—**should be strengthened. Students should be made aware of the advanced training options available now, the CIS courses and on-line materials described before. As needed, the extent and form of such training could be expanded. However, it is often easier and more effective to learn technology, whether Excel, a statistical package or a graphing calculator, while using it in a substantive way. Therefore, we expect a certain amount of Excel training (and training in other such software) to be integrated into classes. That strategy also fits with our second and more important recommendation: Integrate Excel exercises into many quantitative classes. We recommend that as many courses as possible have substantive Excel exercises as part of regular assignments.

Excel training for faculty. Extensive substantive spreadsheet exercises would provide important training for our students in the workplace. One barrier is that some faculty are themselves not particularly qualified in Excel. We should provide training and support for faculty in a way that is valuable to them. That training and support could focus on relevant teaching exercises, thereby making it relevant to the faculty.

Labs. Like Excel, statistical software, graphing calculators and simulation software for operations research are widely used technologies to answer quantitative questions. As for Excel, learning the technique is valuable but applying the tools in substantive applications in the most important thing. In addition to the relatively short applications we recommend for many courses, we recommend particularly meaty applications that would require labs as part of the courses.

One model is the introductory statistics sequence at Carnegie Mellon University. All students in the social sciences are required to take a two semester sequence of statistics. In addition to lectures, each course has a single 50 minute lab session run by two graduate students and one undergraduate student. Each lecture class of 250 students is split across 10-15 lab sections. In the lab session students are given a single real-world problem to analyze with statistical software. The lab handout walks the student through the steps required by the software, but interpretation of the results is left to the student. The three lab monitors are there to help with the software and interpretation of the results when necessary.

There are a number of courses in the Baruch curriculum that would lend themselves to such a lecture-and-lab model, e.g. STA 2000, STA 2100, ECO 4000, and OPR 3300. For a course like STA 2000, where there are approximately 600 students every semester, we would need to have approximately 15 sections of the lab component of the course, assuming each lab could handle 40 students. Finding times and labs that would accommodate such numbers might be problematic.

At Baruch the labs could be led by adjunct faculty, PhD students, or Masters level students; Undergraduate students could be hired through SACC or through a separate program. Fifteen labs would require 45 hours of work by this set of instructors/assistants. If the two lead lab instructors are paid at adjunct rates, the cost might be prohibitive.

Other support services. SEEK and SACC are both excellent programs that should be supported and expanded. SACC's model of training undergraduate students to teach newer students enhances the education of those teaching as well as those learning. On-line resources such as videos and software tutorials should be expanded. The work, family and commuting burdens of our students should be taken into consideration when choosing what resources are developed. For example, resources that can be used while commuting on the subway are of particular value. Audio pod-casts, audio pod casts accompanied by flash cards and perhaps video pod-casts may be easier for students to use than resources that require being on-line. We also recommend greater outreach to make both students and faculty aware of what resources, including on-line resources, area available.

Forums aimed at psychological influences of students. We recommend providing opportunities for students to learn about psychological factors that contribute to successful learning of quantitative skills and the achievement of quantitative literacy. Relevant topics include

a. Malleability of intelligence
b. Effective effort
c. Importance of contributing to a community of learners
d. Reattribution training
e. Goal-setting
f. Costs and benefits of learning and performance goals
g. Overcoming stereotype threat

Because research has shown that each of these topics has the potential to significantly impact students' learning and achievement, it is important that students delve into these topics early in their academic careers. Thus, we recommend that these topics be discussed in the following contexts.

First, freshman orientation sessions could be constructed to deliver the core messages within each of the aforementioned topics. To support the introduction of these ideas, the orientation materials should include a binder with readings and exercises that support the core topics. Second, because Baruch's population includes a significant number of transfer students, similar sessions and binders should be created for use during Transfer Orientation.

Third, because the core content draws heavily from the psychology discipline, these topics should become part of the syllabus for the Psychology 1001 course. Doing so would ensure that all Baruch students are exposed more deeply to these ideas. Currently, these topics may be presented within PSY 1001 at the discretion of the instructor. However, there are few readily-available resources for psychology professors to draw from; thus, we recommend the creation of lessons, lesson-plans, and classroom activities to support the teaching and learning of the important psychological constructs.

Fourth, we recommend an elective course within the psychology department for students who wish to read and discuss the primary research upon which these topics are based. A preliminary version of this course is being developed and will be offered during the spring 2009 semester (see Appendix IV for the course description).

Fifth, because academically disadvantaged students may be particularly vulnerable to poor quantitative literacy skills, we recommend targeting this population. Because the SEEK program serves this population, the summer SEEK program provides an ideal forum in which to expose academically disadvantaged students to these ideas. Currently, a randomized-control study is being conducted to investigate whether exposing SEEK students to key topics (such as the malleability of intelligence) can positively impact their achievement at Baruch. If this pilot study is successful, we recommend expanding the population that receives this information beyond the SEEK program.

Faculty seminars for improving psychological aspects of learning environment. Because the classroom environment can go a long way toward supporting or undermining these ideas, it is important to reach out to the faculty and instructors who teach Baruch's students. Thus, we recommend the development of faculty seminars to teach them methods of creating classroom environments that are optimal for students' learning of quantitative skills. For example, topics in the faculty seminar would focus on methods of teaching from and conveying the idea that intelligence is a malleable quantity, especially as it relates to quantitative skills.

A particularly important area for faculty development is a focus on teaching incrementally. As described in Appendix IV, students who hold the view that intelligence is a malleable trait often do better than those who view intelligence as a fixed trait, especially when faced with challenging material. Creating a learning environment and academic culture that supports the malleable view not only exposes more students to the malleable idea, but also reaffirms and supports that view to the extent that students already hold it. Teachers hold the key to creating a learning environment that supports the idea that all students can get smarter. Thus, we propose creating materials and seminars that support teachers' efforts to create learning environments that convey the idea that all students can learn and increase their intelligence, particularly within quantitative skills. Such seminars could be particularly targeted towards faculty in quantitative subjects.

Interview training. Students should receive training on case interviews and brain teaser interview questions. Most business schools accomplish this through online resources, seminars by career counselors, and library materials.

Involving employers in course design. Our task force interviewed some particularly desirable employers to learn their priorities in quantitative skills. However, relevant skills could vary by major. It is also important that faculty who design, teach and approve courses and major requirements really know and accept employer perspectives. Therefore, we propose meetings between employers and faculty in each department. For each major several employers should be singled out. An administrator and appropriate members of the academic department involved should then arrange to interview the relevant representative of the employer (perhaps over lunch) in order to ascertain what skills were most desirable and what the greatest weaknesses of new employees were. After the interviews, a discussion should take place with regard to changes that might be made in the major courses. It is important that departmental representatives be involved in the process since changes can only take place with the cooperation of the department.

Quantitative literacy exam development. With all endeavors, good outcome measures are valuable. Presently, as described in Appendix VII, we have no tests measuring quantitative literacy. Ideally, we would have a good measure for incoming students, a good measure for students finishing lower division and applying to measures and a good measure for graduating students. The measure would allow for major-specific standards for both admission and graduation. That is a tall order, although it is certainly a worthy goal for the next few decades. In the somewhat shorter (but still long) time horizon, we recommend an exam to be administered just prior to junior status. Separate scores for different aspects of quantitative and mathematical literacy so that it could serve to establish prerequisites for some majors and also identify the specific weaknesses of students.

The exam could serve as a replacement for Task 2 of the CUNY Proficiency Examination (CPE). Given the tremendous resources involved in developing such an exam, this should be a collaborative venture with other CUNY colleges or even a wider group. Once an exam is developed and validated, it could be used for many purposes, particularly judging our success at teaching quantitative literacy.

Some means of providing help to students who do not meet the minimal requirements desired as well as to those students who do not meet the requirements of a particular major should be established. Online tutorials and assistance by tutors in the Student Academic Consulting Center (SACC) should definitely be possible options. The possibility of establishing a quantitative literacy course that does not satisfy the core requirements (except perhaps for some liberal arts majors) should be considered.

As noted, this task will need many partners. Ideally, it could be a national exam. Two possible avenues to explore in this regard are the following. The ACT Compass test that is currently used for placement would have to have its first subtest substantially changed in order to adequately test quantitative reasoning. This possibility should be explored.

Another possibility is the Maplesoft Placement Test. Its first test is most closely aligned with quantitative reasoning skills. Some adjustments would be needed to provide sub-scores. It is a possible alternative to using the ACT Compass test for placement. The last possibility is to explore development of a test either locally or in conjunction with other CUNY colleges. Funding for such an enterprise might be possible, especially if the exam were to be made publicly available without charge.

Priorities. We have given many recommendations. Some will take many years to implement fully. Some will take significant funds; others will not require substantial outlays. We feel compelled to provide priorities for what should be started with some sense of urgency. Starting the process and machinery for creation and/or purchase/adaptation of materials with an oversight committee is our foremost recommendation. Among all the departments and courses, we feel that making pre-business mathematics curriculum more focused on quantitative literacy is one of the highest priorities. We also feel that it is critical that all future decisions on textbooks and other materials take into consideration our recommendations. Finally, we also recommend moving quickly on some of the psychological forms as this could be done with comparatively little disruption and funding.

THE LONG VIEW

Quantitative literacy is not something obtained quickly or easily in just a course or two. For both individuals and organizations like Baruch, the road is inevitably both long and difficult. Our recommendations are extensive and ambitious. Nonetheless, we feel that they are feasible. We look forward to engaging the entire Baruch community in this endeavor.

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APPENDIX I: INTERVIEWS WITH STUDENTS, ALUMNI AND EMPLOYERS ABOUT QUANTITATIVE LITERACY

Task Force member Will Millhiser conducted 15 interviews with employers and young alumni in Fall of 2007. He asked two questions:

1. What analytical, quantitative and/or mathematical skills do Baruch students need most?
2. How do firms assess quantitative literacy (e.g., in interviews)?

The employers represent members of the banking, financial services and management consulting communities of NYC, that is, world-class companies for whom Baruch students might aspire to work. The student respondents are those who have accepted full-time positions starting by summer 2008. Most alumni and students are BBA majors in the Zicklin School. This appendix contains excerpts from the text of 15 interviews.

What Students Need: Employer Perspective

Partner, leading management consulting firm:

> We look for good problem solving skills. We test for that through case interviews. These allow us to (1) test one's ability to structure business problems into manageable, trackable components, then (2) to take each one and apply analytical and quantitative rigor to determine solution for each component and then (3) apply business judgment and good conceptual thinking to draw implications of 1 and 2. Traits that do well is facility with numbers and ideas, ability to set up disparate information into a solvable structure (much like setting up equations in math), and creative thinking that would allow one to get to an answer even with no if industry background with case analyzed.

Operations division manager, leading Wall Street investment bank:

> We interview people on a competency basis; that is to say we look for peoples' experiences that line up with several agreed-upon competencies: teamwork, leadership, technical ability, etc. We ask them questions that are geared to elicit what the candidate themselves actually achieved, or did, in the chosen experience and we try and drill through generalizations like, "I was part of a team that did this..." or "we achieved that in a record time..." We try and get to the specific skills that the candidates themselves have demonstrated.
>
> In my side of the organization we tend not, in the US, to focus on quantitative assessment during interview---but that may change. In Europe, we add group reasoning exercises on top of the competency-based interviewing for instance, as well as some industry standard psychometric tests. These tools have not yet been introduced here in the US.

Job manager, leading financial services management consulting firm:

The primary way we assess the quantitative/analytical/math skills of entry-level job candidates with a bachelors degree is through two rounds of case interviews. That is one or two on campus interviews and two on-site interviews, if they make it through the first round. In addition there is a fit interview to assess personality traits, talk about the company's culture, etc.

In terms of quantitative literacy, we seek the following skills:

- Structuring capabilities - how to break down a problem to solve it
- Understanding of how the world works - concepts like time value of money, probability, pricing, fixed vs. variable costs, etc. are a must
- Response to pressure - new hires need to look confident in front of clients
- Comfort with numbers - an ability to identify relationships between numbers and validate results when solving a business problem

Yet we try not to get too technical on our interviewing to avoid favoring economists and engineers.

