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**Liczba Pi**

Podziwu godna liczba Pi
trzy koma jeden cztery jeden.
Wszystkie jej dalsze cyfry też są początkowe,
pięć dziewięć dwa ponieważ nigdy się nie kończy.
Nie pozwala się objąć sześć pięć trzy pięć spojrzeniem,
osiem dziewięć obliczeniem
siedem dziewięć wyobraźnią,
a nawet trzy dwa trzy osiem żartem, czyli porównaniem
cztery sześć do czegokolwiek
da sześć cztery trzy na świecie.
Najdłuższy ziemski wąż po kilkunastu metrach się urywa
podobnie, choć trochę później, czynią węże bajeczne.
Korowód cyfr składających się na liczbę Pi
nie zatrzymuje się na brzegu kartki,
potrafi ciągnąc się po stole, przez powietrze,
przez mur, liść, gniazdo ptasie, chmury, prosto w niebo,
przez całą nieba wzdętość i bezdenność.
O, jak krótki, wprost mysii, jest warkocz komety!
Jak wątły promień gwiazdy, że zakrzywia się w lada przestrzeni!
A tu dwa trzy piętnaście trzysta dziewiętnaście
mój numer telefonu twój numer koszuli
rok tysiąc dziewięćset siedemdziesiąty trzeci piętro
ilość mieszkańców sześćdziesiąt pięć groszy
obwód w biodrach dwa palce szarada i szyfr,
in którym słowiczku mój a leć, a piej
oraz uprasza się zachować spokój,
a także ziemia i niebo przemina,
ale nie liczba Pi, co to to nie,
ona wciąż swoje niezłe jeszcze pięć,
nie byle jakie osiem,
nieostatnie siedem,
przynaglając, ach, przynaglając gnuśną wieczność
tdo trwania.

Wisława Szymborska
Pi

The admirable number pi:
three point one four one.
All the following digits are also initial,
five nine two because it never ends.
It can’t be comprehended six five three five at a glance,
eight nine by calculation,
seven nine or imagination,
not even three two three eight by wit, that is, by comparison
four six to anything else
two six four three in the world.
The longest snake on earth calls it quits at about forty feet.
Likewise, snakes of myth and legend, though they may hold out a bit longer.
The pageant of digits comprising the number pi
doesn’t stop at the page’s edge.
It goes on across the table, through the air,
over a wall, a leaf, a bird’s nest, clouds, straight into the sky,
through all the bottomless, bloated heavens.
Oh how brief – a mouse tail, a pigtail – is the tail of a comet!
How feeble the star’s ray, bent by bumping up against space!
While here we have two three fifteen three hundred nineteen
my phone number your shirt size the year
nineteen hundred and seventy-three the sixth floor
the number of inhabitants sixty-five cents
hip measurement two fingers a charade, a code,
in which we find hail to thee, blithe spirit, bird thou never wert
alongside ladies and gentlemen, no cause for alarm,
as well as heaven and earth shall pass away,
but not the number pi, oh no, nothing doing,
it keeps right on with its rather remarkable five,
it’s uncommonly fine eight,
it’s far from final seven,
nudging, always nudging a sluggish eternity
to continue.

Wisława Szymborska
translated from the Polish by Stanislaw Baranczak
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From the Editor

Michele Piso, Center for Teaching and Learning

One afternoon in mid-September 2011, eleven LaGuardia faculty participants in The Carnegie Seminar on the Scholarship of Teaching and Learning gathered in the college’s Library conference room, ready to launch a two-year investigation into teaching and learning math and science. Most attendees were familiar with conventional disciplinary scholarship, and several had published in their fields. That day, our goal was to reorient teachers toward the principles of the Scholarship of Teaching and Learning (SoTL). Over a period of two years, we reviewed SoTL history, distinguished its modes, and, ultimately, prepared faculty for systematic and publishable explorations of teaching and learning. Supporting these explicit objectives was a deeper and more urgent vision. We wished to heighten cross-campus awareness of and respect for the magnitude of the day-to-day challenges of teaching communities of students whose educational and personal futures are pinned to their success in high stakes basic skills math and required science courses. Too many of our students express math fear; they say they “hate math.” And many Health Sciences majors, struggling to pass gateway science courses and anticipating low grades, often resent these requirements as obstacles to their dreams. In response to students’ sometimes defiant and defensive sentiments, the pedagogical research collected in these pages reveals their teachers’ unflagging commitment, discipline, and love.

Confronting the complexities inherent in responsible SoTL exploration and description requires serious intellectual work, self-criticism, and a moral vision worthy of our students and our institution. We are grateful to Avrom Caplan, CUNY Associate University Dean for Research, for visiting the Carnegie Seminar and fielding our many questions about quantitative research, a methodology that seemed appropriate for our math and science faculty. Of course, quantitative research is but one way to capture learning. More qualitative research may take the form of case studies, self-reflections, or a teacher’s impressions of “what worked,” and In Transit looks forward to future submissions of this kind. Whatever form SoTL takes, its goal is to widen the path to improved student learning. Our hope is that the current issue, spanning
pedagogical research, reports on quantitative reasoning professional development efforts, memoirs of mathematicians and scientists, and, not least, recollections of math phobia, represents the vibrant diversity of LaGuardia’s pedagogical approaches, aspirations, and demographics.

To achieve our goals, *In Transit’s* writers and editorial team relied upon the extraordinary support of a collective of 46 dedicated colleagues, each of whom contributed to the journal’s shifts in perspective, content, and design. Philip Gimber, Kathleen Karsten, and Helen Rozelman attended The Carnegie Seminar as mentors, responding to each presentation of method and data with informed questions that surprised and enlightened all of us. We are grateful to the alert band of peer readers for guiding the first phases of the manuscripts with close reading and clear advice. We thank Charity Scribner for an editing perspective both critical and kind; her smart suggestions sharpened clarity of word and line. As always, *In Transit’s* meticulous copyeditor, Louise Fluk, gave endless hours to preserve the journal’s integrity and accuracy. Each writer benefitted from her high standards. To the authors whose tireless efforts and extraordinary patience produced outcomes that promise to change the ways we teach and learn math and science at LaGuardia, we express our boundless gratitude. Frank Wang, professor of mathematics and PI of the CUNY Improving Math Learning Project, introduces their efforts with invaluable and comprehensive knowledge of the nation’s STEM crisis and its consequences for mathematics education at LaGuardia and across CUNY. In the midst of so many other obligations, he quickly and generously provided an introduction both eloquent and provocative.

Our acknowledgements of support would be incomplete without warm appreciation for the classroom experience and scholarship of the Center for Teaching and Learning’s new director and Assistant Dean for Academic Affairs, Howard Wach. Historian, lover of music, baseball enthusiast, and excellent listener, Howard lifted spirits with *le mot juste* and humane wisdom. Above all, we are indebted, professionally and personally, to Patricia Sokolski, Roslyn Orgel, and Ethan Ries. for giving time and talent each day for many weeks of every month, semester after semester, to strengthen the value and uniqueness of each paper. Without their skill, companionship, and personal sacrifices, this issue of *In Transit* would not exist.
Finally, we wish to emphasize that *In Transit* is an in-house publication. Its mission is to publish scholarly works-in-progress on classroom practice, and educational policy and philosophy. *In Transit*, V6 authors and editors offer papers to our peers at LaGuardia Community College for critique and commentary. In preparation for external, refereed publication, works-in-progress will be revised, often in the Faculty Scholars Publication Workshop, a professional development seminar, facilitated by faculty for faculty engaged in scholarship. Of the contributors to this volume, several have participated in The Carnegie Seminar on the Scholarship of Teaching and Learning. We are grateful to all contributors, in the seminar and in these pages, for their awareness of teaching as acts of intellect, art, and justice.
Introduction

Frank Wang
*Mathematics, Engineering, and Computer Science*

Anyone who has even a passing acquaintance with educational issues knows that the nation is facing a crisis in math and science education. Every now and then, citizens encounter news headlines such as “U.S. Students Still Lag Globally in Math and Science, Tests Show” from *The New York Times* (Rich, 2012) or “Competitors Still Beat U.S. in Tests” from *The Wall Street Journal* (Banchero, 2012). The dismal state of math and science education and its potentially disastrous consequences were documented in an alarming report entitled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, issued in 2005 by the National Academies, the country’s leading advisory group on science and technology. The report warned of the danger inherent in the fact that most people do not know enough about science, technology, or mathematics to contribute significantly to, or fully benefit from, the knowledge-based society that is already taking shape around us. Moreover, most people do not have enough understanding of the importance of those fields to encourage their children to study those subjects, both for their career opportunities and for their general benefit. America, the report argued, was on the perilous path of losing its economic leadership position and suffering a concomitant decline in living standards because of a looming inability to compete for jobs in the global marketplace. After the publication of *Rising Above the Gathering Storm*, Congress – with strong bipartisan support – passed the America COMPETES Act “to invest in innovation through research and development, and to improve the competitiveness of the United States” (U.S. Congress, 2007). The Act, which forms the basis for structuring federal policy and budgets, pays considerable attention to science, technology, engineering, and mathematics (STEM) education in response to the need to get more of the American population STEM-ready.

About 1,200 community colleges in the United States enroll more than 8 million students annually, yet community colleges have traditionally been an overlooked component in the U.S. education system (Olson & Labov, 2012). Fortunately, that situation is changing.
The administration of President Barack Obama recognized the role of community colleges in ensuring the country’s economic prosperity. During his first year in office, President Obama announced the American Graduation Initiative in an address delivered at Macomb Community College in Michigan (U.S. President, 2009). He enthusiastically highlighted the importance of community colleges: “Community colleges are rapidly growing, and are needed now more than ever to keep America competitive.” Subsequently, the White House held a summit on community colleges, organized by Dr. Jill Biden, an English professor at Northern Virginia Community College and the wife of Vice President Joseph Biden (White House, 2011). On that occasion, Mr. Obama remarked, “In the coming years, jobs requiring at least an associate’s degree are going to grow twice as fast as jobs that don’t require college” (p. 11). Indeed, report after report points to the importance of college education for improving individual income and national economic growth. According to the Bureau of Labor Statistics, the 2012 unemployment rate for persons age 25 and over was 12.4 percent for those who did not complete high school compared to 6.2 percent for those with an associate’s degree. In terms of median earnings, persons without a high school diploma made $471 per week, and persons with an associate’s degree made $785 per week. For those with a bachelor’s degree, the figure was $1,066 (U.S. Department of Labor. Bureau of Labor Statistics, 2013). It is evident that the Great Recession following the 2008 global financial crisis is accelerating the shift to jobs requiring postsecondary education, and the new types of jobs created since have increased the wage gap between college degree holders and everyone else.

The nominal time to obtain a community college’s associate degree is two years, but because many students work full time, the average time to graduation is typically more than that. Furthermore, students who graduated from high school often find a chasm between the requirements for a high school diploma and what is needed to succeed in college and, therefore, require some form of remedial education before proceeding to college-level courses. The terms “remediation,” “developmental courses,” and “basic skills courses” are used interchangeably in most articles. A recent study calculated the annual cost of remediation at community colleges in the United States at $1.9 to $2.3 billion (Bailey, 2009, p. 22). More specifically, “the majority of students entering community colleges are placed . . . into ‘developmental’ (or
remedial) mathematics courses” (Stigler, Givvin, & Thompson, 2010). At the City University of New York (CUNY), over 22,000 students are enrolled in remedial math courses each year, costing the University $33 million annually (Logue & Watanabe-Rose, 2011).

According to a study conducted by LaGuardia Community College’s Achieving the Dream (AtD) Committee (to be discussed below), 59% of new LaGuardia students were placed into math remedial courses (2011). While the organization of remedial mathematics differs from college to college, the sequence at LaGuardia Community College is typical: It starts with MAT095, Introduction to Algebra, that covers basic arithmetic and prealgebra, and goes on to MAT096, Elementary Algebra. A student placed in remedial courses may face up to a full year of math classes before taking a college-level course such as MAT115, College Algebra and Trigonometry, or MAT120, Elementary Statistics I. National data show that most students do not succeed in remediation (Bailey, 2009), and CUNY and LaGuardia data show a similarly depressing pattern: From 2008 to 2012, the pass rates on exit from mathematics remediation ranged from 27% to 41% (City University of New York [CUNY], 2013). Students either get discouraged and drop out altogether, or they get weeded out at each articulation point, failing to pass from one course to the next. Naturally, students requiring remediation graduate from college at a much lower rate than those who do not need remediation. LaGuardia’s AtD data indicate that merely 20% of students who need math remediation graduate, compared to the 36% graduation rate for those students who do not need math remediation. Math is supposed to be the stepping stone to a STEM education, but at the same time, remedial math appears to be a nearly insurmountable barrier for a large proportion of students and has become the biggest obstacle to graduation.

The low graduation rate among students who enroll in remediation certainly does not itself suggest that remedial education is ineffective. After all, students who need remediation tend to have weaker academic skills, and the available data imply only that remediation is not able to make up for the deficiencies. It is quite possible that developmental students would have even worse outcomes if these courses were not available. Nevertheless, improvement in the delivery of developmental mathematics education at community colleges is a pressing need. A growing number of private foundations and the federal government
have turned their attention to this problem, and colleges all over the country are trying new approaches to developmental education. Many schools have instituted courses that teach students how to study, how to organize their time, and how to have a more productive motivational stance towards academic pursuits. They have created forms of supplemental instruction and learning assistance centers. They have tried to break down bureaucratic barriers that make it difficult for students to navigate the complex pathways. Some have redesigned the curriculum; they have accelerated it, slowed it down, or tried to eliminate unnecessary topics (Stigler et al., 2010).

Over the years, LaGuardia Community College has emerged as a prominent player in experimenting with and implementing various strategies for improving remedial math education. In the following sections, I will highlight three large-scale projects in which LaGuardia was involved in partnership with national organizations. The first one is Project Quantum Leap, which was funded by the U.S. Department of Education to teach math in compelling contexts in order to promote student engagement. The second is the effort to infuse supplemental instruction into remedial math, a strategy which was recommended by the Achieving the Dream Initiative and supported by the CUNY Office of Academic Affairs. Then, I will outline the new trend in which students are allowed to take a college-level math course while in remediation, an approach advocated by the Carnegie Foundation for the Advancement of Teaching. Finally, I will introduce the content of this issue of *In Transit* which focuses on teaching and learning math and science. Before discussing these initiatives, I want to describe the math curricular design currently in place at LaGuardia and LaGuardia’s extensive use of technology in math instruction.