Senior research assistant, Standard and Poor's:

Most of the interviews aren't really that structured. Almost all of our work is done in Excel so we base a lot of our questions on that. We don't have a set base of questions. We'll ask the candidates what they have done in Excel and how familiar they are with it. ... We will ask what the most complicated functions they have done or what their favorite shortcut in Excel is. We've started to think about putting a laundry list of functions to do in Excel together for a candidate to do for us. It would be a better way to test.

Investment banker, Credit Suisse:

We hire undergraduates every year into a two-year analyst program. I found my interview experience similar to most investment banking interviews: no formal case-based interview questions, and no formal tests to assess my math skills. However, in every interview, I received a question like, "Consider company X in industry Y. What metrics would you use to measure the value of the company?"

Form letter to management consulting job candidates, McKinsey and Co., circa 2002 (reproduced without permission):

We are looking for fantastic people who demonstrate the ability to listen, process information, think creatively, and clearly articulate ideas. Through a number of different exercises we will assess your capabilities in problem solving, impacting others, building relationships, and achieving.

- Problem solving: Reasons logically, demonstrates curiosity, creativity, good business judgment, tolerance for ambiguity, and an intuitive feel for numbers.
- Achieving: Sets high aspirations for self, expects and achieves outstanding results, handles obstacles well, shows signs of entrepreneurship and willingness to take personal risks.
- Impacting others: Positively influences others, shows an interest in other people, self-confidence without arrogance, listens, understands and responds well to others.
- Building relationships: Takes on leadership roles, seizes opportunities and takes action, helps to build highly effective teams with a shared vision, and is sensitive to the thoughts and feelings of other team members.

What Students Need: Student and Alumni Perspective

Operations management major, class of 2008:

> The quantitative skill we need most is MS-Excel—pivot tables, the WhatIf and SumIf statements, macros, vlookups, etc. I was tested on these skills in a recent interview for an asset management position. This is simple working knowledge, but I never got it in any Baruch class. The SimNet test and tutorial [for teaching MS-Excel] provided at Baruch is horrible. It should be banned.
>
> I recently received an offer at a risk management consulting firm. The interview was highly case based, with individual and group case questions (the group consisted of 4 candidates). The cases were standard for the consulting interviews; I would call them "brain teasers."

Finance major, class of 2008, hired as financial analyst at Unilever:

> Baruch needs to make Excel more built into the classes we already take. Also, pivot tables and V-lookups seem to be in demand. Yet, I have never learned what either function is. These two should be taught rather than, say, how to use the internet, in the mandatory info. systems class. Also, perhaps more papers can be required to be completed in Excel rather than Word or PowerPoint.
>
> I had three interviews and a case study. All questions seemed to be more behavioral rather than analytical. Each interview had its own theme. The first focused more on Leadership, the second on growth and teamwork and the last on thinking process, i.e. "How would you solve this problem?" The case study was more to see how you would interact with others (it involved four other people) and take their view on a matter and use it to benefit the entire team rather than just force your own view on everyone else.

Human resources major, class of 2008:

> In terms of [the skills I lack in] Math, I will need to do some research. …More business writing and business presentation courses are needed at Baruch.

Accounting major, math minor, class of 2008, accepted auditor position, KPMG:

> I love math. In the interview with KPMG, they asked me a lot of questions to see if I would be a good team player. To assess my quantitative skills, they asked me why I was interested in math. I guess my answer was good enough because they didn't ask any other questions. I feel that my training in math at Baruch was pretty good.

Finance major, class of 2008, hired for full time position at JP Morgan-Chase:

> The interview for my position (middle office/operations) was entirely behavioral questions [not quantitative]. However, for front office positions, the interview process is a rigorous 4 to 5 rounds. Round 3 tests the candidate's knowledge of finance, accounting and the stock market in general. I highly recommend the book *Vault Guide to Finance Interviews: Your single best resource for conquering finance interviews*[3], 6th ed. Bhatawedekhar & Jacobson, Vault Inc., 2005. It is a must have.

[3] In addition to the usual review of valuation techniques, equity analysis, stocks, mergers and acquisitions, the *Vault Guide to Finance Interviews* gives a chapter on "brainteasers and guesstimates" (p. 133). How many gallons of white house paint are sold in the US every year? What is the size of the market for disposable diapers in China? How many square feet of pizza are eaten in the US each month? How would you estimate the weight of the Chrysler Building? Why are manhole covers round? If you look at a clock and the time is 3:15, what is the angle between the hour and minute hands? There are 14 more such examples in the text.

Former student, entrepreneur, class of 2007:

> This summer, I founded a company and hired 2 full-time workers as well as hundreds of freelancers. … Basically, neither quantitative/analytical/math skills are needed in a day-to-day job. All I keep focus on is to keep the company organized, goal oriented (sales forecast) and busy. Cash flow statement is important. Negative cash flow can kill us instantly.
>
> What I am looking forward to have from Baruch students is generally a friendly and open personality, good looks, energy, initiative and some analytical skills to compare things, find better outcome, avoid a mistake, choosing a better paying project, etc. I need people who can have a great vision, not just focus on some routine accounting tasks or operating efficiencies. I need people who can justify expense I am putting in them and bring more in return.

Finance major, class of 2008:

> The course which I believe was most useful for teaching Excel skills is CIS 2200. We did some extremely basic things like defining what the cell is (!). It would be helpful to re-fresh our memories or learn more about advanced Excel applications. ... ECO4000 was a great course which emphasized logical and analytical thinking.

Finance major, class of 2008, hired full-time by a major investment bank:

> The interview process for front office is very rigorous. In addition to behavioral questions, they certainly have case-based questions, which are known as “brainteasers.” Example: “How many taxi cabs are operating in NYC?”
>
> Moreover, they will also ask the candidate to walk them through the Discounted Cash Flow model and comparable (comps) analysis. (investment banking related) Other questions include: “How are the three components of financial statements interrelated?” (accounting-related) “Can you pitch me your favorite stock?” (equity research related) “What would you invest in with $100,000?” (asset management related) “How do you price options/bonds?” (sales and trading related)
>
> I never asked my employer about what quant skills that Baruch students lack, but what I’ve heard from some professionals is that they lack TRUE understanding about the financial markets and how the industry operates. More importantly, the students lack hands-on experience in analyzing and projecting financial statements using Excel (referred as “financial modeling” in Wall Street). Other top undergrad business schools have offered such a course, including NYU and UPenn.
>
> The specific skills that I wish to pick up early are financial statement analysis and portfolio management skills. (This has led me to co-found the Portfolio Management Club). We need to realize that Baruch is not a core school for top investment banks, and therefore we truly need to develop more hands-on learning experience for students if we really want to climb the ranks. Keep in mind that we do have incredible aspects that many other top schools do not have such as the Subotnick Center trading floor and proximity to Wall Street.

Finance major, math minor, class of 2008, analyst in a private asset management company:

[In my interview,] I was asked more quantitative than straight finance questions; however they were finance-related. I had a very short test, almost verbal. ... they asked “knowing a monthly Sharpe ratio, how to calculate yearly Sharpe?” … This simple question covers both knowledge of financial concepts, and basic understanding of statistics.

Students who are interested in more quantitative jobs in finance should take 2 classes in statistics. … From what I noticed, many students forget simple concepts ... because what they are taught is plugging numbers in formulas ... A cook-book style is good for solving simple problems, but not for more sophisticated applications. Students must understand that introductory statistics that they take will come back in various forms in other classes.

Also, standards are different in many colleges. There are many transfer students who have statistics listed in their transcript, however don’t have enough understanding… An entrance exam would be very useful.

To my disappointment I happened to have some finance professors who seem to be quantitatively illiterate… With all respect, if a professor uses mathematical notation, one has to a) understand its meaning and b) be able to explain correctly to his students what it means. Many students can’t understand the true meaning behind the formulas, and are doomed to memorize them without thinking. My suggestion is, professors must derive some formulas for students, and show where these the result comes from.

Probably [Baruch] students lack these skills:

- Using excel; students must take advantage of excel workshops held in our library. VBA [visual basic and visual basic macros in Excel] workshops (not offered) would be useful too.
- Using regressions; students must pay more attention to that in Statistics, Operations Management, Econometrics and Introductory Investment Analysis.
- Understanding where to get data and what data to use. Given numbers, students know how to plug these. The question is, what numbers to plug?
- Lots of credit goes to professors who use case studies and real-world data. Example: given a sample of data with interest rates for T-bills and T-bonds of different maturities (including historical rates and current rates) which rate to choose as a risk-free rate in CAPM (capital asset pricing model).
- Ability to solve percentage problems. Other than that, entry-level positions don’t require much math.

For people interested in highly quantitative jobs in finance (such as risk managers, quantitative analyst, quantitative developers etc) I would recommend 1) *Heard on the Street: Quantitative Questions from Wall Street Job Interviews* by Timothy Falcon Crack, 2) *Frequently Asked Questions in Quantitative Finance* by Paul Wilmott.

APPENDIX II: OTHER COLLEGES' QUANTITATIVE LITERACY

By Laurie Beck, Assistant to Task Force and Candidate in Master's of Higher Education Administration

Listed below are examples of how colleges and universities across the country are addressing the issue of quantitative literacy or reasoning. Some schools have instituted quantitative literacy (QL) or quantitative reasoning (QR) graduation requirements. These schools require completion of certain courses or a satisfactory score on a QL qualifying examination. Many of these schools also have QL centers or programs that offer QL-specific workshops, study groups, tutors and on-line tutorials. Some schools with QL graduation requirements do not offer specifically identified QL support services. Still other schools provide QL support services, and may even have a center or a program, but do not have QL graduation requirements.

An updated list of information on schools with QL programs is at http://www.stolaf.edu/people/steen/Papers/qlprogs.pdf.

It is important to note that different schools define QL differently. Some subscribe to a broad definition that encompasses a wide range of disciplines while others hold to a stricter definition that focuses primarily on mathematical ability. Examples are of the different models are listed below:

<u>Hamilton University, Clinton, NY – Graduation requirement; has Center</u>
Quantitative Literacy Center
Each student must demonstrate basic quantitative literacy by passing the quantitative skills examination offered during Orientation, passing a course having a significant quantitative/mathematical component or completing a non-credit-bearing tutorial through the Quantitative Literacy Center. The quantitative skills examination tests basic mathematical and quantitative knowledge, including computation, algebra, analysis of graphs and charts, and probability.

The Quantitative Literacy Center was established to offer peer tutoring in introductory level courses containing a mathematics/quantitative component. Students may drop in to review topics as needed, or use the resources of the computer and video library. Other programs offered by the Center include the non-credit-bearing tutorial for students who need to fulfill the Quantitative Literacy Requirement.
http://www.hamilton.edu/academics/resource/qlit/index.html

<u>Bowdoin College, Brunswick, ME – Graduation requirement; has Program</u>
Quantitative Skills Program
The Quantitative Skills Test is an assessment test given to all incoming students during Orientation. On the test, students demonstrate their current proficiency in four areas: Computation and Estimation, Probability and Statistics, Graphical Analysis and Common Functions, and Logic/Reasoning. The Quantitative Skills

Program Director analyzes the test results and shares them with academic advisors. Students are subsequently informed of their results, which then are added to the students' incoming portfolio of high school performance to form a basis for discussion and advising regarding possible future quantitative course selections. Beginning with students enrolling in Fall '06 (Class of 2010), the graduation distribution requirement requires one course in mathematical, computational, or statistical reasoning and one course of inquiry in the natural sciences.

Services provided by the Quantitative Skills Program include:

- Assessing first-year students' quantitative literacy
- Advising students, in coordination with academic advisors, regarding appropriate quantitative courses
- Establishing study groups for quantitative courses
- Providing individual tutoring, in coordination with the course department, for students in quantitative courses
- Offering supplemental support to quantitative courses, as requested by faculty

See: www.bowdoin.edu/qskills/index.shtml

Wellesley College, Wellesley, MA - Graduation requirement; no formal center or program

The quantitative reasoning requirement consists of two parts:
The basic skills component is satisfied either by passing the QR Assessment given during Orientation or by passing the QR basic skills course (QR 140).
QR 140 is a full-credit course that reviews algebra, geometry, probability and statistics, graph theory, and estimation. Fulfillment of the QR basic skills requirement is a prerequisite for many Wellesley courses, including all QR overlay courses.