**The Nature of Mathematics and the Role of Technology**

Some nonmathematicians attribute the failure of math education to the way school math is taught. Invoking personal experience, they attempt to come up with suggestions for reform based on their own perceptions. As an example, the political scientist Andrew Hacker wrote an op-ed piece for the *New York Times* with a provocative title, “Is Algebra Necessary?” (Hacker, 2012). He argued that many students give up on school because of their difficult experience with algebra. Since algebraic topics such as quadratic equations and polynomials do not seem to
relate to what people need outside the classroom, schools should not force students to study math, given that it holds them back and is not useful. His proposed solution is to teach only quantitative skills that students can use, such as how the Consumer Price Index is calculated. However, although Hacker made some valid points, arguments of this kind largely reflect an outsider's lack of understanding of constraints; they are misleading and create unnecessary distraction. To engage in a useful discussion of math education, it is important to understand the nature of mathematics and the rationale for traditional curricular design.

The curriculum that dominates in American 8th- to 12th-grade classrooms essentially prepares students for calculus, which is the indispensable tool for understanding the natural world and is the gateway to STEM fields (Bressoud, 2010). Remediation is basically a hurried effort to make up student deficiencies in high school math. Traditional curriculum has a highly linear structure: Students need to be fluent in arithmetic before tackling algebra. Algebra, in turn, is a necessary prerequisite to precalculus and calculus must precede the study of differential equations. This linear progression is one of the strengths of the traditional curriculum: “One knows what a student is supposed to learn when and what common mastery can be expected of students in later courses” (Bressoud, 2010). However, this linear structure also makes mathematics “ruthlessly cumulative” (Pinker, 1997, p. 341). A student who lacks certain skills (perhaps simply because he or she missed a few days of school) often finds it extremely difficult to catch up. Furthermore, learning math does not offer instant gratification. It takes many years to become proficient at using the language of mathematics to analyze complex issues such as the Consumer Price Index, and until then, formulas and equations are just alien and abstract concepts.

Recognizing why the curriculum is developed, what the advantage is, and what it is about math that makes it hard is an important first step toward helping students learn how to handle math. Introducing the next step requires some preparation, particularly to understand how the mind works and the distinction between intuition and formal math. The cognitive scientist David Geary has suggested that there are two classes of cognitive ability: biologically primary and biologically secondary (Geary, 1995; Pinker, 1997). Other than simple counting to determine the quantity of small sets, which is a biologically primary ability, most topics in school math, including large number words,
the base-10 system, fractions, multicolumn addition and subtraction, carrying, borrowing, multiplication, division, radicals, and exponents, are biologically secondary. (In the domain of language, reading and writing are biologically secondary abilities.) Children do not have to go to school to learn biologically primary abilities such as walking, talking, recognizing objects, or remembering the personalities of their friends, even though these tasks are much more complex than reading and math. On the other hand, they must go to school to learn written language, algebra, and science, because these skills do not come naturally. With this framework, we are ready to introduce the step crucial to mastering math: practice, practice, practice! Given sufficient repetition, the human mind can become skilled at performing practically any new task, be it swimming, riding a bicycle, typing, understanding and speaking a foreign language, or math. Our grandparents did not know this precisely, but today we can provide a scientific explanation that was not available in the past: The acquisition of skills amounts to the selective development, that is, the creation or strengthening, of various neural pathways in the brain (Devlin, 2005). No one is naturally talented at math; all it takes is sufficient repetition.

Repetition of a particular set of tasks can rapidly become tedious, whether one is learning to play the piano or learning to add fractions. It would be nice if there were some other way, but there is not (Devlin, 2005). Any math reform activist who neglects the boredom associated with drill and practice, the routes to automaticity, is in my opinion an intellectual imposter. But sadly, too many gullible educators and policy makers are misguided by superficially plausible claims purporting that math can be learned in an enjoyable way. While math can be entertaining occasionally, an overemphasis on enjoyment has produced thousands of students with fragmented and shaky knowledge, lacking the computational agility to advance their math level to meet the global competition. To appreciate how much damage “reform mathematics” does in its failure to prepare students, one just needs to talk to any calculus teacher, who will testify that students find the subject difficult not because of derivatives and integrals, but because of algebra. Until students can perform algebraic procedures with little conscious effort, so that they can free limited mental resources for more important features of the problem, they are unlikely to succeed in calculus and enter the STEM fields.
LaGuardia’s math faculty has long emphasized the importance of practice, and recognized that technology is a suitable tool to facilitate extensive practice. Math-learning software basically uses the computer’s random number generator to create many sets of problems for students to practice and gives them instant feedback. With this appreciation of the underlying mechanism and its appropriateness in math instruction, LaGuardia faculty have made tremendous efforts to integrate technology meaningfully into the curriculum. Dr. Kamal Hajallie, who served as Chair of LaGuardia’s Mathematics department from 2004 to 2013, has been instrumental in directing faculty to exploit the benefits of an online learning system called EducoSoft to its full potential. Over the past decade, the Mathematics department has instituted a consistent policy of utilizing EducoSoft software. Starting in 2007, the math faculty has used the system to administer online midterm and final examinations in basic skills courses in an attempt to make the courses fair and consistent among sections. Although these practices sound basic, they all involve significant planning and logistics in terms of space and scheduling.

The EducoSoft system (2013) includes three major functionalities: (a) tutorials, (b) homework, and (c) quizzes. It also collects students’ time-on-task data to allow the instructor to closely monitor students’ progress. Students are encouraged to use the interactive tutorial to preview the material before class, so that professors do not feel pressured to present all the math topics and sample problems hastily. After each lecture, students are required to do online homework to practice problems on their own. The homework module gives instant feedback, and if the students do not answer correctly, EducoSoft can guide them through the solutions and provide additional practice. Because students are allowed to retry homework, the score is entirely under their control. Instructors are encouraged to set strict deadlines, because the rigidity is what most students need to be successful in college. After completing the homework, students take quizzes. Often these quizzes are given after class, without a proctor, to promote student independence and integrity. Unlike the homework, which offers feedback after each problem, students must complete a set of quiz problems to see their score and the analysis of their mistakes. Usually, instructors give students two or three attempts for each quiz to encourage students to learn from their mistakes and retake the quiz to improve their scores.
This policy gives students a clear message that they have the power to improve their grades simply by working harder.

Until 2010, the COMPASS placement exam administered by ACT was used as the exit criterion. Departmental records showed that at least 80% of LaGuardia students who satisfied the departmental requirement and took the COMPASS exam passed. To most educators, LaGuardia’s regimen makes perfect sense. The essence of learning math is doing math: Providing students with ample opportunity to practice using computer software produces positive results. However, while LaGuardia’s basic skills program is admired by CUNY administrators and external observers, no one is satisfied with the situation that many students receive WU (unofficial withdrawal) grades as they simply give up and stop coming to classes. The initiatives highlighted below are designed to help more students succeed.

Developmental Math in Compelling Contexts
As described in the preceding section, equations and formulas are language for describing the natural world. However, many students get the erroneous impression that mathematics is essentially an accumulation of facts, rules, and formulas to be memorized and applied. They view math as dull and difficult. In 2006, Dr. Paul Arcario, then LaGuardia’s Dean for Academic Affairs and currently its Provost, conceived the idea of engaging and exciting LaGuardia’s high-risk, urban community college students by teaching math in “compelling contexts” to those enrolled in basic skills mathematics classes. He was inspired by Science Education for New Civic Engagements and Responsibilities (SENCER), a project initiated in 2001, sponsored by the National Science Foundation. One of the SENCER ideals is to forge a robust connection between science and civic engagement by teaching “through” complex, contested, capacious, current, and unsolved public issues “to” basic science. The goals of SENCER are to get more students interested and engaged in learning in STEM courses, and to strengthen students’ understanding of science and their capacity for responsible work and citizenship (SENCER, 2014).

Before LaGuardia’s involvement, essentially all courses that had been developed based on SENCER ideals had been offered as electives at four-year colleges. In early 2006, Dr. Arcario, joined by faculty members from the Mathematics Department and the LaGuardia Center
for Teaching and Learning (CTL), began to explore how to infuse the SENCER ideals into LaGuardia’s basic skills math courses. Targeting students who had had unsuccessful experiences with math and were most in need of an approach that could interest them more fully, the LaGuardia team sought to strengthen student engagement in the mathematics learning process and advance student retention. LaGuardia presented a proposal to the U.S. Department of Education, and was awarded a $500,000 grant from FIPSE, the Fund for the Improvement of Postsecondary Education (LaGuardia News Center, 2006).

With the support of the FIPSE grant, full-time and adjunct math faculty made a sustained and collective effort to explore new approaches to teaching math and rethinking their classroom pedagogies. Working together in a series of year-long faculty development seminars, known as Project Quantum Leap (PQL), they designed, planned, tested, and discussed new classroom strategies (PQL, p. i). Using the theme of the environment in MAT095, Introduction to Algebra, they developed innovative lessons that included requiring students to calculate carbon dioxide emissions, using math to decide whether paper diapers or cloth diapers are more environmentally friendly, and determining how much electricity we can save by using certain types of appliances. In MAT096, Elementary Algebra, lessons engaged students with questions about public health, including explorations of the issues of asthma and obesity, and calculations of the human and the economic toll of the AIDS epidemic. Students were guided to learn College Algebra & Trigonometry (MAT115), by creating graphs and practicing linear, quadratic, and exponential modeling as they grappled with topics of interest related to the economy and personal finance. In 2009, a collection of math projects and assignments developed by LaGuardia faculty while participating in the seminar was published as the Project Quantum Leap Sampler.

The goals of Project Quantum Leap were to increase student engagement and interest in mathematics, leading to reduced course attrition and improved student learning outcomes. According to the Project Director’s Report submitted to the grant funding agency for the years 2006 to 2010, participating faculty members reduced student attrition in mathematics courses by an average of 40% (Arcario & Eynon, 2011). It also significantly reduced “math anxiety” and built student engagement as measured by the Community College Survey of Student Engagement (Arcario & Eynon, 2011). Since the FIPSE
funding cycle ended, LaGuardia faculty have continued to use the contextualized curriculum. In fact, Project Quantum Leap remains an integral part of LaGuardia’s math instruction, making students aware that mathematical activity is natural and occurs all the time in our lives.

Supplemental Instruction in Remediation

Developmental education is a core part of Achieving the Dream (AtD, 2012), a $100 million initiative funded largely by the Lumina Foundation for Education, an Indianapolis group that focuses on higher education. More than 200 colleges in 34 states are involved in the AtD project (2012). LaGuardia was invited to join this nationwide network in 2009. When President Gail O. Mellow charged LaGuardia’s Achieving the Dream Committee, she outlined three ambitious goals to be reached in 8 years: (a) increase the graduation rate to 47% from the 27% baseline; (b) increase the pass rate out of basic skills (reading, writing, and math) to 80%; and (c) make 80% of LaGuardia’s GED students fully prepared for college-level work.

One of the principles of Achieving the Dream is to use evidence to improve programs and services (AtD, 2012). Specifically, the College establishes processes for using data about student progression and outcomes to identify achievement gaps among student groups; formulates strategies for addressing the gaps identified and improving student success overall; and evaluates the effectiveness of those strategies. Based on this principle of “evidence-based institutional change” (AtD, 2013) and on the experience of other AtD institutions, LaGuardia incorporated supplemental instruction (SI) in basic skills math. SI is an academic support model developed by Deana Martin that uses regularly scheduled peer-assisted study sessions to improve student retention and success within targeted historically difficult courses (Martin & Blanc, 1981). SI sessions are informal study sessions during which students work together to compare notes, discuss course materials, develop study tools, practice problem solving, and prepare for exams. These sessions are facilitated by well-trained SI leaders who attend the course sessions and prepare study materials for use during SI sessions.

LaGuardia’s Academic Peer Instruction (API) program is based on the SI model. Since 1993, under the direction of Dr. Joyce Zaritsky, API has been providing regularly scheduled group study sessions for all students in challenging courses (Zaritsky & Toce, 2006). By encour-
aging all students to participate, even those already doing well, API removes the psychological stigma students feel when they are told to go for tutoring because they are failing. LaGuardia’s API program has been providing academic support for credit-bearing courses until very recently. In 2009, the CUNY Office of Academic Affairs put forth a request for proposals for evidence-based research projects that could lead to better learning in undergraduate mathematics classrooms (Logue & Watanabe-Rose, 2012, p. 3). The competition was an opportunity to fund faculty-led research projects and to encourage CUNY faculty members to consider questions or problems they have encountered in helping students learn mathematics. Faculty were encouraged to devise creative solutions or test ones that they had read about, and to develop the means to assess whether the solutions work. A LaGuardia team, with the author as the principal investigator, responded to the call for action. The team proposed to assign highly trained API tutors in 25 MAT096 Elementary Algebra sections, about half of the total, to promote collaborative learning and effective use of technology. The research hypothesis was that API tutors would motivate students to spend more time studying MAT096 and to use EducoSoft online materials (mentioned above) more effectively, both of which would improve their academic performance. The LaGuardia team was one of the grant recipients chosen from a competitive pool.

The experiment was conducted in the spring semester of 2011. In advance, the principal investigators meticulously recruited and trained the API tutors. During the training, the most important message to the tutors was that they must refrain from instructing or demonstrating step by step how to do a math problem in a misguided effort to make students feel that they understand math. That is illusory learning. We trained tutors to guide students to use the EducoSoft learning system to help them become independent learners. The results were that the overall pass rate for the 625 students in the API group was 58.9% while the pass rate for the 415 students in the control group was 56.6%. In terms of success rate, defined as grades C- or above, the API group led by 5.2 percentage points (33.6% versus 28.4%). The EducoSoft average online tutorial time for the API group was 5 hours and 46 minutes, compared with 3 hours and 12 minutes for the control group. Analysis of the scores on uniform departmental examinations revealed that the API sections consistently showed better outcomes (Wang,
Betne, Dedlovskaya, & Zaritsky, 2012). In short, the study time that participants spent using learning software was associated with positive academic outcomes, and such an association is plausibly causal.