The overlay component is designed to engage students in statistical analysis and in the interpretation of data in a specific discipline. Currently QR overlay courses are offered in economics, political science, sociology, education, psychology, astronomy, biology, chemistry, geology, mathematics, and philosophy. Students must satisfy the overlay component before graduation. It is recommended that students take their QR overlay course after they have decided on their major, as some majors require a specific overlay course. (See www.wellesley.edu/QR/questions.htm#first)

University of Massachusetts at Boston – graduation requirements; no center or program

Students will demonstrate the ability to reason quantitatively and use formal systems to solve problems of quantitative relationships involving numbers, formal symbols, patterns, data, and graphs.
The quantitative reasoning requirement is designed to enhance students' capacity...
1. to pose problems that involve quantitative relationships in real-world data by means of numerical, symbolic, and visual representations;

2. to solve problems, deducing consequences, formulating alternatives, and making predictions;
3. to apply appropriate technologies; and
4. to communicate and critique quantitative arguments orally and in writing.

Students may meet this requirement in various ways, but most will do so by taking specially designed courses (such as Math Q114).

- Students seeking a BA in CLA or CSM will most likely take Math Q114; alternate methods of satisfying this requirement include taking Mathematics 115 or 125; Economics 205; Psychology 270; Sociology 350; by placing into Math 129 or higher on the University's math placement test; or by receiving calculus credit through either Advanced Placement or CLEP test.
- Students seeking a BS in CLA or CSM will fulfill this requirement when they take Math 135 (Survey of Calculus) or Math 140 (Calculus I), or by receiving calculus credit through either Advanced Placement or CLEP test.
- Nursing students in CNHS are required to take a statistics course (Math 125, Economics 205, Psychology 270, or Sociology 350); EHS students in CNHS currently follow the rules listed above for students seeking a BA in CLA or CSM.
- Management students satisfy the QR requirement by taking Math 134 (Managerial Calculus).
- Students in CPCS complete the Understanding Arguments and Quantitative Reasoning competencies.

www.umb.edu/academics/undergraduate/office/gened/seminar_quantitative.html

University of Wisconsin at Madison (Graduation requirement; no formal center or program

General Education Graduation Requirements

Quantitative Reasoning, 3 to 6 credits

Part A: 3 credits of mathematics, statistics, or formal logic. Students may be exempted from Part A by approved college coursework while in high school or by testing.

Part B: 3 additional credits in quantitative reasoning. *Examples include:* Accounting Principles, Exploration of Solar System, Conservation Biology, Topics in Calculus I, Elementary Logic, Political Choice and Strategy, Stats for Sociologists I. Students cannot test out of this requirement.

www.ls.wisc.edu/gened/Students/default.htm

University of Washington at Bothell – No graduation requirement; has Center

Quantitative Skills Center

Primary goals are:

- Serve as a place for academic support in quantitative areas. This is achieved by providing tutoring, workshops, and classroom presentations.
- Act as a sounding board and encourage students, faculty and staff to "talk out" their quantitative ideas, techniques, and analysis.

- Provide evidence that any one can learn math by presenting resources and tools to faculty and students across all disciplines, cultures, and lifestyles

www.uwb.edu/qsc/about/mission.xhtml

Evergreen State College, Olympia, WA - No graduation requirement; has Center
Quantitative & Symbolic Reasoning Center
The QuaSR Center provides designated tutors to support academic programs with foci in mathematics and the sciences. These tutors dedicate 4-8 hours per week to working with a program. They can conduct supplementary workshops on prerequisite or support material, or they can assist faculty with program workshops. They are also available for four hours a week in the QuaSR Center to specifically help students from that program. The QuaSR has reference sheets available for a variety of subjects from chemistry to trigonometry. In these documents, the QuaSR staff has attempted to outline key processes, address frequently asked questions, and provide useful information at a glance.

Services for the faculty:
The folks at the QuaSR would like to...
Listen to your thoughts about including *quantitative & symbolic reasoning* in your curriculum.
Learn about you and the content of your course or program.
Discuss the importance of including relevant *quantitative & symbolic reasoning* in your curriculum.
Identify the *quantitative & symbolic reasoning* that is already present in your course or program and find ways to support you and your students.
Work with you to find meaningful *quantitative & symbolic reasoning* that can be woven into your course or program.
Collaboratively develop *quantitative & symbolic reasoning* activities and assessments for your course or program.
Provide designated tutors for programs that contain a significant amount of *quantitative & symbolic reasoning*.
Continually assess our work to ensure we are meeting the needs of students and your needs as faculty.
www.evergreen.edu/mathcenter/

Self-administered Tutorials to Improve QL Skills[4]

There are self-administered tutorials available to help students improve their QL skills. Some of these tutorials are created by universities and colleges and made available only to the schools' students while others are readily available on-line to everyone. Another, source of tutorials for students who need to enhance their QL skills are those made

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[4] In identifying tutorials, I am using the definition of QL that has been used by the committee – that is basic mathematical ability, including word problems, spreadsheets, solving equations, interpreting graphs, etc. I have not veered off into other related QL disciplines.

available for a fee from private vendors. Examples of self-administered on-line tutorials from other institutions include:

Temple University, Philadelphia, PA

Calculus on the Web (COW)

COW is an internet utility for learning and practicing calculus. It was designed at Temple by two members of the Temple University Mathematics Department, Gerardo Mendoza and Dan Reich.

The principal purpose of COW is to provide you, the student or interested user, with the opportunity to learn and practice problems in calculus (and in the future other topics in mathematics) in a friendly environment via the internet. The most important feature of the COW is that you get to know whether your answer is correct almost immediately. It is as if you had a tutor looking over your shoulder and helping you along as you work. This will be true no matter where you are or what computer you use, as long as it is connected to the internet and has a web browser.
http://cow.math.temple.edu/

West Texas A&M University, Canyon, TX

Virtual Math Lab

If you need help in College Algebra, Intermediate Algebra, Beginning Algebra, you have come to the right place. Note that you do not have to be a student at **WTAMU** to use any of these online tutorials. They were created as a service to anyone who needs help in these areas of math.
http://www.wtamu.edu/academic/anns/mps/math/mathlab/

Rice University

Rice Virtual Lab in Statistics

Examples of real data with analyses and interpretation

- Analysis of Variance
- Boxplot
- Confidence interval
- Contrast among means
- Correlated t-test
- Correlation
- Histogram
- Independent groups t-test
- Regression
- Repeated measures ANOVA
- t-test

http://onlinestatbook.com/rvls.html

University of Arizona, Arizona Mathematical Software
Are You Ready?

Are You Ready: the purpose of this series is to make available to students computer programs which review those materials from prerequisite courses that are essential for success in the present course. They cover courses from Intermediate Algebra to Ordinary Differential Equations.

The following RUR programs have been released:

- Are You Ready for Intermediate Algebra?
- Are You Ready for College Algebra?
- Are You Ready for Business Calculus?
- Are You Ready for AP Calculus (AB)?
- Are You Ready for Calculus I?
- Are You Ready for Calculus II?
- Are You Ready for Calculus III?
- Are You Ready for Ordinary Differential Equations?

Toolkits: these are interactive exploratory tools which are aids to instructors and students, both in and out of the classroom. All have drop-down menus and are self-documenting, with on-line, context sensitive help. They are of use from Beginning Algebra to Fourier Series.
http://math.arizona.edu/~www-main-2002/software/azmath.html

QL Tutorials from Private Vendors
CARNEGIE LEARNING'S COGNITIVE TUTOR® FOR HIGHER EDUCATION

Carnegie Learning's Cognitive Tutor mathematics solutions for Higher Education is based on a cognitive model which simulates the ways in which students think about and attack mathematics problems, the programs engage students in real-world problem-solving activities**.** This approach helps students connect prior knowledge with the new skills and concepts they learn.

- The software responds to each student's individual problem-solving strategies.
- The software assesses student progress on mastering skills and concepts, then diagnostically assigns problems based on each student's strengths, weaknesses and individual problem-solving approach.
- Individualized instruction provides opportunities to learn, practice and master new concepts and skills.
- Immediate and dynamic feedback helps keep students on task.
- The software simulates a one-on-one coaching situation between student and tutor.

http://www.carnegielearning.com/
http://www.carnegielearning.com/highered.cfm

Skills Tutor, Houghton Mifflin
Algebra Series
Students work through introductions and concepts to develop an algebraic understanding in:

- Equations
- Inequalities and Polynomials
- Factoring and Rational Expressions
- Functions
- Graphing
- Systems of Equations

http://www.achievementtech.com/go/products-and-services/cd-rom-products/skillsbank/algebra-series

PLATO® and Academic Systems® - Post-Secondary Services

PLATO® Learning curriculum products are designed to help college students and adult learners achieve success in their academic endeavors.

PLATO® offers flexibility and a variety of formats to meet the client's needs. You get exactly the services you want, when you need it.

- Self-directed elearning
- Online workshops
- Just-in-time online consulting
- Traditional classroom

http://www.plato.com/Post-Secondary-Solutions.aspx
http://www.plato.com/Services-PS.aspx

Eduscape
Eduscape's Course Tutorials

- Elementary Algebra
- Business Algebra
- Computer Assisted Statistics

Eduscape's eTeachers

- Solving Linear Equations eTeacher
- Equations for Lines eTeacher
- Factoring eTeacher
- Quadratic Equations eTeacher
- Exact Equation Solver eTeacher

http://www.emathlearning.com/
http://www.emathlearning.com/showpage.asp?page=tutoring

MathXpert:
Precalculus Assistant includes algebra, and Calculus Assistant includes algebra and precalculus.

Algebra Assistant covers all of algebra, up to but not including exponential and logarithmic functions. Precalculus Assistant covers these as well as trigonometric functions and complex numbers. Calculus is about limits, derivatives, and integrals.

Each Assistant comes with problem sets on a variety of topics, but you can also type in your own problems, or a teacher can prepare a problem file. The only restrictions on what problems you can enter are that Algebra Assistant won't accept trigonometric functions such as sine and cosine, and neither Algebra Assistant nor Precalculus Assistant will accept limits, derivatives, and integrals, which require Calculus Assistant.
http://www.helpwithmath.com/about.php?include=whichassistant.html

James Madison University, The Institute for Computer Based Assessment
Quantitative Reasoning Test
http://www.jmu.edu/icba/prodserv/brochure/ICBA's%20Quantitative%20Reasoning%20Test%20-%20rev.%2009.04.2006.pdf

APPENDIX III: EXAMPLES OF GOOD QUANTITATIVE LITERACY PROBLEMS

An exercise concerning the exponential and logistic function in precalculus/calculus course

When data for a developed country such as Italy was examined, there seemed to be a leveling off in the population characteristic of a logistic function. In fact, the population actually decreased slightly between 1990 and 2000. This has led some people to believe that as the rest of the world becomes more developed, the world population will also display the characteristics of a logistic model. Reasonable estimates for the population of the world in billions of people are:

Year	1650	1750	1850	1900	1950	2000
Population in billions	0.58	0.71	1.19	1.52	2.51	6.10

(Source: Predicting Earth discussion at www.geo.utexas.edu)

(a) What is the logistic model for the data? Graph it on a scatter plot of the data.
(b) What is the exponential model? Graph it on the scatter plot of the data.
(c) In what year does each model predict the world population will be 10 billion people?
(d) What is the eventual population of the world according to the logistic model?
(e) What arguments would support each model?
(f) Choose a point of view (exponential, logistic, or neither) and defend it. You must refer to concrete data (you are free to use data not provided here).
(g) Being honest with yourself, was your assessment biased by your own attitudes regarding environmental and/or social issues? Does this relate to how you should regard the analysis of data presented by others (such as lung cancer research done of cigarette manufacturers)?