Encouraged by the promising results, LaGuardia allocated Coordinated Undergraduate Education (CUE) funds to continue the API intervention. One important modification of the experiment in the second year was a mandatory online tutorial session. In 2011, the researchers found that most students were more concerned with finishing homework and lab assignments than actual learning. Some students did so by playing the system: They tried to breeze through the sections by repeatedly clicking the hint—hardly effective learning. The LaGuardia team worked with the EducoSoft company to reprogram the software to activate a prerequisite tutorial before students can open each lab assignment, so that students are compelled to follow the tutorial to learn the mathematical principles, rather than simply completing tasks. This change drastically increased the average time that students in the API group spent on the tutorial to more than 15 hours and 20 minutes, compared with the control group’s 4 hours and 49 minutes. Again, the API sections had better outcomes in every exam, and their average success rate was 8.0 percentage points higher than control sections (Wang, Toce, & Zaritsky, 2013). LaGuardia’s API study illustrates the faculty’s commitment to using data to formulate strategies to improve student success. And what is the key to student success? Practice! This notion is certainly not new, but such a simple message is also the most powerful message for our students.

Statway
It was mentioned earlier that the sequence of remedial courses at LaGuardia is designed to prepare students for precalculus and calculus. Despite the national effort to encourage students to pursue studies in STEM fields, data and anecdotal evidence indicate that the majority of students in community colleges are not interested in STEM fields and, thus, neither need nor want to study calculus. Some educators believe that the traditional algebra-intensive, precalculus-focused developmental sequence has the wrong goals for students not bound for STEM majors and thereby creates unnecessary impediments to their academic progress (Cullinane & Treisman, 2010). They contend that the college-level, credit-bearing and transferable course most appropriate for many
nonSTEM students is statistics. The choice of statistics as a focus of a new pathway was in part motivated by the belief that it makes fewer demands on students’ algebraic manipulation skills. Although this position is controversial, most educators tend to agree that students, whether in STEM majors or not, would benefit from taking statistics. In this age of Big Data, it is difficult to function in our society without a basic understanding of statistics.

With the intent of integrating developmental mathematics and statistics into a one-year course for community colleges, the Carnegie Foundation for the Advancement of Teaching has launched a comprehensive initiative to create a curricular model called Statway which focuses on statistics, data analysis, and quantitative reasoning. The Statway sequence prepares students for college statistics, decreasing the number of courses they must complete by identifying and focusing on those algebraic skills most relevant to the study of statistics. By integrating developmental mathematics topics with statistics instruction, Statway enables developmental math students in community college to complete a credit-bearing, transferable mathematics course in one academic year while simultaneously building skills for long-term college success. The first cohort of students began Statway in the fall of 2011. Among these 1,077 students from 20 institutions across seven states taught by 53 different faculty members, 550 students, or 51%, had completed the Statway course and earned a grade of C or higher in the final term (Strother, Van Campen, & Grunow, 2013).

At LaGuardia, the AtD data show that earning no credits has a profoundly negative impact on student success. Specifically, a student with one semester of zero credits has a 9% graduation rate, in contrast to a 39% graduation rate for a student who earned credits in each semester of attendance (Dickmeyer, 2013). Statway’s accelerated path toward the earning of college credit seems to be a promising strategy. For this reason, in the 2013–2014 academic year, LaGuardia is piloting six sections that combine MAT096, Elementary Algebra, and MAT120, Elementary Statistics, using the Statway curricular model. Students enroll in this combination of courses for 8 hours per week, 6 lecture hours and 2 computer lab hours, in one 12-week semester. Students receive 3 credits for the statistics portion and fulfill the requirements of MAT096 at the same time. The MAT096 portion of the combined course is designed as a “flipped classroom” that minimizes lecturing. Instead, students are
given short worksheets to work on in the classroom and receive immediate personalized feedback on their performance (M. Cuellar, personal communication, June 27, 2013). There is a consensus that more and more jobs will require data skills, and LaGuardia’s participation in Statway should motivate students to persist and eventually graduate.

**An Ongoing Endeavor**
Contextualization of developmental education, supplemental instruction, and accelerated paths to earning college credits described in the previous three sections are LaGuardia’s responses to the national crisis of remediation. But the story does not end there. LaGuardia faculty and college administration continue to collaborate to advance innovative teaching to promote student success. As noted by LaGuardia Middle States Team, 2012, the Center for Teaching and Learning (CTL) plays a pivotal role in engaging and supporting faculty to design, implement, and assess promising pedagogical practices. Among the CTL’s professional development opportunities is The Carnegie Seminar on the Scholarship of Teaching and Learning, the framing perspective of which is increased emphasis on the scholarship of teaching and learning (SoTL), a concept introduced in 1990 by Ernest Boyer, then president of the Carnegie Foundation for the Advancement of Teaching. Mathematics professors and Carnegie Scholars, Curtis D. Bennett and Jacqueline M. Dewar define SoTL as

> the intellectual work that faculty do when they use their disciplinary knowledge (in our case, mathematics) to investigate a question about their students’ learning, submit their findings to peer review, and make them public for others in the academy to build upon. (p. 459)

National groups such as the National Academies (National Research Council, 2012), the American Association of Colleges and Universities (AAC&U, 2014), and the National Center for Science and Civic Engagement (NCSCE, 2014) continue to advance SoTL. Yet after more than two decades, SoTL goals, methods, and accomplishments remain unfamiliar to many math and science faculty. Determined to bridge the gap in SoTL practice at LaGuardia, the 2011–2013 Carnegie Seminar, facilitated by Michele Piso (CTL), Dionne Miller (Natural
Sciences) and Patricia Sokolski (Humanities), invited four Mathematics, Engineering, and Computer Science and six Natural Sciences faculty to engage in systematic classroom inquiry. As exemplified by the works-in-progress included in the current issue of *In Transit*, SoTL projects range from modest interventions in a single classroom to more elaborate research designs. *In Transit*, V6 proudly introduces work by 2011–13 Carnegie Seminar participants Dennis Aguirre, Maria Entezari, Reem Jaafar, Mangala Kothari, Dionne Miller, Zahidur Rahman, and Dong Wook Won.

Outside the Carnegie Seminar, faculty across the disciplines are equally determined to confront the STEM crisis. Former Carnegie participant, Leslie Aarons, argues for solutions to the problem of underrepresentation of women and minorities in STEM fields. In “Recalculating a Core Competency: New Approaches to Quantitative Reasoning at LaGuardia Community College,” Justin Rogers-Cooper, co-leader of the Quantitative Reasoning strand of the Strengthening Core Learning seminar, and Roslyn Orgel and Judit Török, past co-leaders of PQL, report their experiences in the CTL professional development seminars emphasizing pedagogies designed to increase students’ quantitative reasoning skills.

Demystifying misconceptions, the memoirs of Professors Yelena Baishanski, Milena Cuellar, Marina Dedlovskaya, Preethi Radhakrishnan, Bill Rosenthal, Paul West, Burl Yearwood, and Shenglan Yuan represent the wide diversity and individuality of our math and science faculty. Their accounts reveal passion, determination, diligence, and perseverance, each one a life-changing encounter with joy, creativity and imagination. Finally, I believe that the readers will be surprised and fascinated by the rich memoirs contributed by colleagues who have feared and loved math and science. With humor and modesty, the “math phobes” – Hugo Fernandez, Naomi Greenberg, Louis Lucca, Deborah Nibot, Roslyn Orgel, Bernetta Parson, Michael Rodriguez, and Michele Piso – briefly describe past struggles and present reconciliations with math. May their efforts and discoveries encourage us to become better teachers and explorers of a subject too often associated with humiliation or approached with awe or intimidation. For too many of our students, math and science are the make or break courses driving down retention and smashing dreams. I introduce this issue of *In Transit* with the hope that its pages inspire us as a whole community,
undivided by background or discipline, to reconsider the place of math and science in our conversations and curricula, and in events across campus and throughout our shared world.

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Notes

1. LaGuardia’s AtD data mentioned in this paper are based on the Fall 2003 cohort of new, first-time students.

2. I want to make it clear that technology is not the perfect solution for every course; it can actually be misused and cause harm.

3. Nowadays, all major publishers have similar online supplemental components. One of the most widely used alternatives is MyMathLab by Pearson Education (2014). Another system is ALEKS by McGraw Hill Education (2014).

References


STEMming Inequities

Leslie Aarons, *Humanities*

*One of the things that I really strongly believe in is that we need to have more girls interested in math, science, and engineering. We’ve got half the population that is way underrepresented in those fields and that means that we’ve got a whole bunch of talent … that is not being encouraged…*

– President Barack Obama, February 2013
(U.S. Executive Office, 2013)

Since the late sixties, women have made considerable progress in education and the workplace, achieving visibility in historically male-dominated fields such as medicine, law, and business. But women’s representation in science education has not progressed at the same pace (Bentley & Adamson, 2003). In professional fields related to science, technology, engineering, and mathematics (STEM), recent and extensive research in gender inequities has revealed a dramatic quantitative disparity between male and female presence.

In academia, for example, male tenure-track faculty continue to be forerunners in STEM disciplines. Despite making up nearly half of the college-educated workforce, women “hold less than 25 percent of STEM jobs. This has been the case throughout the past decade, even as college-educated women have increased their presence in the overall workforce” (Beede et al., p. 1). Contributing to gender disparity is the common belief that men are by nature more interested and better skilled in STEM subjects. This article challenges such sociocultural biases and demonstrates how they contribute to inequities in STEM, both in higher learning and in the professional world. It seeks to raise awareness of the need for impartial pedagogies and hiring practices that encourage more inclusive opportunities for STEM success, and offers a critique of the dynamics of gender and gendering that thwart girls’ and women’s participation in STEM academic disciplines and industries and hinder equal opportunity. Our purpose is to move the argument away from assumptions about nature and “natural” cognitive ability toward the view of underrepresentation as effects of culture and social and political conventions. To that end, we offer a brief review of key governmental
interventions and academic inquiries aimed at reducing the drop-out rate and low representation of women in STEM-related academic disciplines and professional fields.

**Making Math and Science Women’s Work**

Many young women graduate from high school with the skills needed to succeed in STEM majors, but a 2010 study by the National Science Board (NSB) indicates that women entering college are less likely than men to choose STEM majors and careers (National Science Board [NSB], 2010). Critical to women’s success in earning degrees in STEM disciplines is the culture of academic departments with the power to shape the assumptions, expectations, and values that influence the behavior of professors, staff, and students. Faculty may not be aware of the impact that their departmental culture has on factors that range from pedagogy and curricular design to student advisement. For example, much of the literature regarding inequities in STEM suggests that the study and practice of science and math are usually considered to be “men’s work” (Eccles, 2006).

The bias that underlies decisions to enter STEM disciplines has been shown to have a negative impact on female students’ degree of self-motivation and ability to develop appropriate skill sets. If educators are to reach young women and other underrepresented students at a critical stage in their lives, we must identify, acknowledge, and reflect upon the often unconscious biases that impede our students’ progress, and we must remedy these lapses with methodologies that promote more equitable representation and successful learning outcomes in STEM disciplines.

Those teaching in community colleges are especially well-positioned to respond to the challenges faced by women and other underrepresented students, and at LaGuardia Community College, there are a number of initiatives to do so in the Math, Engineering, and Computer Science department. The 2012 “Community Colleges in the Evolving STEM Education Landscape: Summary of a Summit” report notes,

Community colleges are an often overlooked but essential component in the U.S. STEM education system. About 1,200 community colleges in the United States enroll more than 8 million
students annually, including 43 percent of U.S. undergraduates (American Association of Community Colleges, 2011; Mullin and Phillippe, 2011). Community colleges provide not only general education but also many of the essential technical skills on which economic development and innovation are based. Almost one half of the Americans who receive bachelor’s degrees in science and engineering attended community college at some point during their education, and almost one-third of recipients of science or engineering master’s degree did so (Tsapogas, 2004). About 40 percent of the nation’s teachers, including teachers of science and mathematics, completed some of their mathematics or science courses at community colleges (Shkodriani, 2004). (National Research Council [NRC], p. 2)

Though underrepresented minorities now account for almost 40 percent of K–12 students in the United States, they earn only 27 percent of the associate’s degrees from community colleges, only 17 percent of the bachelor’s degrees in the natural sciences and engineering, and only 6.6 percent of the doctorates in those fields. (NRC, p. 12)

The focus of this paper is gender inequity in STEM disciplines, but its argument implies that obstacles to women’s progress are also responsible for stemming success for other minority groups. In fact, an analysis of gender discrimination can contribute to a much-needed dialogue about how cultural biases in the classroom impede progress for all of us.

The Obama Administration’s “Educate to Innovate” Campaign
Recognizing that the United States is in a disadvantageous position in both its own domestic progress and in its competitive status in the global market, President Barack Obama has launched Educate to Innovate, a partnership between the federal government and “leading companies, foundations, and non-profit organizations and science and engineering societies” (2013). Among its major goals, and the one most relevant to this article, is “broadening participation to inspire a more diverse STEM talent pool” (2013). In June 2012, the President received an open letter from the Business-Higher Education Forum
(BHEF) establishing a partnership between the government and a host of powerful professionals, American academic organizations, and elite industries. The letter stated:

Of particular concern to us are the first two years of college, when students, especially women and underrepresented minorities, are most likely to switch out of STEM fields into other majors or not complete a degree at all. (Business-Higher Education Forum [BHEF], 2012)

The “priorities” of this partnership are as follow:

• Increase the number and diversity of undergraduates in STEM disciplines and the rate at which they graduate and enter the STEM workforce or enroll in graduate programs.
• Better align undergraduate education (including community college education) with STEM industry workforce needs in strategic areas.
• Identify roles and responsibilities for academic, industry, and government organizations in studying, advancing, and evaluating comprehensive and systemic reform in undergraduate STEM education and workforce development, recruitment, placement, and retention. (BHEF, 2012)

If the government achieves its goal of increasing the number of STEM graduates by one third by 2020, an additional one million graduates will join these fields (Cross-Agency Priority [CAP] Goal, 2013). Most relevant to this paper is Educate to Innovate’s central goal of reducing gender disparity in STEM fields (U.S. President, 2012). As its highest charge, Educate to Innovate seeks to transform our society’s normative views of gender roles and what is believed to be socially and behaviorally appropriate for girls and women.

Change Your Perspective, Change Your World
Drawing on a substantial and diverse body of research, a longitudinal study conducted by the American Association of University Women (AAUW) supports growing evidence that social and environmental factors – lack of role models, gender bias, absence of family-friendly flexibility in the workplace – result in the underrepresentation of women in science and engineering (Hill, Corbett, & St. Rose, 2010). The study found that throughout their elementary, middle, and high school
educations, boys and girls enroll in math and science courses in equal numbers. But in spite of the fact that almost equal numbers of females and males graduate from high school prepared to pursue science and engineering majors in higher education, fewer young women than men actually enroll in these majors. In almost every science and engineering major, men continue to outnumber women; for example, only 20 percent of bachelor’s degrees in physics, engineering, and computer science are awarded to women (Nosek et al., 2009). In sum, as female students progress through their undergraduate education, their participation in science and engineering diminishes, and their participation diminishes further at the graduate level, a decline that continues into the STEM workforce.

In attempting to explain the deficit of women in STEM fields, there is, as noted above, an intriguing consensus among researchers that social biases discourage women from STEM pursuits. Three main trends have been identified. First, there is the prevalent belief that men are superior to women in mathematics and inherently better suited to STEM fields. This cultural belief is epitomized by the now infamous speech given by former Harvard University President Lawrence Summers on January 14, 2005. In a keynote speech at a conference on diversity, Summers theorized that the underrepresentation of female scientists at top universities may substantially be due to innate differences between men and women, making male students naturally more proficient in STEM subjects. Second, social and academic practices discourage girls’ and women’s interest in STEM. A third consensus in the research cites discriminatory STEM workplace practices, including the academic workplace, with concerns ranging from work-life balance to gender bias. These trends merit our consideration.

Anatomy Is Not Destiny
Contrary to persistent stereotypes, recent research indicates that men are not superior to women in math or inherently better suited to STEM fields. Ceci, Williams, and Barnett (2009) conducted a review of more than 400 articles examining the reasons for women’s underrepresentation in STEM fields. Their study found that the evidence for a hormonal (biological) basis for the relative deficiency of female scientists is “weaker than the evidence for other factors,” such as environmental and social barriers, including stereotypes, gender bias, and the partisan climate of science and math pedagogies in education (p. 224).
Inspiring Female Students to Succeed in STEM

A second trend raises the essential question of how – directly or inadvertently – female students are discouraged from engaging in STEM study. A number of provocative theories address this sociocultural predicament. For example, the 2010 AAUW report states:

Most people associate science and math fields with “male” and humanities and arts fields with “female,” according to research examined in this report. Implicit bias is common, even among individuals who actively reject these stereotypes. This bias not only affects individuals’ attitudes toward others but may also influence girls’ and women’s likelihood of cultivating their own interest in math and science (Hill et al., 2010, p. xvi).

In fact, many female students report that they are not interested in science and engineering. In 2009, the American Society for Quality (ASQ) conducted a survey of more than one thousand youths aged 8 to 17 (American Society for Quality [ASQ], 2009). The poll found that boys (24%) are significantly more likely than girls (5%) to say they are interested in an engineering career. Also, 31% of boys vs. 10% of girls say their parents have encouraged them to consider an engineering career. “It’s clear that there is a low level of interest and knowledge about engineering careers for both parents and children,” notes Maurice Ghysels, chair of ASQ’s K–12 Education Advisory Committee. He continues, “Educators and engineers need to work more closely together to get students excited about the profession and spotlight interesting role models.”

Stanford sociologist Shelley J. Correll has conducted research on how cultural beliefs about gender influence educational and career choices. Although there are many factors that can influence one’s interest in a career choice, Correll stresses the personal belief that one can succeed in a particular career path is essential (Correll, 2001). While teaching high school chemistry, Correll became interested in the dissimilarity between boys’ and girls’ self-assessments of their abilities in math and science. In particular, she noticed a marked difference between boys’ and girls’ confidence in their math and science problem-solving skills. For example, however poorly the boys performed on tests and projects, they remained self-confident. Yet no matter how well the girls performed on the same tests and projects, Correll found
that they doubted their aptitude. In her research, she explains the ways sociocultural stereotypes deeply erode girls’ and women’s confidence to be successful in STEM subjects. Similarly, Singh, Allen, Scheckler, and Darlington (2007) found that female undergraduates in computer-related majors often report having lower self-confidence than their male peers in their abilities to succeed in the field. This finding holds true regardless of success outcomes.

Research indicates that even if individuals do not personally believe that men are better than women in math and science, there remains an awareness that this belief exists and is endorsed by our culture. For women and other underrepresented groups, such endorsement creates an expectation of discrimination and hardship in STEM pursuits (Foschi, 1996). This research suggests that the perception of a male propensity to succeed in STEM disciplines may function to heighten boys’ and men’s self-regard and lower it for girls and women.

It has been shown that positive and equitable expectations in a student’s immediate classroom environment can supplant the more general (i.e., negative and inequitable) expectations of their sociocultural environment (Whitten et al., 2007). That is, educators can counter and remedy discriminatory tendencies in the social realm by creating and implementing pedagogies that reinforce the value that all students are equally capable in and essential to STEM studies and career pursuits. When this message is communicated in the classroom, women tend to assess their own abilities and interests in STEM more accurately. Further, by engaging students to think critically about gender stereotypes, we can promote a culture of respect that will enable everyone to reach their fullest academic and professional potential.

Creating a More Inclusive Workforce
A number of factors play a role in job retention, among them job satisfaction. Women and people of color are more likely than white men to report that they are dissatisfied with their academic workplace; and these individuals are more likely to vacate their positions earlier in their career. It has been found that female STEM faculty are less professionally satisfied than their male colleagues: These women report feeling that they do not “fit” in their departments and cite the challenges of balancing work and family obligations while on the tenure track (Trower & Chait, 2002).
Equitable practices in hiring, promotion, and tenure are imperative to creating successful teaching and learning environments. Better hiring practices must be put in place to ensure that instructional staff is selected from the entire pool of qualified and skilled individuals. A broadly representative pool can be better assured by recruiting women and candidates from underrepresented groups to participate in the application process.

Increased numbers of female faculty may also improve a department’s ability to attract and retain female students. Improved gender ratios may, in turn, help to establish the environment necessary for successful teaching and learning outcomes. Periodic departmental reviews help to assess the climate for faculty. It is crucial to create an inclusive departmental culture by communicating consistent messages to all faculty and by ensuring equitable practices for all tenure-track faculty.

Encouraging the Chic Geek
A host of additional researchers concur that the perception of being excluded from a field can derail a student’s confidence in her ability. The AAUW report *Why So Few?* quoted Allan Fisher, co-author with Jane Margolin of *Unlocking the Clubhouse: Women in Computing* to the effect that “there is a dominant culture of ‘this is how you do computer science,’ and if you don’t fit that image, that shakes confidence and interest in continuing” (Hill et al., p. 60). Citing a study of women’s experiences in the School of Computer Science at Carnegie Mellon University, Margolis and Fisher maintain that “a critical part of attracting more girls and women in computer science is providing ways to ‘be in’ computer science” (p. 72). In other words, in order to succeed academically, students must feel that they “belong in” their discipline.

One way to create a healthy and inclusive climate in academic departments is to project an unbiased or gender-neutral image of the “good” STEM student. Colleges and departments can create a “brand” that encourages young women to see themselves as vital participants in these disciplines and fields. Departmental social activities and other cocurricular events can make students feel that they are a part of the valuable mission of their department. Faculty should get involved in actively mentoring student-driven academic clubs for their respective disciplines. Such cocurricular opportunities foster interaction among
undergraduate majors outside of the classroom, creating a space that promotes inclusiveness and enlivens student interest in the field.

Actively recruiting female students into the major is another effective approach to stimulate interest. Open houses and mentorships can provide interested new students with pathways to the major. Many students enter college, especially community college, unsure of what field of study they want to pursue. Departments can attract new majors by organizing stimulating activities and offering courses that appeal to students’ interests at varying levels of difficulty.

LaGuardia’s own Mathematics, Engineering, and Computer Science department is proactively involved in a number of exciting initiatives to attract and encourage students who are underrepresented in STEM. For example, the goal of the “Women in STEM Day” programs held in Fall 2013 and Spring 2014 is to offer students opportunities to interact with women faculty, researchers, and staff who are active in STEM fields, and create a supportive environment for female students in STEM majors. In “Talks” organized by the Math Society, speakers introduce students to math beyond the textbook and engage women and other underrepresented LaGuardia students in scientific discussions. In February 2014, Dr. Michael Dorff, founder and director of the Center for Undergraduate Research in Mathematics at Brigham Young University, gave an inspiring talk entitled “How Math is Changing the World” in which he discussed career opportunities in STEM fields. These are just a few examples of the many activities that are underway at LaGuardia to encourage women and minorities interested in pursuing STEM majors and career goals. Community college educators are at the center of an exciting era. Presented with an historic national initiative, we have the privilege and opportunity to help remedy the inequities in STEM fields and professions, thereby promoting greater progress and innovation for everyone.
REFERENCES


Carnegie Seminar on the Scholarship of Teaching and Learning

Math and Sciences
Works-in-Progress
JUMPing Math

Dong Wook Won
Mathematics, Engineering, and Computer Science

Abstract
The JUMP Math program, a recently developed teaching model, claims effectiveness in teaching mathematics in grades 1 through 8. JUMP Math is organized around three guiding principles: small breakdowns, raising difficulty incrementally, and praise and encouragement. Tested in Canada, application of the JUMP methodology has been associated with significant increases in children’s test scores. This paper studies the effectiveness of applying JUMP methods and materials in two basic skills mathematics classes at LaGuardia Community College. A slight increase in passing rates suggests that JUMP Math may improve student learning in basic skills mathematics courses.

Keywords: JUMP math, math pedagogy, basic skills math, math anxiety

Introduction
One Korean afternoon in the autumn of 1986, a class of about 55 male middle school students fell silent as the mathematics teacher scanned the roster to send one of us to the front of the class. It was homework assignment checkup time and we were expected to show to the entire class the solution to a problem chosen by the teacher. If the student solved the problem successfully, he received a brief compliment. But if the solution was incorrect or, worse, if one had nothing at all to contribute, the student had to face the board. Rather than bestowing praise, the teacher penalized the student with swift raps to the calves with the so-called “stick of love.” In Korea, we have a saying: “A good teacher beats his student out of love.”

The scene described above is a memory of my middle school years in Korea: a class full of students, a teacher with total authority, instruction directed from the teacher to students, and a traditional method of punishment for expectations unmet. Consequently, the classroom atmosphere was docile. Even if at the end of the lesson our teacher routinely asked for questions, no one raised a hand. In sum, I learned mathematics in middle and high school according to the traditional cycle, i.e., teachers lectured, drilled, and gave more problems for homework.
Before the next day’s lesson, students prepared the assigned homework, and, once back in class, waited to be summoned to the blackboard. While we were punished for unsatisfactory homework, it was largely left to us to figure out how to solve the assigned problems. Most people – teachers, parents, and even students – believed that learning results only from individual effort. The teacher and the school provided the struggling student with virtually no attention or support other than saying, “You should study harder.” Many students had to find their own ways to overcome their obstacles, such as finding math books to supplement the textbook or engaging expensive private tutors. The results were not always successful and many students lagged behind in the course. To them, mathematics was a subject that they simply did not understand. Some of my classmates became totally uninterested; I still remember some members of my high school math class, sleeping in class and others using math class to study English for the college entrance exam! It is embarrassing, but I must confess that I was one of those many students who did not understand much math in my high school days.

With the exception of the “stick of love,” I have observed similarly depressing behaviors and attitudes in my basic skills mathematics courses at LaGuardia Community College. Students in MAT095 (Introduction to Algebra) are often convinced that they will once again fail to understand the same mathematics that they had not understood in middle or high school, that they will not get the necessary help from the instructor, and they will be left alone to decipher problems. Given these anxieties, the atmosphere of a basic skills math class can be quite different from the atmosphere in upper level math classes where, despite a bit of nervousness, students are highly energetic and hopeful about learning a new subject.

As I was raised without the expectation of academic support, I did not, as an instructor, acknowledge at first the psychological dimension of learning and its effects on student success. However, I gradually realized that students with little confidence in themselves and in their ability to learn math tend to give up easily when encountering difficulties. Worse, if the math professor’s methods are identical to those that were wasted on the students earlier in their education, it is very likely that these students will repeat their failures in college. Again and again, I found that students who had difficulty understanding fractions in
high school will experience the same difficulty in college, and students challenged by decimals in high school will most probably anticipate similar challenges in basic skills math. To break this cycle of math failure, we must develop and employ an instructional method that will help the weakest student understand and master math, a process of teaching that, step by step and with sustained effort, can guide the student to experience success when learning mathematics, developing math confidence, not from praise or penalty, but from methodically “doing” mathematics.

Background: Challenges to Learning Basic Skills
Teaching basic skills mathematics (also known as remedial mathematics or developmental mathematics) in community college is a difficult task. About three-fourths of community college students are advised to take basic skills mathematics courses before they take the college’s credit-bearing courses (Birmingham & Haunty, 2013). As widely reported, the pass rate for these courses is discouraging. A study from 2006 revealed that only 30% of the students who took a basic skills mathematics course passed the course and the percentage is even lower for students who completed the sequence of basic skills mathematics courses in 3 years (Attewell, Lavin, Domina, & Levey, 2006). I have experienced similar results in the basic math courses I teach at LaGuardia Community College.

Reasons for poor math performance vary: inaccurate placement, family obligations, financial pressures, or, as discussed in this paper, a personal lack of confidence to “do math” (Birmingham & Haunty, 2013). Indeed, it is not unusual to hear math basic skills students casually remark, “I was never good at math;” “Math is not my subject;” or, “I hate math.”