Problems from a statistics class for public affairs masters students

1) A study looked at the effects of anti-tobacco ads on smoking using very large observational datasets. It found that the presence of ads was associated with a lower prevalence of smoking by a statistically significant .01 percentage points (e.g., reducing smoking from 30% of the population to 29.99% of the population). What do you think of the importance of these results? Why might they be statistically significant?

2) Using a random sample of births in three states, a cross-tabs and chi-square test of adequacy of care and delivery method was carried out. The SPSS output is given below.

Delivery Method * Adequacy of Care Crosstabulation

			Adequacy of Care				Total
			Adequate	Intermediate	Inadequate	Unknown	
Delivery Method	Vaginal	Count	58553	17933	4576	3134	84196
		% within Adequacy of Care	78.4%	80.6%	82.8%	78.5%	79.1%
	Vaginal after Previous C-Section	Count	2417	719	176	153	3465
		% within Adequacy of Care	3.2%	3.2%	3.2%	3.8%	3.3%
	Primary C-Section	Count	8408	2157	439	431	11435
		% within Adequacy of Care	11.3%	9.7%	7.9%	10.8%	10.7%
	Repeat C-Section	Count	5002	1387	321	260	6970
		% within Adequacy of Care	6.7%	6.2%	5.8%	6.5%	6.5%
	NA	Count	279	55	12	16	362
		% within Adequacy of Care	.4%	.2%	.2%	.4%	.3%
Total		Count	74659	22251	5524	3994	106428
		% within Adequacy of Care	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	128.049(a)	12	.000
N of Valid Cases	106428		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.59.

(a) What information does the 78.4% figure give us?

(b) What is the null hypothesis of the chi-square test?

(c) Are the results statistically significant? Interpret the statistical significance measure, explaining what it means.

(d) Describe qualitatively what the cross-tabs and chi-square results show. Do you think that the results are practically (or clinically) significant for those concerned with reducing the C-section rate? Do you think that adequacy of care affects C-section rates?

3) Below is an example of regression output from the survey of physician data which we discussed in class.

Regression

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	surgeon[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: B1: patients seen in week

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.017[a]	.000	.000	53.02009

a. Predictors: (Constant), surgeon

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	83.012	1.455		57.056	.000
	surgeon	1.950	2.523	.017	.773	.440

a. Dependent Variable: B1: patients seen in week

(a) Consider the coefficient of the surgeon variable. Interpret the coefficient. Is it practically significant? Explain your reasoning.

(b) What hypothesis is being tested for the sig number given for the coefficient? Is the coefficient statistically significant? Interpret the sig number.

(c) Discuss why the coefficient is statistically significant or not statistically significant (whichever you said). What factors drive that result?

Assignment from a research methods class for public affairs masters students

In the media, policy world or practice world, find an example of someone leaping from a correlation or association to an assumption of causation, where there is insufficient evidence to support the conclusion of causation. (Provide a copy of the article or report, or just a portion of it. If the example is from radio or television, use a link to it on the internet. You must have an example that you can document in some way.)

Briefly describe what correlation was observed and what causation was implicitly or explicitly assumed to follow. Describe some *other* reason that the observed correlation could occur but that is not consistent with the causation assumed, such as some common cause or reverse causation. For example, in the Dad-time teen drug use correlation, we speculated that teens who use drugs may avoid spending time with their Dads, an example of reverse causation. Note that your alternative theory must BOTH be consistent with the correlation or association observed AND be inconsistent with the causation assumed.

APPENDIX IV: PSYCHOLOGICAL ASPECTS OF QUANTITATIVE LEARNING

By Catherine Good, Department of Psychology

Summary. Both educators and psychologists are increasingly interested in understanding the factors that prevent students from attaining high achievement and fulfilling their potential, particularly in quantitative disciplines. Recent research in social psychology, for example, has dramatically demonstrated the pernicious effects that negative stereotypes about one's abilities can have on achievement. This research suggests that stereotyped individuals often suffer negative performance outcomes, not necessarily because they lack ability, but because of their vulnerability to the effects of negative stereotypes. Indeed, the research shows that when stereotypes are not activated, stereotyped individuals often perform as well on an intellectual task as do non-stereotyped individuals. However, when negative stereotypes are activated, they appear to trigger psychological processes that undermine the performance of individuals from a wide range of stereotyped groups, including females in quantitative fields such as mathematics and science and minority students in academics more broadly.

In addition, the achievement motivation literature can teach us a great deal about the effects of messages that imply fixed ability—as stereotypes do—on students' performance. This research shows that students who think of intellectual ability as a fixed trait rather than as a potential that can be developed are at greater risk of negative academic outcomes when faced with difficulties or setbacks. Due to the culture of talent that often accompanies quantitative disciplines, a majority of students are likely to hold the view that their quantitative abilities are fixed by nature. Research shows, consequently, that these students are at particular risk for underachievement in quantitative disciplines, particularly when content in those disciplines becomes challenging.

Research has shown, however, that students can overcome their vulnerability to both negative stereotypes and messages that suggest that quantitative abilities may be fixed by encouraging students to adopt a more malleable view of intelligence, in general, and of quantitative skills, in particular. Below, we review this research in terms of its implications for both students and faculty and provide research-based recommendations for improving students' quantitative literacy.

Research Base

Stereotype threat. Research on "stereotype threat" suggests that simply the existence of negative stereotypes is sufficient to undermine the academic performance of individuals coming from stereotyped groups (Steele & Aronson, 1995). Stereotype threat—the apprehension people feel when they are at risk of confirming a negative stereotype about their group—can impair the performance of African American and Latino students on intellectual tasks (Steele & Aronson, 1995; Aronson & Salinas, 1997), women taking math tests (Good, Aronson, & Harder, 2008; Inzlicht & Ben-Zeev, 2000; Shih, &

Pittinsky, & Ambady, 1999; Spencer, Steele, & Quinn, 1999), students from low socio-economic backgrounds (Croizet & Claire, 1998), and even white men when faced with the stereotype of Asian superiority in math (Aronson, Lustina, Good, Keough, Steele, & Brown, 1999). Even elementary school children can experience vulnerability to stereotype threat (Ambady, Shih, & Pittinsky, 2001; Good & Aronson, 2001). Although the particular details of each study may vary slightly, one thing remains constant—the situation of having one's ability evaluated in a domain in which one's performance is negatively stereotyped.

Research has shown, however, that the consequences of stereotype threat extend beyond underachievement on an academic task. For example, it can lead to self-handicapping strategies, such as reduced practice time for a task (Stone, 2002), and to reduced sense of belonging to the stereotyped domain (Good, Dweck, & Rattan, 2008). In addition, consistent exposure to stereotype threat (e.g., faced by some ethnic minorities in academic environments and women in math) can reduce the degree that individuals value the domain in question (Aronson, et al. 2002; Osborne, 1995; Steele, 1997). In education, it can also lead students to choose not to pursue the domain of study and, consequently, limit the range of professions that they can pursue.

Research has also given us a better understanding of who is most vulnerable to stereotype threat. Although stereotype threat can harm the academic performance of any individual for whom the situation invokes a stereotype-based expectation of poor performance, it is particularly damaging to those who have high identification with the domain. Ironically, this means that those who care most about their performance in a domain are precisely the ones who may be most vulnerable to stereotype threat effects.

The situation that students find themselves in also has been shown to predict one's vulnerability to stereotype threat. In general, the conditions that produce stereotype threat are ones in which a highlighted stereotype implicates the self though association with a relevant social category (Marx & Stapel, 2006b; Marx, Stapel, & Muller, 2005). When one views oneself in terms of a salient group membership (e.g., "I am a woman, women are not expected to be good at quantitative skills, and this is test has difficult quantitative content"), performance can be undermined because of concerns about possibly confirming negative stereotypes about one's group. Thus, situations that increase the salience of the stereotyped identity can increase vulnerability to stereotype threat.

Of particular interest to researchers and practitioners are the mechanisms underlying stereotype threat. How, specifically, do negative stereotypes lead to the demonstrated consequences? Although the research is not entirely clear on this question, we are beginning to better understand the moderators and mediators of stereotype threat. For example, recent research has shown that stereotype threat can reduce working memory resources, ultimately undermining one's ability to successfully complete complex intellectual tasks (Schmader & Johns, 2003).

Reducing Stereotype Threat

Stereotype threat effects have been demonstrated in many studies using different tests and tasks. However, research has also shown that performance deficits can be reduced or eliminated by several means.

Emphasizing an incremental view of intelligence: implicit theories of intelligence. Because stereotype threat has proven to be such a pernicious factor affecting stereotyped individuals' achievement and identities, researchers have turned their attention toward understanding methods of reducing its negative effects. Methods range from in-depth interventions that teach students about the malleable nature of intelligence (e.g., Aronson, Fried, & Good, 2002; Good, Aronson, & Treisman, 2008) to simple changes in classroom practices that can be easily implemented by the instructor, such as ensuring gender-fair testing (Good, Aronson, & Harder, 2008; Spencer, Steele, & Quinn, 1999). These methods are reviewed in more detail below.

For many years literature on achievement motivation has been dealing with the very same issue as the stereotype threat literature—when students focus on proving their ability and that ability is questioned, how is their academic performance affected? Achievement motivation literature has defined the mindsets created as a result and has monitored the processes that accompany impaired performance when students focus on proving rather than improving their abilities (Diener & Dweck, 1978; 1980; Elliott & Dweck, 1988; Elliot, McGregor, & Gable, 1999; Grant, 2000; Pintrich & Garcia 1991; Utman, 1997). Thus, research on achievement motivation can help us understand the processes through which messages of fixed, limited ability— including those conveyed by negative stereotypes—affect academic achievement. In particular, Dweck and her colleagues have shown that people's theories about the nature of intelligence or ability influence a host of academic variables including sustained motivation and achievement in the face of challenge or difficulty (e.g., Dweck & Sorich, 1999; Hong, et al., 1999; see Dweck, 1999 for a review).

As Dweck has shown, people may believe their intelligence is a fixed trait (an "entity theory") or a more malleable quality that can be developed (an "incremental theory"). Because of their belief that intelligence is a fixed trait, entity theorists are highly concerned with messages and outcomes that might define their "true" abilities (Dweck & Leggett, 1988; Dweck & Sorich, 1999). Research has shown that, in the face of academic setbacks, students with this view see their setbacks as reflection of their deficiencies (Dweck & Sorich, 1999; Henderson & Dweck, 1990; cf. Mueller & Dweck, 1998). Furthermore, in the wake of these negative assumptions regarding their capability, entity theorists often exhibit a "helpless response" to challenge. This response is characterized by decreasing meta-cognitive processes (such as planning and strategy generation), and by an increase in distracting thoughts (such as off-task thoughts and ability-related worries), accompanied by a decline in performance (Diener & Dweck, 1978; 1980). In other words, entity theorists' concern with their ability interferes with their capability to perform well.

Incremental theorists, in contrast, believe that intellectual skills are largely expandable. Because this belief system implies that one can influence her level of intellectual skill, incremental theorists focus on improving rather than proving their intellectual ability (Dweck & Leggett, 1988; Dweck & Sorich, 1999). In the face of challenge, they show a "mastery" oriented pattern characterized by increasing meta-cognitive activity, enhanced task focus, and an absence of off-task thoughts, accompanied by maintained or improved performance (Diener & Dweck, 1978.). Relative to entity theorists, who are focus on their ability, incremental theorists are focus on effort—as a way to further learning and as a way to overcome obstacles (Hong, et al., 1999; Dweck & Sorich, 1999; cf. Mueller & Dweck, 1998).

These differences have been consistently found in laboratory studies—in which students' theories of intelligence have been measured as a chronic individual difference variables (e.g. Dweck & Leggett, 1988) and in which students' theories of intelligence have been manipulated experimentally (e.g., Hong, et al., 1999)—as well as in real-world academic settings (e.g., Dweck & Sorich, 1999). As an example of the latter, Dweck and Sorich (1999) followed four waves of seventh-grade students across their transition to junior high school, a time when school becomes considerably more challenging and grades tend to drop appreciably. Students' incoming theories of intelligence were assessed, as were a variety of other motivational variables, and their ensuing grades were monitored. Although entity and incremental theorists entered junior high with equivalent grades, their theories of intelligence predicted dramatically different strategic and motivational responses to the challenge and significantly different math grades across the seventh and eight grades. In summary, much research shows that students' implicit theories of intelligence can have important effects on academic achievement, and that incremental theorists generally fare better than entity theorists in the face of ability-threatening academic challenges.