More troubling, if many students feel that they were not born for math, it is also true that many basic skills mathematics instructors agree with them. Faced with the ongoing challenges of delivering their knowledge to remedial students who “hate math,” even the most dedicated teacher might express, in exasperation: “These students are different;” “They are especially difficult;” or, “You cannot do anything for them.” In short, before the first class even begins, students and faculty alike may doubt that they will find joy in learning or teaching math.
Compounding the emotional challenges of teaching and learning math is the course structure: content-heavy, lecture-based, and designed to accommodate a 12-week semester. In class, time constraints force coverage to supplant “uncoverage.” Unfortunately for the learner, coverage wins the conflict between the need to cover large amounts of information and the lack of time required to create deep knowledge. In distinguishing between coverage and uncoverage, Mark Sample, blogging in The Chronicle of Higher Education, refers to Understanding by Design, by Grant Wiggins and Jay McTighe:

To highlight the pitfall of coverage as the default model of course design, Wiggins and McTighe recall a more “ominous” definition of the verb *cover*: “to protect or conceal, to hide from view” (106). They suggest that in the race to cover more ground – more history, more literature, more formulas, more physics – we can end up actually *covering or hiding* the underlying principles that make those subjects important in the first place. Uncoverage, in contrast, emphasizes revealing assumptions, facts, principles, and experiences that would otherwise remain obscured. Uncoverage is uncovering in order to learn something new; uncoverage is digging down. (Sample, 2011)

In my own classes, I have observed that at the initial phase of learning, students can recognize a topic introduced in class. But as suggested by Sample, real “knowing” implies a deeper comprehension that leads to the ability to solve problems presented in a variety of contexts. The gap between *covering/recognizing* and *uncovering/knowing* and the tension between the needs of coverage and the lack of time undermine the very nature of mathematics, a discipline whose procedures build upon each other, step by step, level by level. In other words, fluency in the application of math procedures requires returning again and again to previously covered topics. Thus, if students do not master the procedures up to a level at which they can solve problems independently, their weak comprehension will prevent progress. Although practice is essential to any skilled endeavor, whether math or music or learning a language, practice is of particular significance for students whose mathematical maturity is not well developed.
The JUMP Method

JUMP (Junior Undiscovered Math Prodigy) Math is a teaching program started in 1998 by John Mighton, an award-winning Canadian playwright, author, and mathematician (Mighton, 2004). JUMP began as an after-school tutoring program for children struggling to learn mathematics and evolved into a method that promised an effective approach to teaching mathematics within the classroom. While few peer-reviewed research papers have explored the effectiveness of the JUMP Math instructional model, several reports published on the JUMP Math website (http://jumpmath.org/cms/) testify to the success of the JUMP Math program in elementary schools in Canada (e.g., JUMP Math: Brock, 2005) and the United Kingdom (e.g., Aduba, 2006).

Based on current brain research, JUMP Math’s learning model proposes that mathematical intellect can develop suddenly from a series of small advances in learning based on three principles: small breakdowns; raising difficulty incrementally; and praise and encouragement. The transformation is comparable to a chemical process: If one keeps adding a drop of a chemical substance to a chemical solution, at some point the color of the solution will suddenly change. Similarly, through an accumulation of small successes, an instructor adopting JUMP principles can change students’ abilities to do mathematics (Mighton, 2008).

Small Breakdowns

To achieve a learning shift, JUMP Math reduces complex learning materials in mathematics to a set of small, basic, and intuitive concepts and procedures. In mathematics, one can always reduce a difficult concept or procedure to a series of simpler ones. This is how mathematics is constructed: Starting from a small number of axioms, mathematicians build larger and more complex structures. When a student has difficulty grasping a concept or procedure, often it is because he or she does not understand one part of the complex structure. Once that lack of understanding is overcome, the student can suddenly develop the whole idea. Thus, when a mathematical concept is presented as a series of simpler and more intuitive ideas, even the complicated-looking overall concept can be grasped and eventually appreciated, as each of the simpler concepts is mastered (Mighton, 2014).
Raising Difficulty Incrementally
This shift in learning will not occur if students do not feel confident in class. In the JUMP Math program, students gain confidence by accumulating a number of small successes, mastering concepts, and solving problems. JUMP Math instruction starts from a very elementary level, so that even students with little knowledge and understanding of mathematics can follow the instruction. Unique to JUMP Math is the incremental raising of the level of difficulty, so that students gradually face slightly harder problems. To make sure that students are not suddenly overwhelmed by difficult problems, the gradual progression in complexity is presented very carefully. JUMP Math will always parallel natural learning styles, a method of instruction that can have an especially big impact on slow learners and those with learning disabilities (Mighton, 2014).

Praise and Encouragement
In each JUMP Math class, students will work and practice carefully designed exercise problems. When an instructor checks a student’s work in class, the small breakdown design will reveal how well the student is actually doing. When an instructor observes students’ success in completing assigned problems in class, she or he will provide immediate feedback and praise students’ work. The praise and encouragement will be a driving force for students to continue doing mathematics (Mighton, 2014).

The following graphs shows dramatic differences in the performance of students in Toronto, Canada on the Test of Mathematical Abilities (TOMA) after the adoption of JUMP Math (JUMP Math Research, 2013).
Implementing JUMP in a College-Level Basic Skills Math Course

While there is much research on remedial mathematics education, research that measures the impact of different approaches to remedial math education is scarce. In fact, there is no consensus about how to teach basic skills mathematics most effectively (Bailey, 2009). The purpose of the present paper is to investigate whether community college students enrolled in basic skills mathematics and exposed to the JUMP

1. The Test of Mathematical Abilities (TOMA) is a widely-used, normed test.
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approach could realize a significant increase in academic performance similar to those shown in Figure 1 above.

Several elements stand out as hurdles to student learning in basic skills mathematics. Some students experience personal problems such as family and financial issues while taking the course (Rath, Rock, & Laferriere, 2013, p. 11–12). Others have a hard time in class because of inaccurate placement (Community College Research Center, 2012). Most important among the hurdles, in my opinion, is the conflict between the amount of basic skills content and the instructor’s methodology and teaching philosophy, a challenge summarized by Swail (2013): “You can’t fix 13 years of schooling in one or two remedial courses” (emphasis in the original).

A basic skills mathematics course is, by definition, a “review” course. That is, students are assumed to have some prior familiarity with the skills and topics; based on this assumption, the syllabus is heavily loaded with review content. For instance, at LaGuardia Community College, students in the MAT095 course (Introduction to Algebra) need to master the arithmetic of integers, fractions, and decimal numbers; understand the basic facts of whole numbers; analyze word problems on diverse topics; solve linear equations and linear inequalities; and learn scientific notation; and all of these skills and knowledge are to be internalized in 12 weeks. In fact, however, this “review” course cannot function as a true review course: Too many students lack the prerequisite knowledge.

In addition, students’ previous math experiences may confound their professor. For example, for some students, earlier experiences of failure have created extremely negative feelings toward mathematics. A second frustration for the instructor is the diverse levels of student familiarity with course topics: Some students feel confident working on integers, while others do not. Most students are not confident about working with fractions, and some students are as deficient at decimals and percentages as they are with fractions. Hence, very often the instructor has to assume that the class has no uniform knowledge of the topic under discussion.

The lack of uniformity creates a problem with pacing lectures. The instructor is required by the department to teach all the topics in the syllabus even if some students do not have the necessary prerequisite knowledge. The lack of uniform prerequisite knowledge creates
pedagogical dilemmas in deciding what to emphasize and where to spend extra time. If the instructor fails to identify accurately which topics require more time, the result is confusion caused by moving too quickly or disengagement brought on by redundancy. The traditional instructional model lacks an efficient method to check student understanding of course concepts and topics; in other words, checking means sacrificing class time. The traditional method forces instructors to place greater stress on covering all the topics in the syllabus than on uncovering/discovering which topics require deeper comprehension. Needed is a methodology that allows instructors to teach students mathematics well enough to enable them to work independently, while maintaining a reasonably paced course schedule.

In addition to the problem of pacing, another reason that the traditional lecture-based instructional model does not work well in basic skills mathematics courses lies in the very nature of mathematics. As mentioned earlier, mathematics builds upon itself. Again, if a student does not master a skill up to the level at which he or she can independently use the skill to solve a math problem, that gap will weaken the student’s ability to learn a new topic. And the importance of the psychological dimension of teaching and learning basic skills mathematics cannot be overestimated, especially since students who perceive that they have fallen behind their peers enter basic skills mathematics courses feeling stigmatized by “remediation” and demoralized by low self-confidence (Birmingham & Haunty, 2013).

To resolve these issues in basic skills mathematics courses, we need to find an instructional model in which (1) students do not feel inferior when doing mathematics, and (2) instructors teach all topics in the syllabus effectively so that students can do mathematics independently after the lecture. While there are not many instructional guidelines supported by positive evidence of student learning, the JUMP Math program has shown potential for success in teaching basic skills mathematics, addressing the points where traditional lecture-based instruction is lacking, i.e., effective delivery and coverage.

**JUMPing Math: An Example**

JUMP Math explains concepts simply and is structured in ways that allow students to follow along easily. For example, adding and subtracting signed integers is a fundamental skill; yet, many students in
MAT095 become confused when calculating expressions such as $-5 + 3$. Students tend to answer -8, rather than -2. For an expression like $-9 - 3$, they respond -6, rather than -12. Students are even more confused with expressions such as $-3 - (+2)$ or $4 - (-6)$. Below, I provide a comparison of two approaches to teaching students how to add and subtract integers. The first approach is the one presented in the MAT095 textbook, *Pre-algebra* by Man M. Sharma, Roxann King, and Asha Mittal (2008); the second demonstrates the JUMP Math approach (*JUMP Math: Workbook*, 2007).

**Approach A: Pre-algebra**
To find the sum of integers, the authors teach students to use a number line:

On a number line, to add $3 + 4$, we start with 3. Then, to add 4, we move 4 units to the right. The number corresponding to the end point is the required sum $3 + 4 = 7$.

In short, to add 4 to 3, we count 4 units to the right of 3. The point reached gives us the sum. We shall use this idea to find the sum of positive and negative integers. (p. 42)

Then, Sharma, King, and Mittal guide students through a study of the effect of this operation on the number line. For example, when adding 4 to 3, the sum is found by starting at 3 on the number line, moving 4 units to the right (corresponding to the addition operation), reaching position 7. So, the authors conclude: “On a number line, adding a positive number means to move ‘to the right’ or in the positive direction. Adding a negative number means to move ‘to the left’ or in a negative direction” (p. 42).

After explaining how the number line can illustrate what happens when positive and negative numbers are added and subtracted, the authors explain a different process which will lead to the same conclusion. They outline the following steps and provide the example of
how this alternative method can be used to add \(-3 + (-4)\). The steps the authors suggest are as follows:

1. First, add the absolute values of the numbers
   \[\lvert -3 \rvert = 3 \text{ and } \lvert -4 \rvert = 4, \text{ so } 3 + 4 = 7\]

2. Then, attach the sign that is common to both the original numbers, in this case, the negative sign. Therefore,
   \[-3 + (-4) = -7\]

The textbook then lists three examples, and provides the solutions to the problems, together with graphics outlining the two steps that are followed; i.e., first add the absolute values and then indicate the common sign.

Sharma, King, and Mittal write that the same process is used to add integers with unlike signs:

- **Step 1** Find the absolute values of the two numbers.
- **Step 2** Subtract the smaller absolute value from the larger one.
- **Step 3** Prefix the sign of the number that has the larger absolute value. (p. 44)

The textbook presents the following example: \(-10 + 12\). To compute \(-10 + 12\), students are instructed to first determine the absolute values of \(-10 + 12\), thus, \(\lvert -10 \rvert = 10, \lvert 12 \rvert = 12\). Students must then, “subtract the smaller absolute value [10] from the larger one [12]” (p. 44). The authors instruct students that “the positive number has the larger absolute value, so the sum is positive” (p. 44). The answer to the problem of \(-10 + 12\) is 2.

**Approach B: JUMP Math**

The JUMP Math approach to introducing students to the positive and negative signs of integers is quite different from the methods proposed by Sharma, King, and Mittal in the *Pre-algebra* textbook. The JUMP Math method suggests that the instructor first discuss the concept of gain and loss with students, and then have students practice applying
their understanding of gain and loss by completing the following exercises:

1. Write a plus sign (+) if the net result is a gain. Write a minus sign (−) if the net result is a loss.
   
   (a) a gain of $5: +
   (b) a loss of $3: −
   (c) a gain of $4: +
   (d) a gain of $2 and a loss of $5: −
   (e) a gain of $3 and a loss of $1: −
   (f) a loss of $3 and a gain of $4: +
   (g) a loss of $6 and a gain of $2: −

Notice that the exercise starts with the easiest type of problems – (a), (b), and (c) – and then increases the level of difficulty slightly – (d), (e), (f), and (g). Most JUMP practice problems follow this format, so that it is virtually impossible for students not to find the correct solutions at each step.

Then, the JUMP Math approach teaches that adding or subtracting integers is merely a translation of writing a sequence of gains and losses with signed numbers. Students practice these translations with the following exercise:

2. Write each sequence of gains and losses using numbers and signs (+ and −).
   
   a) a gain of $3 and a loss of $5: +3 -5
   b) a loss of $2 and a gain of $8: −2 +8
   c) a loss of $4 and a gain of $3: −4 +3
   d) a gain of $6 and a loss of $5: +6 -5
   e) a loss of $5, a gain of $8, a loss of $2, then a gain of $1: −5 +8 -2 +1
   f) a gain of $3, a gain of $5, a loss of $6, then a gain of $2: +3 +5 -6 +2
   g) a loss of $5, a loss of $8, a gain of $10, then a gain of $5: −5 −8 +10 +5
   h) a gain of $4, a loss of $3, a loss of $2, then a gain of $5: +4 -3 -2 +5

One thing to notice is that there are quite a few practice problems, all slightly different but not difficult to solve, so that students have a chance to practice their skill and to ground their understanding thoroughly. The advantage to having students work on the JUMP problems is that, because these exercises are easy, students can do all of them in a relatively short amount of time. With JUMP, the problems are not designed to challenge students’ understanding, but rather carefully chosen to reinforce their knowledge of the concept. Students build that
knowledge not merely by trying to follow a lecture, but by solving many problems in class.

After the students have completed the first two sets of practice problems, JUMP Math asks them to apply what they have learned to the next two sets of problems which use only signed integers:

3. Decide whether each sequence of gains and losses is a net gain (+) or a net loss (-) by looking only at the sign of the numbers:

   a) +5-3: +    b) +3-5: ___    c) -2+4: ___
   d) -5+1: ___    e) +8-7: ___    f) +5-9: ___
   g) -4+5: ___    h) -3+2: ___    i) -9+5: ___

4. How much was gained or lost overall? Use + for a gain, - for a loss, and 0 for no gain or no loss.

   a) +6 -5 = ___+1    b) -4+ 3 = ___    c) +5 -5 = ___
   d) -6 +6 = ___    e) -3 +5 = ___    f) +8 -12 = ___

Many math instructors learned to add and subtract signed numbers just as Sharma, King, and Mittal explained. However, because this method requires students to learn additional terms and concepts – absolute value notation, number line, like and unlike signs – that they may have struggled with in the past, I believe the Pre-algebra textbook method is less effective than the gain/loss method and context used by JUMP Math.