Encouraging evidence has begun to support the relationship between theories of intelligence (as either fixed or malleable) and stereotype threat. Specifically, a series of studies, in which the idea of expandable ability was explicitly invoked, has shown sharply reduced vulnerability to stereotype threat (Aronson, 1998; Aronson, Fried, & Good, 2002; Good, Aronson, & Inzlicht, 2003). In a recent field study, Aronson, et al., (2003) sought to determine whether teaching an incremental theory of intelligence would affect college students' academic engagement and achievement outside the laboratory. Three groups of African American and Caucasian undergraduates participated in the study. One group participated in an intervention that used various attitude-change techniques designed to teach them, help them internalize, and make cognitively available the notion that intelligence is expandable (malleable condition). The attitudes and achievement outcomes for this group were compared to those of two control groups, one that participated in a comparable intervention with a different intelligence orientation (i.e., the idea that there are many kinds of intelligence), and a third group that did not participate in any intervention. The results showed that teaching African American students that intelligence is malleable resulted in greater enjoyment and valuing of academics. Even more striking was the fact that the students in that group received significantly higher grades that semester than those in the other conditions. Moreover, the gap in GPA between Caucasian and African American students was smallest in the malleable condition. Interestingly, African Americans in the malleable condition reported no less stereotypes in their environment. That is, the intervention did not change their perception of their stereotyped environment; rather it appeared to reduce their vulnerability to the stereotype when they later encountered it.

Similarly, Good, Aronson, & Inzlicht (2003) designed an intervention that they hypothesized would reduce children's vulnerability to stereotype threat by encouraging them to view intelligence as something that could increase and expand with effort rather than something that was a fixed trait. In this program, college students mentored Latino and Caucasian junior high students over the course of a year and endorsed one of the following educational messages: the expandability of intelligence or the perils of drug use. The mentors also helped the students design and create a web page in which the students advocated, in their own words and pictures, the experimental message conveyed by the mentor.

At the year's end, results showed that compared to students in the anti-drug condition, girls mentored in the malleability of intelligence performed better on the state-wide standardized math achievement test and Latinos in this condition performed better on the state-wide standardized reading test. Not only did girls' math performance increase in the malleability condition, but they even outperformed the boys in this condition. These studies provide encouraging evidence of the potential benefit to holding an incremental theory of intelligence—especially when faced with a stereotype suggesting limited ability. As shown in the Aronson, et al. study, the group taught the incremental theory reported no less stereotype threat after participating in the study—it did not make them see the world through rose-colored glasses. Rather, learning the incremental theory appeared to reduce their vulnerability to the debilitating aspects of the stereotype.

In addition, a recent study that experimentally manipulated the entity and incremental messages in the learning environment showed similar findings (Good, Rattan, & Dweck, 2008). In this study, students were randomly assigned to one of two learning environments in which they watched an educational video that taught new math concepts from either an entity or an incremental perspective. They then solved math problems under either stereotype threat or non-threat conditions. Results showed that when females learned the new math concepts with an entity perspective, they performed less well on the math test in the stereotype threat condition than in the non-threat condition. However, when they learned the new math concepts portrayed from an incremental perspective, there were no differences between the stereotype threat and the non-threat conditions on the math test. Other research suggests that encouraging an entity theory even appears to harm performance. For instance, attributing gender differences in mathematics to genetics reduced performance of women on a math test compared with conditions in which differences were explained in terms of experience (Dar-Nimrod & Heine, 2006; see also Shih, Bonam, Sanchez, & Peck, 2007). In other words, the concern with confirming abilities believed to be fixed or biologically-determined can interfere with one's capability to perform well.

One source of these messages may be *instructors'* implicit theories of intelligence. Indeed many educators may espouse the view that skills are expandable and that all students can learn, but they may contradict these views with day-to-day actions. For example, as research is beginning to show, entity and incremental teachers differ in the way they evaluate students' abilities: either through comparison to other students (normative evaluations) or through observation of personal improvement (individual evaluations) (Butler, 2000; Lee, 1996; cf. Plaks, et al., 2001). These different methods of evaluation have important implications, for it has been found that students of math teachers who emphasize normative evaluation rather than individual progress over time (in line with an entity perspective) come to value math less over time (Anderman, et al., 2001). Additionally, teachers' beliefs about the nature of math intelligence have consequences for their other pedagogical practices (Good, Rattan, & Dweck, in preparation). Specifically, compared to participants who were oriented towards an entity view of math intelligence, those who were oriented towards an incremental view were more likely to endorse such teaching practices as telling students they can improve if they work hard in math, providing students with challenging math tasks, and *not* telling students that some people are math people and some people are not.

Another source of entity versus incremental messages may be the types of praise teachers use. For example, Mueller and Dweck (1998) and Kamins and Dweck (1999) showed that simply praising students' ability after they performed well on a task served to promote a more fixed view of ability, whereas praising effort led to a more malleable stance. Moreover, those praised for ability, when they later encountered difficult problems, showed a sharp drop in intrinsic motivation, confidence in their abilities, and performance. Those praised for effort continued to show strong motivation and performance.

Although it will always be important to work on reducing stereotyping in educational environments, stereotypes have proven difficult to eradicate. Thus, focusing efforts on communicating an incremental view of quantitative abilities in classrooms can be an important path for educators to take in their quest to increase students' quantitative literacy. Doing so involves emphasizing the importance of effort and motivation in performance and de-emphasizing inherent "talent" or "genius."

Recently, educators and researchers have teamed up to develop a research-based curriculum to address these issues for high school algebra students (Good, Rosenkrantz, & Treisman, 2008). In a 3-week summer course, students learned various psychological constructs that research has shown to have positive implications for students' learning, motivation, and achievement. For example, they learned about the malleable nature of intelligence. To support this view, students learned basic neuroscience constructs including ways in which the brain forms new connections when you are engaged in effortful processing of novel information. They also learned that the path to increased intelligence is effective effort, and they discussed concrete effort strategies such as metacognitive strategies, the importance of goal-setting, and study skills. Other topics included effective communication skills, the importance of fostering a community of learners, and the effects of students' attributes (to either controllable or uncontrollable causes) on their subsequent learning and achievement. Preliminary results of this study indicate that after the summer program, students were more likely to endorse an incremental view of math intelligence, showed gains in understanding how to work hard to be successful, increased their confidence in their mathematics ability and their sense of belonging to the mathematics learning community, and reported less vulnerability to stereotype threat.

Other methods of reducing stereotype threat have also proved effective, as described below.

Reframing the task. Because stereotype threat arises in situations where the task descriptions highlight negatively-stereotyped social identities stereotypically, modifying task descriptions so that stereotypes are not invoked or are disarmed can eliminate stereotype threat. Methods include explicitly ensuring gender-fair (or race-fair) testing (e.g., Good, Aronson, & Harder, 2008; Quinn & Spencer, 2001; Spencer, Steele, and Quinn, 1999) or explicitly nullifying the assumed diagnosticity of the test (Steele & Aronson, 1995). Of course, removing the diagnostic nature of a test is unrealistic in regular course examinations or in standardized math testing situations. Nevertheless, research has shown that stereotype threat can be reduced by directly addressing the specter of gender-based performance differences within the context of an explicitly diagnostic examination (Good, Aronson & Harder, 2008). Applications of this approach could be as simple as including a brief statement that the test, although diagnostic of underlying mathematics ability, is sex-fair (or race-fair).

Deemphasizing threatened social identities. Another method for reducing stereotype threat is to modify procedures that heighten the salience of stereotyped group memberships. A study conducted for the Educational Testing Service (ETS) (Stricker & Ward, 2004) provided evidence that simply moving standard demographic inquiries about ethnicity and gender to the end of the test resulted in significantly higher performance for women taking the AP calculus test (see Danaher & Crandall, in press). If the ETS were to implement this simple change in testing procedures, it is estimated that an additional 4,700 female students annually would receive Advanced Placement credit in calculus (see Danaher & Crandall, in press).

Encouraging individuals to think of themselves in ways that reduce the salience of a threatened identity can also attenuate stereotype threat effects. Ambady, Paik, Steele, Owen-Smith, and Mitchell (2004), for example, showed that women encouraged to think of themselves in terms of their valued and unique characteristics were less likely to experience stereotype threat in mathematics. This particular approach may also relate to the benefits of self-affirmation, as described below.

Encouraging self-affirmation. Self-affirmation has long been shown to be a general means for protecting the self from perceived threats and the consequences of. Recent research has shown that a simple self-affirmation exercise can also reduce stereotype threat (Cohen, Garcia, Apfel, & Master 2006). In this study, students who self-affirmed as part of a regular classroom exercise indicated values that were important to them and wrote a brief essay indicating why those values were important. This 15-minute intervention resulted in a .3 grade point benefit for African-American students who had been led to self-affirm. Moreover, African-Americans who self-affirmed showed lower accessibility of racial stereotypes on a word fragment completion task. European-American students showed no effects of affirmation.

Emphasizing high standards and assurances of the student's capability for meeting them. As teachers, we are constantly faced with decisions about the nature of the feedback we provide our students regarding performance. And as research shows, the effectiveness of critical feedback, particularly on tasks that involve potentially confirming group stereotypes, varies. Constructive feedback appears most effective when it communicates high standards for performance but also assurances that the student is capable of meeting those high standards (Cohen, Steele, & Ross, 1999). Such feedback reduces perceived evaluator bias, increases motivation, and preserves domain-identification. High standards accompanied by assurances of capability appear to signal that students will not be judged stereotypically and that their abilities and "belonging" are assumed rather than questioned.

Providing competent role models. Providing competent role models in a domain can reduce stereotype threat effects (Blanton, Crocker, & Miller, 2000). For example, Marx & Roman (2002) showed that women tend to perform as well as men on a math test when the test was administered by a woman who had high competence in math, but they performed more poorly and had lower self-esteem when the test had been administered by a man. Importantly, these effects were due to the perceived competence, and not just the gender, of the experimenter. Thus, providing competent role models, for example by increasing the number of female faculty, in quantitative disciplines can go a long way toward reducing stereotype threat. Even reading essays about successful women can alleviate females' performance deficits under stereotype threat. (McIntyre, Lord, Gresky, Ten Eyck, Frye, & Bond Jr., 2005; McIntyre, Paulson, & Lord, 2003), suggesting that providing even a single role model that challenges stereotypic assumptions can eliminate performance decrements under stereotype threat.

Providing external attributions for difficulty. Research has shown that stereotype threat harms performance, in part, because anxiety and associated thoughts distract stereotype-threatened individuals from focusing on the task at hand. Several studies have shown that stereotype threat can be reduced by providing individuals with alternative explanations for their anxiety and distraction that do not implicate the self or validate the stereotype. For example, women who were told that they would be exposed to a "subliminal noise generator" that might increase arousal, nervousness, and heart rate performed as well as men on a math test (Ben-Zeev, Fein, & Inzlicht, 2005. In short, these women were given an alternative explanation for their subsequent anxiety and arousal and consequently, performed better. A more feasible external explanation that can be implemented in classrooms comes from a study by Good, Aronson, and Inzlicht (2003). These researchers had mentors emphasize to young students that the transition to middle school is often quite difficult and that challenges can typically be overcome with time. Encouraging students to attribute struggle to an external, temporary cause eliminated typical gender differences in math performance on the state-wide standardized test of mathematics achievement. Other researchers have used the stereotype threat phenomena itself as an external attribution. Johns, Schmader, and Martens (2005) showed that explicitly teaching students about the possible effects of stereotype threat—specifically it's potential to invoke anxiety—before they took a math test eliminated stereotype threat effects in women's math performance. Together, these studies not only show that providing individuals with an external attribution for anxiety and arousal can disarm stereotype threat, but also suggest realistic strategies that faculty can implement in their classrooms to alleviate stereotype threat for their students.