Research Questions
JUMP Math has proven effective in K–8 math classes. In this paper, I investigate whether the JUMP Math program would also have a strong impact on student learning in basic skills mathematics in community college courses. As mentioned above, LaGuardia students who take the basic skills mathematics courses come from a wide range of backgrounds. Some students are recent high school graduates, while others are more mature, entering college for the first time; still others are returning students. Some students may have failed math before; some have learning disabilities; others are second language learners. Despite the variation in obligation, experience, abilities, and knowledge, all are under the same time constraints. Given this classroom diversity and the time challenge, can the JUMP method, adapted to a community col-
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In college setting, effectively promote student learning? This paper explores whether the JUMP Math teaching method, which breaks a difficult concept/procedure into a sequence of small and simple concepts/procedures, the JUMP problem solving activities done in class, and constant encouragement and feedback helps students understand and master the learning materials and engage in a learning experience that results in student success.

Method

The experiment conducted in Spring I, 2013 at LaGuardia Community College involved students in two MAT095 (Introduction to Algebra) courses. The two classes were randomly assigned by the department. MAT095 uses EducoSoft, a web-based computer software program, for various assessments – homework assignments, quizzes, and tests. Students meet 6 hours each week; they meet the instructor for 4 hours of lecture and 1 computer lab hour per week, and also meet a tutor for one additional computer lab hour. Grading is based on student achievements in the following categories: online homework (10%), online quizzes (5%), math lab sheets (5%), instructor’s tests and projects (15%), two departmental exams (30%), and the departmental final exam (35%).

The experiment consisted of changing from the traditional lecture format I had employed to date: I lectured; the students listened; occasionally, there were class activities such as group work or short projects. For this experiment, I prepared lectures based on the JUMP Math method of instruction to teach students basic arithmetic. In a one-hour-long class, I spent approximately 35–40 minutes on lecture using JUMP methods, 10–15 minutes for individual/group work on a JUMP Math worksheet I had prepared, and the last 5–10 minutes for wrap-up. The problems on the worksheets were carefully selected, mostly from the JUMP Math Workbooks (Mighton, J., Sabourin S., & Klebanov A. (2009)).

Starting in Fall 2012, CUNY raised the passing score for basic skills courses from 60 (D-) to 74 (C). To evaluate the success of my JUMP intervention, I compared the average number of students who achieved 74 or more and 60 or more in the two MAT095 sections I taught in 2013 using JUMP methods with the average number of students achieving 74 or above in 7 sections of MAT095 I had taught between 2009
and 2012. The data excludes students who registered for a MAT095 course but did not register for access to EducoSoft, since those students did not complete most of the course assessments.

Findings
The table below compares two sections of MAT095 I taught in Spring I and Fall I 2013 using the JUMP Math approach with the average results from 7 sections of MAT095 I taught between 2009 and 2012.

Table 1: Comparison Data for MAT095 classes, 2013 and 2009–2012

<table>
<thead>
<tr>
<th></th>
<th>Average no. of students per section registered with EducoSoft</th>
<th>Average course score (out of 100)</th>
<th>Average no. of students per section who passed the course with a score &gt;= 74</th>
<th>Average score of students who passed the course with a score &gt;= 74</th>
<th>Average no. of students per section who passed the course with a score &gt;= 60</th>
<th>Average score of students who passed with a score &gt;= 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 sections, 2013</td>
<td>29</td>
<td>49.01</td>
<td>12</td>
<td>80.56</td>
<td>13</td>
<td>79.62</td>
</tr>
<tr>
<td>7 sections, 2009–2012</td>
<td>25</td>
<td>55.39</td>
<td>7</td>
<td>83.18</td>
<td>14</td>
<td>72</td>
</tr>
</tbody>
</table>

The data shows a slight increase in the average number of students per section in the 2013 JUMP Math sections who pass the course with a score of 74 or above. This increase is modest when compared to the radical changes cited in the above graphs from the JUMP website (Figure 1, above). In addition, the average score of students who passed with the current minimum grade of 74 is lower in the sections where JUMP was implemented; yet the average score using the prior standard (passing score greater than or equal to 60) shows a slight increase. It is important to note that most students who achieved an average course score greater than or equal to 60 in MAT095 courses in 2013 had a course average score of 79.62 compared to 72 for the 2009–2012 sections. I have concluded that while the JUMP Math instruction had a minimum impact on the pass rate in the two sections of MAT095, using this method did have a positive effect on students’ academic performance.

Discussion and Future Directions
In truth, the numeric results obtained from this experiment are disappointing, but they do not convey the changes I observed in students’ attitude toward the class. Nor do the results reflect how much students liked the way JUMP explains mathematics. After students slowly but
continuously built confidence in their ability to do mathematics by accumulating the experience of solving JUMP mathematical problems, they actually began to like working with math problems. In the past, it was difficult to stimulate students in MAT095 to do mathematics, regardless of whether they were good at it or not. I sensed that many were not interested in the subject and were taking the course only because it was required. But in my JUMP Math sections, thanks to the careful instructional design, I observed that a lot of students actually enjoyed solving the problems. The difference seems to be that JUMP Math problems do not defeat their efforts from the beginning. Instead, JUMP helps students to understand concepts and methods that they were previously unable to figure out.

At the end of the semester, I asked students to write what they liked most about the course and what they liked least. The responses were overwhelmingly positive. Fourteen out of 25 students wrote that they liked my method of instruction, for example, “He broke down everything really well;” “You didn’t move fast from subject to subject. You made sure that everyone understood what you were teaching before you moved on;” “I think the best part of the class was the professor because I understood everything he taught. He explained everything very clearly and I loved the handouts because I got to practice doing the problems on my own;” “I liked coming to a class. You teach in a way people understand and you make it easy.” Even if the exam scores did not improve by much, my students’ comments do suggest that the JUMP instructional method helps them understand and learn math.

While the JUMP methodology holds promise for community college basic skills math students, the curriculum, originally designed for students in grades 1 to 8, must be adapted to college students’ prior knowledge and to their needs. My Spring 2013 experience revealed the positive effect of JUMP on student attitudes towards math. In a future study, I will continue to explore the correlation between improved attitudes and course pass rates.

In closing, I want to stress that students in basic skills mathematics courses are not ‘different,’ a misperception often held by others outside of the math classroom and internalized by basic skills students themselves. Rather, our students are smart, they like to learn, and they love to do well. But just like some of my classmates in Korean middle school and high school, if they have lost the thread of the subject and
are without strong academic survival strategies, they give up in frustration. It is my belief that as teachers, whatever our discipline, we should not simply repeat modes of instruction that, however effective for us as learners, fail to reach our students. If the majority of our students enter LaGuardia in need of basic skills math, and if a large number of those students do not make progress, then we must consider redesigning both the curriculum and our pedagogy. If we attempt these changes in response to student needs, perhaps, like the students quoted above, their attitudes may evolve from hating math to excitement about solving problems once perceived as insurmountable.

References


Learning How Students Learn General Chemistry
An Exploration of Self-Regulation Strategies

Dionne A. Miller, Natural Sciences

Abstract
The study measured students’ ability to predict accurately their performance on a course exam and identified correlations that exist between the use of self-regulation strategies and the ability to predict performance, and between the use of self-regulation strategies and actual grades obtained on the course exam. Correlations with other aspects of learning such as management of time and study environment, effort regulation, peer learning, and help seeking were also analyzed. To obtain the data, students completed the Motivated Strategies for Learning Questionnaire (MSLQ) and predicted their performance on a recently completed course exam prior to receiving their exam score. The study revealed a fairly strong correlation between accuracy of prediction and actual performance. Based on these findings, interventions to improve self-regulation are proposed.

Keywords: self-regulation, chemistry, MSLQ, time and study environment, peer learning, help seeking

Introduction: Defining Self-Regulation
What is self-regulated learning? Boud (1991) defines it as “the involvement of students in identifying standards and/or criteria to apply to their work, and making judgments about the extent to which they have met these criteria and standards” (p. 5). It is the process by which students acquire knowledge and assess the quality of their learning. Thus, a self-regulated learner is able to monitor his or her learning and identify and implement strategies that reach the predetermined standards of the course. Self-regulation, therefore, plays an important role in learning even if this role is not explicit to the student; that is, self-regulation encourages self-assessment and effective students are always self-assessing “what they know and what they can do” (Boud, 1995, p. 11). One example of self-assessment occurs when mathematics and science students work end-of-chapter problems and then check their solutions against answers provided in the back of the book.

Boud (1995), Zimmerman (2002), and Schraw, Crippen, and Hartley (2006) all agree that self-regulation enables students to become
effective and responsible learners who can continue their education without the intervention of teachers or formal courses; that is, self-regulation generates life-long learning. These theorists also agree that the goal of self-regulation is a central aim of any college education and is an implicit and important component of all college courses. Schraw et al. (2006) go a step further in suggesting that self-regulation is necessary for skilled science learning in particular. Students who are self-regulated report much higher levels of academic satisfaction and are more likely to persist in the face of significant challenges (Bandura, 1997; Zimmerman, 2002), all highly desirable traits for students, especially those in STEM courses and majors.

Self-regulation can be described as consisting of three main components: cognition, metacognition, and motivation (Schraw et al., 2006; Schraw & Moshman, 1995). Cognition encompasses the skills necessary to learn and includes problem-solving strategies and critical thinking. Metacognition consists of knowledge about our individual learning styles, the factors that affect our performance, knowledge of learning strategies (such as note-taking and memorization aids), and knowing why and when to use a particular strategy (Schraw & Moshman, 1995). In their description of metacognition, Schraw and Moshman (1995) also include “regulation of cognition,” which consists of planning (selection of appropriate strategies, allocation of resources, goal-setting, activating relevant background knowledge, and budgeting time), monitoring (self-testing skills necessary to control learning), and evaluation (re-evaluating goals, revising predictions, and consolidating intellectual gains). Lastly, motivation includes self-efficacy, the degree to which individuals believe they can accomplish a task or achieve a specific goal (Bandura, 1997), and thus affects persistence in the face of challenges and epistemological beliefs (Pajares, 1996).

Pintrich and De Groot (1990) examined the relationships between motivational orientation, self-regulated learning, and the academic performance of 173 seventh-graders in eight science and seven English classes. Their study claims to provide empirical evidence that while motivational beliefs (including efficacy beliefs) are important to academic performance, self-regulated learning components are more directly implicated. In their words, “students need to have both the ‘will’ and the ‘skill’ to be successful in classrooms” (p. 38). In a later study, VanderStoep, Pintrich, and Fagerlin (1996) examined disciplinary
differences in self-regulated learning in college students. The results suggested that self-regulation was one of the components that distinguish high from low achievers in social and natural science courses, but interestingly, not in humanities courses. This study seems to support the argument of Schraw et al. (2006) that self-regulation is necessary for skilled science learning.

For the purposes of this paper, self-regulation is defined as the set of behaviors that include the awareness, knowledge, and control of cognition; the ability to manage time and resources; the ability to regulate effort (maintain focus and complete tasks); and the ability to recognize the need for help and to identify and utilize sources of help.

Review of the Literature
Schraw et al.’s (2006) extensive review of the literature on self-regulation in science education concluded that while there is some research focused on metacognition, there is little available on the broader topic of self-regulation.

Additionally, data on self-regulation for students at two-year urban institutions such as LaGuardia Community College is even more scarce. Nevertheless, community colleges like LaGuardia have been recognized, most recently by President Barack Obama, as vital to the success of the nation in producing STEM majors: Almost half of Americans who receive bachelor’s degrees and one third of those with master’s degrees attended community college at some point in their lives (Tsapogas, 2004). Underperformance by community college students or, worse, their withdrawal from STEM courses, represents a loss of potential STEM innovators in our future economy.

Additionally, two-year colleges serve the most ethnically diverse student body in the history of the United States. For example, in 2012, LaGuardia’s enrollment was 34% Hispanic and 14% black (LaGuardia, 2013, p. viii). Low retention of these students weakens the diversity pool needed to ensure global competitiveness. To allow these students to withdraw or fail without intervening is to adopt the “weeding out” approach that suggests that if students are not successful, it is because they do not belong in the course. But as open access institutions, community colleges welcome many students who, for a variety of reasons, are untrained for academic success. A more proactive pedagogy should include helping students identify and practice the self-regulation skills
necessary for academic success. A learner’s ability to predict realistically when or how well he or she has mastered course material suggests possible learning strategies that could be applied to close gaps in deep comprehension of the material.

Problematizing Self-Regulation
LaGuardia’s General Chemistry I is a required course for students pursuing science and engineering majors. It introduces students to the basic concepts of chemistry and stresses understanding, application, and synthesis of these fundamental concepts rather than simple memorization. Repeatedly, students come to me after failing an assessment, insisting that their unsatisfactory performance did not reflect their confidence and expectations after taking the exam. In other words, they felt that they had done well and were genuinely surprised by a poor grade. These students frequently express an interest in science, attend class regularly, and appear motivated to study and do well, as opposed to students who perform poorly because they have put in very little effort. All the students registered in the General Chemistry course have also taken and passed the required prerequisites of college-level English and mathematics. In other words, their failures cannot be attributed solely to lack of motivation or weak academic preparation. Many of these students eventually become frustrated and disheartened by their poor performance and withdraw from the course.

Aware of the disparity between students’ predictions and their real performance, I became interested in which learning strategies students were actually utilizing in General Chemistry I. What were the students doing when they studied? How did they know they had mastered the concepts? I hypothesized that students who could not correctly assess their own performance did not possess sufficiently developed self-regulation behaviors and skills. With this hypothesis in mind, I was immediately tempted to intervene with “fixes” aimed at teaching students how to become better self-regulated learners. However, rather than seeking immediate short-term solutions, I decided to heed the advice of Randall Bass (1999) and frame lack of self-regulation as a “problem” in teaching and learning worthy of further investigation.

In sum, this paper explores the degree to which students’ accurate prediction of their performance is linked to a set of behaviors practiced by self-regulated learners. The study asked students to identify which
strategies they employ to learn the material and assess their learning in the General Chemistry I course. It also investigated how accurately students predicted their performance on a course exam and if any correlation existed between their (self-reported) self-regulation skills and their prediction accuracy. Finally, since the results of the study demonstrated that students were deficient in some or all areas of self-regulation, I suggest appropriate interventions to improve these skills.

Method
LaGuardia students enrolled in General Chemistry I used the Motivated Strategies for Learning Questionnaire (MSLQ) to report on the learning strategies they employed in the course. In addition, students were asked to predict their performance on a recently completed course exam prior to receiving their actual test scores. These predictions were compared with their actual performance to confirm whether students had accurately evaluated their learning and performance.

The MSLQ consists of two main parts, motivation and learning strategies, and it inventories the self-regulation knowledge and practices that learners possess and use. For the research undertaken in this study, only the learning strategies portion (Part B) of the MSLQ was considered. The learning strategies section is further subdivided into the following areas: metacognitive self-regulation (MSR), management of time and study environment (TSE), effort regulation (ER), peer learning (PL), and help seeking (HS). The questionnaire includes 31 items that measure students’ use of different cognitive and metacognitive strategies and 19 items about their management of resources. Each of the 50 Likert-type items is scored on a 7-point scale where 1 = not at all true of me, and 7 = very true of me. (Of these 50 items, 7 items are negatively worded so that the rating has to be reversed: 1 becomes 7, 2 becomes 6, and so on.) Appendix B contains the questionnaire items used in this study.

Students completed the MSLQ after taking the third of four course exams and prior to receiving their exam results. They were asked to respond in terms specific to their learning and study behavior in the General Chemistry I course up to that point and to predict their performance on the third exam. Demographic information was also collected (Table 1, below). Based on the findings, interventions are proposed to increase students’ self-regulatory skills and, consequently, their academic performance.
Participants
Participants formed a cohort of 142 students registered in General Chemistry I (SCC201) at LaGuardia Community College during the Fall I semester of 2012. They enrolled in the course to complete requirements for an Associate Degree or to fulfill prerequisites for graduate

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major</strong></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>44.0</td>
</tr>
<tr>
<td>Liberal Arts: Mathematics and Science</td>
<td>27.1</td>
</tr>
<tr>
<td>Health-Related</td>
<td>13.3</td>
</tr>
<tr>
<td>Biology</td>
<td>8.4</td>
</tr>
<tr>
<td>Other and Nonmatriculated</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Credits Completed</strong></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>23.5</td>
</tr>
<tr>
<td>15-30</td>
<td>34.9</td>
</tr>
<tr>
<td>31-45</td>
<td>24.1</td>
</tr>
<tr>
<td>45-60</td>
<td>8.4</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>9.0</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>60.2</td>
</tr>
<tr>
<td>Female</td>
<td>39.8</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>28.3</td>
</tr>
<tr>
<td>African-American</td>
<td>18.1</td>
</tr>
<tr>
<td>Asian</td>
<td>31.9</td>
</tr>
<tr>
<td>Caucasian</td>
<td>10.2</td>
</tr>
<tr>
<td>Other</td>
<td>11.4</td>
</tr>
<tr>
<td><strong>Paid Employment</strong></td>
<td></td>
</tr>
<tr>
<td>Do not work</td>
<td>40.6</td>
</tr>
<tr>
<td>1-10 hours/week</td>
<td>5.5</td>
</tr>
<tr>
<td>11-20 hours/week</td>
<td>19.4</td>
</tr>
<tr>
<td>21-40 hours/week</td>
<td>29.1</td>
</tr>
<tr>
<td>&gt; 40 hours/week</td>
<td>5.5</td>
</tr>
</tbody>
</table>
programs. The sample included a range of GPA achievement levels and numbers of college credits completed. A detailed demographic breakdown of the students is provided in Table 1. Students were assured that participation in the study was completely voluntary and confidential and would not affect their grades in any way, and they were asked to sign an explanatory consent form.

Measures
Each questionnaire was coded with an anonymous identifier (a 3-digit number). Students reported this 3-digit number to their instructor who then supplied the principal investigator with the actual third exam scores, each matched to a 3-digit code. In this way, the questionnaire responses and scores remained anonymous but allowed the principal investigator to compare responses, predicted scores, and actual scores for each student.

Data Analysis
A correlational study examined the relationship between students’ ability to accurately predict their grade (defined as prediction within ±10% of actual grade) and their score on the metacognitive self-regulation (MSR) section of the MSLQ, actual grade, and college credits earned. Correlations were also drawn between actual grade and the other areas measured under learning strategies: time and study environment (TSE), effort regulation (ER), peer learning (PL), and help-seeking (HS).

The data analysis was performed using the software program Mathematica™. For each subsection of the MSLQ discussed in this paper, each student’s score was computed by averaging the responses to the items that make up that scale. The means for the total population were also calculated for each scale. For example, the metacognitive self-regulation scale has 12 items: An individual’s score was computed by taking the mean of the responses to all 12 items; the mean for the entire population for the scale was then computed. Box plots were used to represent the spread of the responses of the entire population to each item as well as the scale mean. Similar analyses were done for resource management strategies: time and study environment (8 items), effort regulation (4 items), peer learning (3 items), and help seeking (4 items).

Using the individual scores thus calculated, linear correlations were performed as described above using Pearson correlation analysis.
Levene’s test for equality of variances was also used when dichotomous variables were created in the data set as, for example, when students were split into categories of pass/fail, high/low MSR, and good/bad predictors. A \( t \)-test was then used to analyze for equality of means.

Results
This study determined the ability of students to predict correctly their third exam score (±10% of the actual grade) and correlated this ability with their MSLQ scores and actual grade. Additionally, the study analyzed the responses to the learning strategies items in the MSLQ that encompass self-regulation skills and behaviors, including 12 items that measure metacognitive self-regulation, 8 items that measure the management of time and study environment, 4 items that measure effort regulation, 3 items that measure use of peer learning, and 4 items that measure help seeking. Appendix A shows the box plots of the quartile distributions of the student responses to the individual items on the scale, as well as the overall scale average. Also shown to the right of the box plot are the means of the individual items as well as the scale mean.

Figure 1 shows a histogram of the students’ skill at predicting their grade in the third exam. This skill is defined as the difference between the actual grade and the predicted grade. Positive skill corresponds to students underestimating their performance (they performed better than they predicted) while negative skill corresponds to the opposite. The histogram shows that about 58% of the students overestimated their performance while 37% accurately predicted their grade on the exam with an error of up to 10 points.
The result of the Pearson’s correlation analysis is shown in Table 2. In all cases, the sample size N = 142. An asterisk (*) indicates that the correlation is significant to the 0.05 level; two asterisks (**) indicate significance to the 0.01 level. The results suggest that the dependent variable (prediction accuracy) correlated with only one of the predictor variables, student grade (p < 0.01) and that the strength of association was fairly strong (0.79). Students who were good predictors (within 10% accuracy) got better grades (mean (M) = 86.01, standard deviation (SD) = 9.26) than those who were not (M = 61.81, SD = 15.51). The difference in mean score (24.917) of good versus bad predictors was shown to be statistically significant when the independent-samples t-test for equality of means was applied (F(142) = 17.912, p < 0.001).

Table 2: Pearson Correlation Table for MSLQ Learning Strategies Categories, Prediction Accuracy, and Student Exam 3 Grade

<table>
<thead>
<tr>
<th></th>
<th>Self-Regulation</th>
<th>Time and Study Environment</th>
<th>Effort Regulation</th>
<th>Peer Learning</th>
<th>Help Seeking</th>
<th>Prediction Accuracy</th>
<th>Exam 3 Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Regulation</td>
<td>1.000</td>
<td>.455**</td>
<td>.409**</td>
<td>.190*</td>
<td></td>
<td>.215*</td>
<td></td>
</tr>
<tr>
<td>Time and Study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>.455**</td>
<td>1</td>
<td>.511**</td>
<td>.205*</td>
<td></td>
<td>.259**</td>
<td></td>
</tr>
<tr>
<td>Effort Regulation</td>
<td>.409**</td>
<td>.511**</td>
<td>1</td>
<td></td>
<td>.492**</td>
<td>.187*</td>
<td></td>
</tr>
<tr>
<td>Peer Learning</td>
<td>.190*</td>
<td>.205*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Help Seeking</td>
<td></td>
<td></td>
<td>.492**</td>
<td>1</td>
<td></td>
<td>-.024</td>
<td></td>
</tr>
<tr>
<td>Prediction Accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Exam 3 Grade          | .215*            | .259**                     | .135              | .187*        | -.024        | .787**              | 1.000*

For the other variables that showed a significant correlation (p < .05), for example, between help seeking and peer learning and between metacognitive self-regulation and effort regulation, the strengths of these associations were generally weak (< 0.3) to moderate (0.4-0.5).

An independent-samples t-test for equality of means analysis was done on factors such as help seeking, management of time and study environment, peer learning, effort regulation, and actual third exam grade to see how they varied by category for students who reported
self-regulation scores of 5 or greater (high MSR) and less than 5 (low MSR). The results (tabulated below in Table 3 only for categories with significant differences) indicated that:

a. With the exception of time and study environment (TSE), the variances in the categories between the two groups (high and low MSR) were equal, since the Levene’s test for equality of variances had a p > 0.05; and

b. Only the TSE variable (-0.8266, F(142) = -4.707, p < 0.05) and the effort regulation (ER) variable (-0.6191, F(142) = -3.440, p < 0.05) exhibited a significant difference between the two groups.

<table>
<thead>
<tr>
<th>Levene’s Test for Equality of Variances</th>
<th>T-Test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig. &gt; .05</td>
</tr>
<tr>
<td>Time and Study Environment</td>
<td>Equal variances assumed</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
</tr>
<tr>
<td>Effort Regulation</td>
<td>Equal variances assumed</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
</tr>
</tbody>
</table>

Finally, independent-samples t-tests for equality of means analysis were done for the factors of help seeking, management of time and study environment, peer learning, effort regulation, prediction accuracy, and exam 3 grade to see how they varied by category of students who passed exam 3 (70% or greater, C- and above) and those who failed (< 70%, D+ or below). The results indicated that:
a. With the exception of self-regulation, the variances in the categories between the two groups (pass and fail) were equal since Levene’s test for equality of variances had a $p > .05$; and

b. Only the TSE variable had a significant difference ($-0.6381$) between the two groups ($F(142) = -3.174$, $p < .05$). The data analysis for this variable is shown in Table 4 below.

### Table 4: Independent-Samples Test Table for Pass/Fail Students and Time and Study Environment Categories of MSLQ

<table>
<thead>
<tr>
<th>Time and Study Environment</th>
<th>Levene’s Test for Equality of Variances</th>
<th>$t$-Test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig. &gt; .05</td>
<td>$t$</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>2.182</td>
<td>.142</td>
<td>-3.174</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>2.813</td>
<td>.757</td>
<td>-.007</td>
</tr>
</tbody>
</table>

### Discussion

The discussion presented here focuses on correlations between the self-regulation scores, prediction accuracy, and actual grades on the third course exam. Correlations between self-regulation and the management of time and study environment and between self-regulation and actual grades are also considered. The analysis identifies areas of student learning that suggest a need for interventions that would affect the greatest number of students. The suggested interventions, while made here in the context of studying chemistry, have broad applicability to other STEM disciplines.

### Correlations Between Self-Regulation, Prediction Accuracy, and Actual Grades

The original hypothesis was that students who are unable to predict correctly their performance on course exams have not developed sufficient self-regulation skills; that is, they are not able to assess how well they have learned or how to close any performance gaps that exist. In this study, prediction accuracy is defined as the ability to predict perfor-
formance to within ±10% of the actual grade. However, the data revealed no correlation between the ability to predict performance correctly and the self-regulation skills as measured by the MSLQ in the categories of metacognitive self-regulation (MSR), management of time and study environment (TSE), effort regulation (ER), help seeking (HS), or peer learning (PL). Hence, the hypothesis that better prediction accuracy would correlate to self-regulation skills was disproved.

Prediction accuracy was in fact shown to be correlated to only one variable studied, actual grade ($p < 0.01$), and the strength of association was fairly strong (0.79). This relation is described by the regression equation $Y = 0.552X - 51.635$, where $Y$ denotes the accuracy of predicting performance and $X$ is the student grade. The linear regression $R^2 = 0.617$ suggested that 62% of the variation in the dependent variable $Y$ is due to variation in the independent variable $X$, i.e., student grade can account for only 62% of the change in prediction accuracy. Additional research is therefore required to determine the other causative factors that affect students’ ability to predict their grades. Students who were good predictors (within 10% accuracy) got better grades ($M = 86.01$, $SD = 9.26$) than those who were not ($M = 61.81$, $SD = 15.51$). The difference in mean score between the two groups (24.917) was shown to be statistically significant when the independent samples $t$-test for equality of means was applied ($F(140) = 17.912$, $p < 0.001$).

Figure 2 below shows a box plot of student grades for categories of good and bad predictors.

![Box Plot of Actual Student Grades vs. Prediction Accuracy Categories](image-url)
Self-Regulation and Management of Time and Study Environment, and Actual Grades: Correlations and Suggested Interventions

Weak but significant correlations were obtained between actual grades and metacognitive self-regulation (0.22, p < 0.05) and between actual grades and the management of time and study environment (0.26, p < 0.01). The correlation between actual grade and effort regulation was not shown to be significant. It is interesting to compare these correlations to those obtained by Pintrich and his colleagues when the MSLQ was developed and tested on a larger sample of students spanning five academic disciplines (Pintrich, Smith, Garcia, & McKeachie, 1991). In their study, the correlations with final grades obtained in these three areas were 0.30, 0.28, and 0.32 respectively. These correlations were described as significant though moderate and able to demonstrate predictive validity. Similarly, the current study demonstrates that self-regulation, while influencing student performance, is only one factor among several.

An analysis of the individual metacognitive self-regulation items (MSR) on the MSLQ (see Appendix A, Figure A1) indicates that monitoring and regulating activities are areas in which students are proficient. Responses to these items (see Appendix B) on the questionnaire (#41, M = 5.75; #76, M = 5.77; #79, M = 4.78) indicate that a significant majority of students (75%, 75%, and 50% respectively) go back when studying to areas about which they were confused in class and attempt to identify which concepts they do not understand well.

However, responses to several other items in the MSR category suggest a need for intervention. Item 33 is worded “During class time, I often miss important points because I am thinking of other things.” This item (which is reverse-scored) has a mean of 4.36 with approximately 65% of students reporting a score of 5 or less and 50% reporting a score of less than 4. This behavior may be due to a lack of interest in the material, the presence of other significant responsibilities such as work and family that compete with academic responsibilities, or simply a lack of attentiveness and focus on the part of the student. Interventions could include instruction in strategies to help improve focus and attention during class, and instruction in active learning strategies such as note-taking, asking/answering questions, and other types of participative behavior.
Item 36 is worded, “When reading for this course, I make up questions to help focus my reading.” This item had a mean of 3.55 with 75% of students reporting a score of 5 or less and 50% reporting 4 or less. Closely related is item 55, “I ask myself questions to make sure I understand the material I have been studying in class,” which had a mean of 4.52 and for which 50% of students reported a score of 5 or greater. Self-questioning is an important monitoring and regulatory activity to help students assess understanding: This skill is particularly important in a course such as chemistry where the exams measure primarily the ability to synthesize and apply concepts rather than the simple restatement of information. Interventions could include guiding students in how to make up appropriate questions or monitoring learning by working end-of-chapter exercises to which answers are provided. Instructors could also provide students with practice quizzes and exams.