Note: The full set of references is available from Catherine Good upon request.

APPENDIX V: INCORPORATION OF QUANTITATIVE PEDAGOGY INTO MATH COURSES

With regard to quantitative literacy, it has been observed that “large schools tend to rely almost exclusively on the mathematics department to provide appropriate courses, with very little effort to infuse quantitative material into courses outside of the quantitative intensive disciplines” (Gillman, 2006, p. ix). Insofar as students at Baruch College already have very little room for additional courses, the purpose of this appendix is to consider the possible incorporation of more quantitative skills into current math courses at Baruch College.

The major obstacle to incorporating more quantitative skills into current math courses involves deciding what current course content can be sacrificed in order insert the new material into the course. Are there topics in algebra, precalculus and calculus that are not needed by the students for whom those courses are required? Is the current highly symbolic approach used in those courses best for the students?

Currently the stress in the math courses is to prepare students for calculus since approximately 85% of the students at Baruch College are required to take calculus. The approach to calculus used is highly symbolic (algebraic) and this in turn determines the content of the other courses. In this regard there are several questions that need to be considered. Are there topics in the current precalculus-applied calculus courses that are irrelevant to the future of these students? Should the topics be approached in a manner that is less symbolic and more data and graph driven? If some content can be replaced, what should it be replaced with that is more important? It is hard to address these questions abstractly, so they will be considered in the context of current math courses at Baruch College.

CSTM 0120

Currently CSTM 0120 exists to provide the elementary algebra that students need to succeed in any future course that requires algebra. There are several reasons why the current course design should be questioned. In order to see why that is so, it is best to look at a representative sample of the students who take the course and see what happened to them at Baruch College.

In the Fall 2004 semester 27 new freshmen took CSTM 0120. Of these 27 students:

10 were still registered at Baruch College in Spring 2008.
9 passed precalculus and 2 of these are not currently registered.
4 passed calculus and these students apparently should not have been in CSTM 0120:
    One had Math Regents I and II scores of 99 and 76.
    One had a Regents A score of 72, ACT C1 score of 57 and an Sat score of 500.
    One had a Regents A score of 78.
    One had an SAT score of 570 and 3 units of high school mathematics.

The 5 students who passed precalculus but not calculus only needed CSTM 0120 for review purposes, as evidenced by Regents scores and high school math units.

Table A1 at the end of this appendix displays the detailed information concerning these students. The information presented suggests that the purpose of CSTM 0120 should not be to prepare students for calculus and the Zicklin School of Business since it does not achieve that purpose except for those students who did not need CSTM 0120 in the first place. A better approach for the course (or its replacement with a different course number) might be to design it with a fundamental quantitative literacy orientation that incorporates much of the basic algebra currently in the course but in the context of topics that the students see as relevant to their lives. In the process of redesigning the course, it should be kept in mind that the revised purpose of the course is to prepare the students for dealing with some of the quantitative aspects of current life in a democracy, including the interpretation of graphs and data (with a review of basic algebra included in the applications). An added benefit of such an approach is that there is evidence that such an approach improves student retention (Gillman, 2006, p. 168).

There are relatively few textbooks on the market that are oriented towards developing quantitative literacy. And of those textbooks almost none incorporate basic algebra into the development of the topics. However, The Consortium for Foundation Mathematics (2008) has published one possible textbook. A list of some of the "activities" the book includes are: course grades and your gpa, income and expenses, AIDS in Africa, percent growth and decay, fuel economy, blood-alcohol levels, earth's temperature, college expenses, body parts, fund-raiser, Sherlock Holmes, leasing a copier, how long can you live, algebra of weather, math magic, comparing energy costs, summer job opportunities, graphs tell stories, how fast did you lose, snowy tree cricket, descending in an airplane, charity event, software sales, predicting population, housing prices, oxygen for fish, business checking account, healthy lifestyle, modeling a business, fatal crashes, volume of a storage tank, room for work, the amazing property of gravity, inflation and diving under pressure. The algebra covered includes solving linear equations and inequalities, systems of equations in two variables, factoring and solving quadratic equations. Topics that are currently covered in CSTM 0120 that are omitted are working with rational expressions (algebraic fractions) and working with radicals. Working with radicals appears in MTH 1030 and need not appear in CSTM 0120. Basic work with rational expressions should appear in MTH 1030 in any case.

MATH 1030

In the Fall 2004 semester 138 new freshmen took Math 1030. Of these, 3 had grades of ABS and 2 had grades of WA. The 5 students mentioned were omitted so that 133 students were left. A sample of 39 students was examined that was chosen so that each grade was approximately proportionally represented. For example, since 8 students out of 133 (6.0%) had a grade of B, 2 students of the 39 students in the sample (5.1%) had a grade of B. In particular, 37.6% of all 133 students passed Math 1030 the first time they took it and 38.5% of the sample passed it. The transcript of each of the 39 students was examined in order to gain a better understanding of what happened to such students while they were at Baruch. Table A2 at the end of this Appendix provides the data concerning these students.

Of the 39 students, 32 (82.1%) eventually passed Math 1030 and 24 (61.5%) were registered for the Spring 2008 semester. Considering the fact that the students who take Math 1030 are among the poorest students mathematically speaking, an examination of AVI2 reveals the fact that these students are being adequately prepared for what are considered quantitative courses:

> 27 took ECO 1001, 23 (85.2%) passed it with 21 (77.8%) passing it the first time.
> 18 took ECO 1002 with all of them (100%) passing it the first time.
> 17 took STA 2000, 16 (94.1%) passed it with 14 (82.4%) passing it the first time.
> 11 took FIN 3000, 10 (90.9%) passed it with 9 (81.8%) passing it the first time.

However, these students still struggle to pass the more mathematically demanding courses. For example, of 34 students who took precalculus (2 took precalculus without first passing Math 1030) 29 (85.3%) passed it but only 21 (61.8%) passed it the first time; of 24 students who took calculus 19 (79.2%) passed it with only 12 (50.0%) passing it the first time. Table AVI2 reveals the fact that a large percentage of these students repeat the math courses several times whereas they usually pass the other courses listed above the first time.

As a result of the above analysis, questions arise with respect to introducing more quantitative reasoning skills into Math 1030. If the algebra were kept as it is and more material were added, then the pass rate would drop below the current 38% pass rate when the course is taken for the first time. If the algebra were reduced, then the students would experience even more difficulty in the other math courses. That leaves open the possibility of reevaluating the algebra that is included in the course, omitting the algebra that does not get used in a future math course, and increasing the understanding of the algebra that is taught by relating it to visual graphical representations and data that the students perceive as relevant to their personal lives.

MATH 2003-2205 and MATH 2207

Math 2003-2205 combines precalculus with applied calculus and Math 2207 is an applied calculus course that exists for transfer students who have passed precalculus before coming to Baruch College and for new freshmen who have demonstrated a mastery of precalculus either by having high Regents math exam scores or by achieving a high score on the ACT Compass placement test. The treatment of these courses offered by the Department of Mathematics has to be treated differently than the other courses because calculus is required by the Zicklin business school. As a result, the content is determined by what is perceived to be desired by the business school. The particular approach used in conveying that content is essentially determined by the textbook that is used. Consequently, comments concerning these courses will be limited to two general observations pending input from the business school.

In Math 2205 exponential functions are explored in some detail and the TI-89 calculator is used to form exponential and logarithmic regression functions. If the logistic function were developed as well, it would take very little additional time to use this feature of the calculator to work with relevant data to explore a concrete topic of interest such as the correct function to use to model population growth (exponential or logistic?) or data related to learning curves or some other data relevant to business or the personal lives of the students. It would be especially desirable if the students were required to write a report that included tables of data, graphs of some sort, the functions that might be used to model the data, a discussion of the advantages of each model, and a conclusion that advocated a particular point of view based on the discussion. It would be highly desirable to have graders paid to grade the reports. Grading should reflect all aspects of the report (including the writing) and be incorporated into the grade for the uniform final examination. Unfortunately, the exclusive focus on calculus that occurs in Math 2207 militates against doing that in Math 2207.

The second observation to be made here concerning these courses is that the issues involved are very relevant to the business school and quite often collaboration between the right people can lead to an overhaul of what is done. Many topics are included in the calculus portion of these courses that are not relevant to calculus as used in finance and economics. Do the students need to know the limit definition of the derivative? Do they need to know about rational functions? How much do they need to know about continuity beyond the basic graphical concept? The applied calculus course explores functions in their symbolic form. As a result, if students in the course were presented with the graph of a function and asked to estimate what the derivative (or rate of change) were at a particular value of *x*, they would be at a loss as to what should be done. Is this okay? Quite often the best results may be obtained by a collaboration between faculty in the business school and faculty in the mathematics and statistics departments. For example, when Deborah Hughes-Hallett was invited to speak to the Department of Mathematics at Baruch College she outlined the two part course that emerged at the University of Arizona as a result of the collaboration between three professors from the departments of finance, management information systems and mathematics. The extensive materials developed by Thompson, Lamoureux and Slaten (2007) consist of two parts: Part 1 is devoted to probability and simulation and Part 2 is devoted to calculus and optimization. Mathematical topics are presented in PowerPoint files, as tools that student teams apply to major real-world business projects. Prepared and student created Excel files are used to support the mathematics and for simulation. Major projects involve loan work outs, stock option pricing, managing ATM queues, marketing computer drives and bidding on an oil lease. Calculus is developed via numerical and graphical methods; there are two versions of the calculus part, one of which has limited symbolic manipulation and the other one has more symbolic material.

MATH 2160

Math 2160 is designed for the liberal arts student and the topics are left to the discretion of the instructor. Many of the students who take this course have switched to the liberal arts because they simply cannot manage to pass precalculus and calculus. It traditionally does include some topics related to quantitative reasoning, but quantitative reasoning is not its primary focus. Recently enrollment in Math 2160 has increased to the point where two sections of the course can be offered. It might be time to develop a new course devoted to quantitative reasoning. An example of a book that takes this approach is by Bennett and Briggs (2008).

TABLE A1

FALL 2004 NEW FRESHMEN TAKING CSTM 0120

	RA	RB	RI	RII	RIII	C1	C2	C3	C5	Csum	SAT	Last	GPA	TotCr	CrAttmp	LocCr	CSTM0120	MTH1030	MTH200x	MTH220x	ECO1001	ECO1002	STA2000	FIN3000
1	0	0	0	0	0	69	25	0	0	25	530	S05	2.033	18	24	18	P	B+						
2	0	0	0	0	0	45	24	0	0	24	540	S08	2.014	43	78	43	R,W,R	F						
3	72	0	0	0	0	57	23	0	0	23	500	S08	2.781	108	134	108	P		D+	F,B+	C+	C+	W,B	B-
4	72	0	0	0	0	20	23	0	0	23	420	S06	1.844	46	49	46	R,R							
5	0	0	0	0	0	42	15	0	0	15	620	S08	2.568	65	80	65	R,P	W,F,F	F,A-		B-			
6	69	0	0	0	0	45	21	0	0	21	490	S06	1.622	40	48	40	R	WU						
7	0	0	84	81	0	37	24	0	0	24	430	S06	2.680	33	47	33	P	F,F,C						
8	0	0	0	76	0	57	23	0	0	23	490	S08	2.655	116	123	107	R,R							
9	78	0	0	0	0	41	20	0	0	20	470	S08	2.545	103	145	100	R,R,P	C+	F,C	F,D	C-	D	C-	W
10	0	0	0	0	0	48	20	0	0	20	520	S07	1.469	28	76	28	R,W,WU,W							
11	0	0	0	0	0	53	19	0	0	19	510	S08	2.735	82	107	82	R,W,P	F,F,C+	D	W,F,W	C-			
12	0	0	0	0	0	56	25	0	0	25	430	s07	1.360	21	61	21	W,WU,R	F						
13	0	0	0	0	0	32	18	0	0	18	570	S08	2.406	73	107	70	R		W,C	B	B	C		
14	76	0	0	0	0	17	25	0	0	25	470	F04	1.925	12	12	12	R							
15	0	0	0	0	0	63	23	0	0	23	530	s05	3.203	34	31	28	R,WU							
16	68	0	0	0	0	85	22	0	0	22	660	S08	2.047	98	146	98	R		F,C	F,F,F,F	B	B	C+	
17	0	0	0	92	0	21	17	0	0	17	0	S05	1.614	12	21	12	R							
18	77	0	0	0	0	0	0	0	0	0	350	F06	1.506	37	59	37	P	F,F,F						
19	0	0	99	76	0	0	0	0	0	0	430	S08	3.049	113	125	113	P	A	A-	B-	C+	B+	B+	C+
20	65	0	0	0	0	84	25	0	0	25	500	S08	2.913	102	118	96	P	F,W						
21	66	0	0	0	0	0	0	0	0	0	390	F07	2.361	60	87	60	P	W,F,F,C	F,D	W	W			
22	82	0	0	0	0	70	26	0	0	26	490	S05	0.426	6	26	6	R							
23	0	0	65	71	0	69	15	0	0	15	500	S07	2.111	54	69	54	P	WU,W,F	W					
24	76	0	0	0	0	84	24	0	0	24	530	F05	3.489	47	39	35	P	W,F						
25	0	0	0	0	0	36	18	0	0	18	520	S07	0.911	33	70	33	P	C	D+	WF				
26	0	0	0	0	0	45	47	32	16	95	0	S06	2.937	8	20	8	R,P	W,F,C+						
27	0	0	80	0	0	49	25	0	0	25	550	S07	1.717	31	33	25	R,P	W						

RA = Regents Math A
RB = Regents Math B
RI = Regents Math I
RII = Regents Math II
RIII = Regents Math III

C1 = ACT Compass Score 1 (Pre-Algebra)
C2 = ACT Compass Score 2 (Algebra)
C3 = ACT Compass Score 3 (Intermediate Algebra)
C5 = ACT Compass Score 5 (Precalculus)
Csum = C2 + C3 + C5
SAT = SAT Math Score

Last = Last Semester Registered
F = Fall, S = Spring, s = Summer
TotCr = Total Credits
CrAttmp = Credits Attempted
LocCr = Local Credits
MTH200x = Precalculus Math 2001 or 2003
MTH220x = Applied Calculus Math 2201, 2205, 2206 or 2207

TABLE A2
FALL 2004 NEW FRESHMEN TAKING MATH 1030

	RegA	RegB	RI	RII	RIII	C1	C2	C3	C5	Csum	SAT	Last	GPA	TotCr	CrAttmp	LocCr	MTH1030	MTH200x	MTH220x	ECO1001	ECO1002	STA2000	FIN3000
1	68	0	0	0	0	0	35	28	35	98	500	S08	3.415	92	104	86	A	B+	W,A-	A	C-	A	B-
2	0	0	0	66	0	55	38	28	37	103	440	F06	1.181	35	64	35	W						
3	78	0	0	0	0	0	30	24	0	54	450	S08	2.174	58	95.5	58	W,F,F,C	W					
4	0	0	60	0	0	30	27	22	0	49	430	S06	1.986	36	57	36	F,C	D					
5	70	69	0	0	0	0	0	0	0	0	460	S08	2.312	84	105	78	W,F,A	F,W					
6	0	0	58	67	65	0	36	25	0	61	520	S08	2.828	107	130	107	F,B-	F,B-	C-	A-	A	D+	B
7	0	0	72	65	46	44	25	0	0	25	500	F06	2.500	45	61	45	B	D+	C	F			
8	56	0	0	0	50	0	37	22	0	59	500	S08	2.716	91	106	85	B-	W,F,C+		B-	B-	B	W,B
9	57	0	0	0	0	0	24	0	0	24	560	S08	2.775	118	156	118	W,F,F,B-	W,C+	W,W,C	B	C	C	B-
10	0	0	0	77	51	0	31	18	0	49	400	S08	3.021	79	79	70	B+	C-	F,C	C+	B+	C	B
11	0	0	85	59	65	0	0	0	0	0	580	S08	2.497	96	129	96	C	A	B	C	C-	W,A	F
12	65	0	0	0	55	44	34	25	0	59	440	S05	1.717	22	31	22	F,F,F						
13	77	0	0	0	65	0	0	0	0	0	530	S08	2.467	91	112	91	B	C	C-	D	C+	D	
14	0	0	90	53	65	0	29	19	0	48	510	F05	1.613	24	39	24	B-	W,B-	WU	F			
15	0	0	0	0	0	0	33	23	0	56	510	S08	3.851	112	122	112	F,A-	C-		A-			
16	65	0	57	0	65	17	15	0	0	15	600	S08	2.716	82	105	82	F,A	A	WU	C+		W,D+	
17	0	0	74	0	44	0	42	25	0	67	540	S08	3.588	103	111	96	B	B+	A	B	B+	A	C+
18	0	0	0	0	0	27	22	0	0	22	500	S08	2.547	101	123	98	W,F,F	C	C	A-	B-	B	B
19	0	0	71	42	60	0	0	0	0	0	550	S08	2.163	89	118	89	B-	C-	F,W,F,D	C-	D	C	
20	69	0	0	0	68	0	38	22	0	60	560	S08	1.462	14	45	14	A-	W,W					
21	60	0	0	0	0	0	34	18	0	52	510	S08	2.010	69	110	63	WU,F,C+	F					
22	71	0	0	0	69	62	46	25	0	71	460	S08	2.583	85	113	85	B+	C	W,A	C+	B	D+	B
23	0	0	56	0	0	0	28	20	0	48	480	S08	2.997	87	121	87	W,C	W,W,F,B-	D	A	B	B+	A-
24	0	0	69	66	0	0	0	0	0	0	440	S06	1.347	36	54	36	C+	F	D	F			
25	0	0	0	95	67	0	28	15	0	43	480	S05	1.500	9	28	6	W,W						
26	0	0	0	65	0	0	0	0	0	0	460	F07	2.578	74	98	74	W	WF,W,F,C-		B-			
27	57	0	0	0	0	40	30	48	30	108	370	S08	2.840	100	117	100	B-	C	C+	D	C	B+	
28	0	0	0	0	0	0	39	29	20	88	510	S05	1.269	9	29	9	WU						
29	0	0	81	60	68	0	56	27	22	105	490	S08	2.828	83	108	83	W,B-	C-	W,F,W,B-	D+	C		
30	77	0	0	0	0	0	27	34	32	93	470	S08	2.587	88	129	88	C	D	W,C+	F,C+		W	
31	80	0	0	49	69	0	0	0	0	0	640	F07	2.000	48	90	48	F,C	F,W,D	W,W	F,W			
32	0	0	0	0	0	35	32	20	0	52	0	F05	2.325	24	39	24	W						
33	65	0	0	0	31	43	27	28	43	98	440	S08	2.420	103	130	100	F,C	C+	W,F,W	D	C		
34	74	0	0	0	0	38	29	19	0	48	390	s05	0.785	8	29	8	F,B-	W,C	W				
35	83	0	0	0	0	0	55	26	0	81	500	S08	2.946	115	129	115	A-	A	A	B-	B+	A	B+
36	0	0	0	0	0	0	35	24	0	59	600	F06	1.341	38	60	38	C+	C		C-			
37	0	0	82	68	54	0	46	28	18	92	590	S07	2.220	68	72	65	F,F,B+	B	A-	D	D		
38	0	0	0	0	0	0	0	0	0	0	740	S08	2.676	95	124	95	A-	B-	C+	W,D+	C	D+	
39	0	0	0	80	0	0	0	0	0	0	500	S05	1.047	11	31	11	C	D+					

See Table A1 for abbreviations used in the column headings.

APPENDIX VI: SEEK PROGRAM

(The task force was extremely impressed with the work that SEEK is doing. We asked its director, Jill Rosenberg to describe its accomplishments.)

By Jill Rosenberg, Director of Academic Support for SEEK

For the past 4 years, the SEEK Program has begun a number of new initiatives intended to improve students' quantitative literacy. While we have always offered students private tutoring and supplemental instruction in math (group tutoring associated with Algebra, Precalculus and Calculus in which students can ask questions and review material covered in class), we have begun to reconsider the kind of instruction we provide, the way math is taught at SEEK and the materials used to teach it. Math labs are no longer comprised of a whole class and instead allow groups of 5-10 students to work through problems together with the instructor. Instead of teaching from the textbook and sample finals exclusively, we have introduced new curriculum. Algebra drills are used to reinforce problem-solving techniques that can only be learned through repetitive practice.

These drills were used for the past two years in our January Math Program, and for the first time in 2007, with our incoming freshman the summer before their freshman year. During our mandatory SEEK Summer Experience, students are placed in small groups and given math instruction, often encouraged to work with one another. While the January Math Program is intended for those who failed or withdrew from math (or did so poorly we doubt their success in future math courses), the summer program provides instruction to any student entering Algebra or Precalculus in the fall, and even some of the weaker calculus students. Students in these two programs are grouped according to skill level, on the basis of an assessment test developed by a math instructor and members of our academic support staff. Using these assessments also allows us to see if students have been placed in the right course by the COMPASS exam.

While these programs—in particular the January Math Program—have proven successful, we felt that the drills did not address one of the problems prevalent among our students: their inability to seek true comprehension when dealing numbers and quantitative matters. Students sought instead to identify formulas and apply them but had little interest in knowing why one formula was used as opposed to another, little desire to see graphical representations of what they studied. We had to conclude that the students had never approached math as *quantitative literacy*, and therefore took minimal interest in the subject, concerning themselves only with finding the correct answer. Therefore, for the 2008 Summer Program, we have created a new curriculum, developed by a professor in the math department, which allows students to work with real data and explore topics sequentially so that each topic flows logically from the last. Graphs are used to let students see what it is they are considering numerically, and word problems appear frequently in lab work and homework. We feel that the students working with this curriculum are gaining a better foundation with which to approach their classes in the fall. We plan to use this or similar curriculum in the January Math Program.

In addition, in January of 2008, we began to invite our incoming Transfer students to participate in a Math Bridge Program, using the curriculum from our January Math and Summer Programs. These students are often the weakest in math, as the courses they took at feeder institutions are often not at the level of Baruch courses. In the past, many of them had to take and retake math courses multiple times before passing. However, the students who participated in the January Bridge Program passed their courses the first time around. We plan to continue to offer these Bridge Programs in both January and August.

At this point in time, SEEK students pass math at higher rates than non-SEEK students—a huge feat since they enter Baruch with weaker skills. We believe that the higher pass rates are due entirely to the extra support that students receive, the extra work that they complete, and the fact that they feel supported in their efforts.

APPENDIX VII: ASSESSMENT OF QUANTITATIVE REASONING SKILLS

Assessment of quantitative reasoning skills falls into two separate categories. One aspect of assessment involves determining what quantitative reasoning skills are needed by graduates of Baruch College both as citizens in a complex democracy and as employees in the workforce. The other aspect of assessment involves making sure that the students possess the quantitative reasoning skills needed both for their academic work at Baruch College and as graduates. To a large extent this boils down to evaluating the literature in the field and conducting surveys to determine the skills that are needed and then testing those skills at appropriate points in the lives of the students.

Identifying Necessary Quantitative Reasoning Skills

With regard to identifying the skills that alumni need on the job, surveys provide the most feasible means for accomplishing the task. In that regard, such a survey could focus on the employers or the alums.

A routine survey of the employers of Baruch students is not currently conducted. However, a separate part of this report does provide information concerning an informal survey by a member of the task force of several employers and former students with regard to the quantitative reasoning skills required on the job. Apart from the specific skill involved in handling Excel, overall the employers interviewed did not single out other specific skills. However, the employers did indicate that analyzing problems, breaking them down into manageable components (exemplified by using case studies in interviews) and understanding basic concepts were very important. Obtaining this type of information is important, but if it is not acted on then it serves no purpose.

Likewise, a routine survey of all alums is not currently conducted, but surveys of specific affinity groups are sometimes conducted. It would be useful to determine what specific quantitative reasoning skills were considered to be important on the job as a function of an alum's major from the point of view of the alum. It would also be useful to determine which of those skills the alum believed he or she was deficient in at the time of graduation.

Recommendation

> Each year one or more majors should be selected for two surveys. The first survey would be a survey of alums who graduated with the designated major and obtained a job in the field of the major. Appropriate questions related to quantitative reasoning skills (and other skills) should be asked about both in terms of what skills were important on the job and what skills the alums believed were not adequately provided for by their education at Baruch College.

For the second survey several employers should be singled out for an interview. An administrator and appropriate members of the academic department involved would then arrange to interview the relevant representative of the employer (perhaps over lunch) in order to ascertain what skills were most desirable and what the greatest weaknesses of new employees were.

After the two surveys are conducted, a discussion should take place with regard to changes that might be made in the major courses. It is important that departmental representatives be involved in the process since changes can only take place with the cooperation of the department. In addition, the departmental representatives should identify those skills that are needed before a student embarks on a major in the department.

In addition to possible surveys of alums and employers, it might be desirable to survey current students. One possible approach to this would be to place one or two relevant questions on the student course evaluations that occur at the end of each semester. Another possible approach would be to include questions related to quantitative reasoning on a questionnaire that graduating students fill out.

It is expected that the surveys mentioned will identify quantitative reasoning skills that are needed by students at Baruch College. The next step would be to ascertain the skills possessed by each student and then provide a means for the student to acquire any skills that he or she is deficient in.

Assessing the Quantitative Reasoning Skills of Students

There are two distinct categories of quantitative reasoning skills needed by students. The first category involves the skills necessary for any college educated citizen in a democracy. The second category involves the skills necessary to succeed in the major field of study pursued and on the job. Ideally, a test should be available that identifies specific skills and tests those skills at varying levels of competency. It is assumed, for example, that an economics major should be more proficient at interpreting and constructing graphs than an English major. Once an instrument for determining the quantitative reasoning skills has been established and deemed satisfactory, the means for correcting deficiencies should be explored. This might involve adjusting the syllabi for a few courses, recommending that students seek help from the Student Academic Consulting Center (SACC) or recommending that some students take a special quantitative reasoning course.

The following recommendation sets forth the overall goal with the understanding that it would take several years to implement. It is assumed that the recommendation would be implemented in stages. In the first stage, the assessment instrument would be developed, tested on a sample of the students and revised. In the second stage a larger sample would be tested and a means of correcting student deficiencies established. If the assessment instrument is deemed to be satisfactory and worthwhile, then the final stage would involve extending the use of the assessment instrument to all students.

Recommendation

Quantitative literacy is essential for good citizenship and all majors. In addition, varying degrees of greater quantitative literacy are required for some majors. Therefore, it is recommended that the possible institution of an examination dedicated to insuring that the students at Baruch College fulfill these requirements be explored in detail. Aspects of such an examination that should be considered are as follows.

The exam should provide scores for different aspects of quantitative reasoning skills so that it could serve to identify the specific weaknesses of students and enable them to obtain the appropriate assistance in correcting those weaknesses.

The exam should at least be administered just prior to junior status for students at Baruch College. The possibility of using it as a replacement for Task 2 of the CUNY Proficiency Examination (CPE) should be explored along with the possibility of having some of the other colleges in CUNY join Baruch College in using the exam.

Some means of providing help to students who do not possess the minimal skills desired as well as to those students who do not possess the skills needed in a particular major should be established. Online tutorials and assistance by tutors in the Student Academic Consulting Center (SACC) should definitely be possible options. The possibility of establishing a quantitative literacy course that does not satisfy the core requirements (except for some liberal arts majors) should be considered.

One possible option for such an exam involves using a national exam. Two possible avenues to explore in this regard are the following. The ACT Compass test that is currently used for placement would have to have its first subtest substantially changed in order to adequately test quantitative reasoning. Another possibility is the Maplesoft Placement Test. The first test of the Maplesoft suite of tests is most closely aligned with quantitative reasoning skills. Some adjustments would be needed to provide subscores. It is a possible alternative to using the ACT Compass test for placement. The other option is to explore development of a test either locally or in conjunction with other CUNY colleges. Funding for such an enterprise might be possible, especially if the exam were to be made publicly available without charge. There already exists a framework for such an exam that is used by the Department of Mathematics at Baruch College: WeBWorK. WeBWorK is freeware that is used by a large number of colleges and universities.

At this point various tests will be considered with respect to the evaluation of quantitative reasoning skills. Currently there are two tests related to quantitative reasoning that are administered to most of the students admitted to Baruch College. One test is the SAT Mathematics test and the other test is the ACT Compass test. In addition to being used for admission, the ACT Compass test scores are used for placement in conjunction with the New York State Regents examinations.

The ACT COMPASS Test

The ACT Compass test provides for 5 subtests for categories ranging from pre-algebra (score 1) to precalculus (score 5). CUNY does not utilize the fourth subtest. All students who are admitted based on their SAT math score start the Compass test in subtest 2 (algebra) and thus are not tested in pre-algebra, the part of the test that is most related to quantitative reasoning skills that do not involve algebra. Interpreting data provided by graphs (such as bar graphs) and similar data related tasks are absent from the pre-algebra subtest and as a result even the pre-algebra subtest has limited usefulness in terms of assessing quantitative reasoning skills.

Nevertheless, the records for the 131 freshman of the Fall 2004 cohort who took the pre-algebra subtest were examined. Only 56 of the students actually attended Baruch College. The correlation was determined between the scores of the students on the pre-algebra ACT Compass subtest and the grades in 6 quantitative subjects as well as the grade point average. The following table summarizes the results.

	Number	**Correlation with ACT Pre-algebra score**
Grade Point Average	56	0.139
ECO 1001	31	0.027
ECO 1002	18	0.152
FIN 3000	16	0.066
MTH 1030	27	-0.138
Precalculus	30	0.072
STA 2000	19	0.159

The sample sizes are really too small to be reliable and the correlations are very small. Nevertheless, at least all the correlations are positive with the exception of MTH 1030.

The ACT Compass test has proven useful in assessing the mathematical skills of students who are admitted to Baruch College, but its usefulness in terms of assessing quantitative reasoning skills appears to be rather limited. The test does not involve the interpretation and formation of many of the types of graphs and data that a student will encounter in life. Also, the lack of a substantial correlation between the pre-algebra subtest score and the grades of students in quantitatively intensive courses at Baruch College would suggest that a better assessment instrument should be sought.

The SAT Mathematics Test

The questions that the College Board characterizes as "data analysis, statistics, and probability" on the SAT math test are quite relevant to quantitative reasoning. Unfortunately, a subscore is not reported for those particular questions. As a result, the ability of an incoming student to think in a quantitative manner cannot be separated from the mathematical content questions. It is difficult to track all freshmen in a given cohort longitudinally in terms of many specific courses. Insofar as the data presented concerning the ACT Compass test suggested that ECO 1002 and STA 2000 were the courses most likely to be correlated to quantitative reasoning skills, data for the Fall 2004 freshman cohort were examined in this connection. The SAT math scores of this cohort were compared with all the grades of all students who took ECO 1002 or STA 2000 between Fall 2004 and Fall 2007. Students who were not in the cohort or did not take the SAT math test were eliminated. Much of this work was done by hand and the intent was simply to get a good idea of the correlations that existed. So, approximately half of the 1672 students with SAT math scores were examined. The following table summarizes the results.

Course	Number	Correlation with SAT math score
ECO 1002	651	0.220
STA 2000	569	0.220

The correlation is still low but better than the ACT Compass test. It would be interesting to see how the SAT math score changed as a result of taking a specific set of courses at Baruch College, but there does not appear sufficient justification for doing so at the present time.

The CUNY Proficiency Exam

The CUNY Proficiency Exam is divided into two tasks. The first task is not of concern here since it involves analytical reading and writing. The second task involves analyzing and integrating material from text and graphs. It is extremely limited in scope with respect to quantitative reasoning skills and passing the exam is not indicative of the skills required of a graduate of a senior college that offers a BBA degree.

The Maplesoft Placement Test

The Maplesoft Placement Test consists of 6 test banks covering "arithmetic and skills" through "calculus readiness." Each test consists of 25 to 32 multiple choice questions and each test is expected to take between 30 to 45 minutes for a student to complete. The question bank for each test consists of between 100 and 128 questions. The "arithmetic and skills" test is a fairly good test of basic quantitative reasoning skills. It requires a substantial ability to make approximations (many questions require number sense) and an understanding of the use of numbers. It includes questions that require an understanding of what a basic histogram is and what an ordinary Cartesian coordinate system represents. Overall the tests appear to be more balanced than the ACT Compass test. However, there are only a limited number of questions in the test bank (although they can be augmented). Unlike the ACT Compass exam, a student has to complete an entire fixed test and then get graded; the ACT exam interprets student answers as the student progresses and then adjusts questions accordingly so that the test is completed relatively quickly.

WeBWorK

The Department of Mathematics at Baruch College currently uses WeBWorK freeware developed at the University of Rochester for assignments in precalculus and applied calculus. WeBWorK is utilized at many other colleges and universities and has been supported by the National Science Foundation and appears on the Mathematical Association of America web site. The parameters for each problem are randomly generated so that each student gets his or her own unique problem set. Free response answers are possible and utilized in the assignments. The results are machine graded (more than one attempt to answer a question can be provided for before the grading takes place). Programming the questions can be time consuming insofar as a relatively unfamiliar language is used (Perl, with mathematical formulas written using the syntax of LaTeX). However, an overall framework for testing and grading is provided and a large number of problems are available as freeware. In many ways it is ideal for testing students and the software is free. Also, there are faculty in the Department of Mathematics who are familiar with its programming and operation. The Baruch Computing and Technology Center currently has WeBWorK on its servers.

APPENDIX VIII: MS-EXCEL AT BARUCH
(undergraduate and instructional offerings as of Spring 2008)

Why teach Excel? Microsoft Excel is now ubiquitous in industry. Our interviews with alumni revealed that the ability to use Excel to solve real world problems is a critical skill in the workplace. It is such an important skill for graduates to compete in the job marketplace that Pat Imbimbo offers special Excel training to our *best* students—the 30 that qualify for her Wall Street Careers Program.

Students can acquire beginner, intermediate and advanced MS-Excel training at Baruch College in several ways. The required training for Zicklin students is at a low level, equivalent to what many middle and high schools are now teaching in New York City suburbs. Worse, it's not integrated across the curriculum to reinforce "in context" Excel skills. However, contrary to student complaints, advanced training options do exist through BCTC and the CIS 3367/4367 electives.

Required Excel Training. All Zicklin students must pass the SimNet test as part of their quantitative skills general education requirements (except for a small few students who have passed particular CIS courses). It is a hands-on computer evaluation of rudimentary Excel skills. Students who cannot pass in three attempts may take a newly-approved 1-credit course. All Zicklin students take CIS 2200, which includes 0-4 classes on Excel, depending on instructor. In the new SPA curriculum, PAF 3401 contains several applied Excel exercises.

Optional Classes, Workshops and Resources

- CIS 3367 & 4367: Microcomputer Applications in Business I & II (available to all non-CIS majors) are half roughly half advanced Excel and half Access. They provides promising training but no opportunities to use Excel for substantive applications.
- BCTC offers free technology workshops for students and faculty. The introductory one is basic and overlaps with the SimNet test. The second one is also still fairly elementary. These workshops do not provide experience using Excel in substantive applications.
- BCTC partnered with EnterpriseTraining.com to offer online training for a number of information technology skills. There are three comprehensive Excel courses, each requiring an estimated 6 to 8 hours to be completed by the student. According to the descriptions, they appear to give solid advanced skills including pivot tables, vlookups, hlookups, and macro programming.
- In the Baruch College Digital Media Library, there is an MS-Excel Video Tutorial by Professor Joshua Appel of CIS, produced by Baruch College's SEEK program and BCTC. The series of videos provides detailed instructions on using Microsoft Excel spreadsheets.
- The Wall Street Careers Program is a selective program to which students apply and 30 or so are admitted to receive special career guidance for the top Wall Street front office positions. They have special Excel workshops.