Item 44, “If course materials are difficult to understand, I change the way I read the material,” had a mean of 4.17. This item is related to item 57 (reverse-coded), “I often find I have been reading for a class but don’t know what it was all about,” which had a mean of 4.43. For both items, approximately 65% of students reported a score of 5 or less and 50% reported a score of less than 4. Interventions could include workshops on how to read textbooks, providing strategies for reading difficult material such as reading more slowly and making notes in the student’s own words, breaking up the reading of the material into smaller segments, reading from alternative sources to gain different perspectives or alternate ways of explaining concepts, utilizing worked examples from the text or other sources, and finally, starting with easier practice exercises and building up to more difficult ones.

Other possible areas for intervention are suggested by items 54 and 61. Item 54 (“Before I study new course material thoroughly, I often skim it to see how it is organized,” M = 4.57) and item 61 (“I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying,” M = 4.70) both address the issue of task analysis. For both items, 50% of students reported the target score range of 5 and over. Possible interventions could include providing students with clear learning and performance objectives for each topic, encouraging them to review the objectives before studying,
and suggesting that students review chapter summaries before starting the study of a topic.

Self-Regulation and Time and Study Environment, and Effort Regulation: Correlations and Suggested Interventions

Moderately strong, significant correlations were found between meta-cognitive self-regulation (MSR) and the management of time and study environment (TSE) (0.46, p < 0.01) and effort regulation (ER) (0.41, p < 0.01). As defined by Pintrich et al. (1991), MSR focuses on the awareness, knowledge, and control of cognition which involve three general processes: planning (goal setting and task analysis), monitoring (of learning), and regulating (checking and correcting learning behavior). TSE assesses students’ scheduling, planning, and management of study time and study environment. TSE incorporates setting realistic goals, effective use of study time, as well as a distraction-free study space (Pintrich et al., 1991). ER is the ability of students to maintain focus and complete tasks even if they find the tasks boring or they are “not in the mood.” It is therefore unsurprising that good management of cognition correlates with effective time and effort management.

When a dichotomous variable was created of students with high self-regulation skills (MSR score of ≥ 5) and low self-regulation skills (MSR < 5), a significant difference was shown for the means of those two groups for time and study environment (TSE) and effort regulation (ER) (Table 3, above). In other words, students with high MSR also had better time and effort management skills than those with low MSR. TSE and ER were also shown to be moderately correlated (0.51, p < 0.01; Table 2, above), the second strongest correlation found in the study, after prediction accuracy with grades.

Appendix A, Figure A3, shows the box plots and means of the items on the MSLQ that measure effort regulation. Half of the students reported that they are likely to quit before they finish a planned task if they feel lazy or bored (item 37) or if the work is difficult (item 60). A possible intervention here is to encourage students to keep lists of topics they find difficult and bring them to tutorial sessions, instructor office hours, or study group meetings so that they can be effectively dealt with. Another technique that can be suggested is that, if students find themselves unable to focus on a planned task, they should substitute another so that some work is done and the study time is not wasted.
When a second dichotomous variable was created comparing students who passed exam 3 (with C- and above) and those who failed (with D+ and below), the only category in which a significant difference in means was observed was TSE. These results suggest that, for our population, helping students develop appropriate time management strategies is crucial to their success.

A deeper analysis of the TSE responses on the MSLQ (see Appendix A, Figure A2) indicated that students have good study habits from the perspective of studying in a place where they can concentrate, that is, in a distraction-free environment, even if they do not have a regular place where they can study (item 65). Lack of a regular study space does not appear to be significant: Many students study at home, at school, and even at their place of employment. Where they study seems to be simply a matter of what their schedule permits. Item 73 with a mean of 6.3 showed almost 100% reporting that they attend class regularly with a score of 5 or over. High attendance rates may be influenced by the school’s attendance policy, which records attendance for every class meeting; financial aid is also, for some students, dependent on attendance.

However, students are weaker when it comes to making good use of study time and this weakness is likely related to a lack of specific goals for their study time. For item 52 (“I find it hard to stick to a study schedule,” reverse-scored), only 25% of students reported a score of 5 or greater, while only 50% of students reported a score of 5 or greater for making good use of study time (item 43), keeping up with course readings (item 70), and reviewing notes or readings before an exam (item 80). For item 77 (“I often find I don’t spend very much time on this course because of other activities”), 75% of students reported a score of 5 or less. This item is significant for our student population as many of our students work: 34.6% reported that they work 21 or more hours per week; if students who work 11 or more hours per week are included, 54% of the students work (Table 1, above). It seems likely that work is the main “other activity” that reduces the time spent on the course.

Possible interventions that would improve student performance include coaching on time management strategies such as creating realistic course and study schedules and scheduling shorter, more focused study periods with specific goals on a checklist rather than lengthy study periods with vague goals. To encourage students to major in
STEM disciplines, grants and scholarships at the federal, state, and college level should be offered to reduce the amount of time students have to work. Colleges can also assist with job placement in related fields or create job opportunities on campus, such as research internships with faculty, so that students learn from work as well as earn money.

**Additional Areas for Intervention: Peer Learning and Help Seeking**

The resource management strategies peer learning section of the MSLQ examines how students interact with each other as colearners. Research has shown that collaborating with peers can have a positive effect on learning and achievement (for example, Lumpe & Staver, 1995). Appendix A, Figure A4, shows the box plot and means of the items on the MSLQ that measure peer learning.

For all three items, less than 50% of students reported that they regularly work with other students to learn the course material or complete assignments. Again, this factor is significant for our population: LaGuardia is an urban commuter school, and because of students’ work schedules, they tend to leave the campus immediately after class. A lack of physical space for group work on campus also makes peer collaborations more difficult. Interventions could include instructors actively encouraging and promoting study groups by explaining their benefits, implementing “ice-breaker” activities at the beginning of the semester to help students get to know each other sooner rather than later, and assigning students to groups for low-stakes assignments to jump-start the process. The College could also endeavor to provide physical spaces on campus dedicated to group study.

Help seeking examines whether students are able to recognize when they need help and can identify and utilize sources of help, whether peer or instructor. Help seeking can avert possible failure, maintain engagement, lead to task success, and increase the likelihood of long-term mastery and autonomous learning (Newman, 2002). Appendix A, Figure A5, shows the box plots and means of the items on the MSLQ that measure help seeking. Interestingly, there was a significant, moderate correlation between peer learning and help seeking (0.492, p < 0.01). This correlation suggests that students who are likely to seek help are also likely to pursue opportunities for peer learning.

Seventy-five percent (75%) of students reported that they often do not seek help with material they are having trouble understanding.
In Transit

(40, M = 2.99); 50% reported that they identify other students they could ask for help (item 75), and 50% reported that they usually ask for help from the instructor or other students (items 58 and 68). One intervention could include providing a school-managed peer instruction program by identifying and training students (current and former) as peer instructors. Peer instruction services need to be actively advertised and promoted: Students are sometimes unaware that these services exist. Instructors could promote office hours as time for one-on-one instruction, not just time to consult on administrative issues. Instructors could also arrange to have office hours in a neutral space and recast them as small group tutoring to reduce the anxiety of students who find one-on-one contact with the instructor in an office setting intimidating.

Conclusion

The self-regulation practices of LaGuardia students enrolled in General Chemistry I were inventoried through the use of the Motivated Strategies for Learning Questionnaire. The ability of students to assess correctly their performance on a course exam was also measured. Only 37% of students correctly predicted their performance on a course exam within a 10-point accuracy range. The statistical analysis of the data showed no correlation between prediction accuracy and self-regulation skills as measured by the MSLQ: Thus, the original hypothesis that poor prediction accuracy is due to low self-regulation skills was not supported. Instead, a fairly strong correlation was shown between prediction accuracy and actual performance. Weaker but significant correlations were identified between performance and self-regulation and between performance and the management of time and study environment.

An item-by-item analysis of survey responses in the areas studied showed that students were proficient in some skills, such as going back to clarify areas about which they were confused in class, studying in distraction-free environments, and sustaining effort even in the face of dull or uninteresting material. In many more areas, however, student behavior exhibited weaknesses. These included maintaining focus in class, using self-questioning techniques when studying, knowledge of strategies for reading difficult material, identifying learning objectives and using them to guide study, time management, and help seeking.
the areas identified as deficient, possible interventions are proposed. The interventions, if implemented, should improve students’ self-regulatory behavior with the end result of improving their academic performance not only in chemistry courses, but in STEM disciplines in general.

Acknowledgements
The author gratefully acknowledges the invaluable help of Dr. Milena Cuellar, Mathematics, Engineering, and Computer Science Department, LaGuardia Community College, and Mr. Maurice Miller, University of the West Indies, Mona Campus, Jamaica with the statistical analysis of the data; Dr. Mariajosé Romero, Education and Language Acquisition Department, LaGuardia Community College, for helpful discussions; and the mentors of the Carnegie Seminar and the editors of In Transit: The LaGuardia Journal on Teaching and Learning, for guiding the development of the study and this paper.
APPENDIX A

Figure A1: Resource Management Strategies: Metacognitive Self-Regulation Items on the MSLQ

<table>
<thead>
<tr>
<th>Item number on the MSLQ and overall scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
</tr>
<tr>
<td>4.36</td>
</tr>
<tr>
<td>1.95</td>
</tr>
</tbody>
</table>

Likert scale values
(1 = not at all true of me; 7 = very true of me)

Figure A2: Resource Management Strategies: Time and Study Environment Items on the MSLQ

<table>
<thead>
<tr>
<th>Item number on the MSLQ and overall scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
</tr>
<tr>
<td>5.48</td>
</tr>
<tr>
<td>1.57</td>
</tr>
</tbody>
</table>

Likert scale values
(1 = not at all true of me; 7 = very true of me)
Figure A3: Resource Management Strategies: Effort Regulation Items on the MSLQ

<table>
<thead>
<tr>
<th>Item number on the MSLQ and overall scale</th>
<th>Item</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>4.84</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>5.10</td>
<td>1.82</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>5.14</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>5.63</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td>5.20</td>
<td>1.09</td>
<td></td>
</tr>
</tbody>
</table>

Likert scale values (1 = not at all true of me; 7 = very true of me)

Figure A4: Resource Management Strategies: Peer Learning Items on the MSLQ

<table>
<thead>
<tr>
<th>Item number on the MSLQ and overall scale</th>
<th>Item</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>3.92</td>
<td>2.08</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>4.17</td>
<td>2.09</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>3.05</td>
<td>1.99</td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td>3.71</td>
<td>1.62</td>
<td></td>
</tr>
</tbody>
</table>

Likert scale values (1 = not at all true of me; 7 = very true of me)
Figure A5: **Resource Management Strategies: Help Seeking Items on the MSLQ**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Item Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>2.99</td>
<td>1.72</td>
</tr>
<tr>
<td>58</td>
<td>4.46</td>
<td>2.02</td>
</tr>
<tr>
<td>68</td>
<td>4.28</td>
<td>2.09</td>
</tr>
<tr>
<td>75</td>
<td>4.88</td>
<td>2.02</td>
</tr>
<tr>
<td>Scale</td>
<td>4.15</td>
<td>1.26</td>
</tr>
</tbody>
</table>

(1 = not at all true of me; 7 = very true of me)
APPENDIX B

Motivated Strategies for Learning Questionnaire (MSLQ)

Part B. Learning Strategies

The following questions ask you about your learning strategies and study skills for this class. Again, there are no right or wrong answers. Answer the questions about how you study in this class as accurately as possible. If you think the statement is very true of you, circle 7; if a statement is not at all true of you, circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you. Use the same scale to answer all the questions.

32. When I study the chapters for this course, I outline the material to help me organize my thoughts.

    Less true 1 2 3 4 5 6 7 More true

33. During class time, I often miss important points because I am thinking about other things.

    Less true 1 2 3 4 5 6 7 More true

34. When studying for this course, I often try to explain the material to a classmate or friend.

    Less true 1 2 3 4 5 6 7 More true

35. I usually study in a place where I can concentrate on my coursework.

    Less true 1 2 3 4 5 6 7 More true

36. When reading for this course, I make up questions to help focus my reading.

    Less true 1 2 3 4 5 6 7 More true

37. I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.

    Less true 1 2 3 4 5 6 7 More true

38. I often find myself questioning things I hear or read in this course to decide if I find them convincing.

    Less true 1 2 3 4 5 6 7 More true

39. When I study for this class, I practice saying the material to myself over and over.

    Less true 1 2 3 4 5 6 7 More true

40. Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone.

    Less true 1 2 3 4 5 6 7 More true
41. When I become confused about something I’m reading for this class, I go back and try to figure it out.
Less true 1 2 3 4 5 6 7 More true

42. When I study for this course, I go through the textbook chapter and my class notes and try to find the most important ideas.
Less true 1 2 3 4 5 6 7 More true

43. I make good use of my study time for this course.
Less true 1 2 3 4 5 6 7 More true

44. If a chapter in the course is difficult to understand, I change the way I read the material.
Less true 1 2 3 4 5 6 7 More true

45. I try to work with other students from this class to complete the course assignments.
Less true 1 2 3 4 5 6 7 More true

46. When studying for this course, I read my class notes and the textbook chapter over and over again.
Less true 1 2 3 4 5 6 7 More true

47. When a theory or conclusion is presented in class or in the textbook, I try to decide if there is good supporting evidence.
Less true 1 2 3 4 5 6 7 More true

48. I work hard to do well in this class even if I don’t like what we are doing.
Less true 1 2 3 4 5 6 7 More true

49. I make simple charts, diagrams or tables to help me organize course material.
Less true 1 2 3 4 5 6 7 More true

50. When studying for this course, I often set aside time to discuss the course material with a group of students from the class.
Less true 1 2 3 4 5 6 7 More true

51. I treat the course material as a starting point and try to develop my own ideas about it.
Less true 1 2 3 4 5 6 7 More true

52. I find it hard to stick to a study schedule.
Less true 1 2 3 4 5 6 7 More true

53. When I study for this class, I pull together information from different sources, such as lectures, textbook and discussions.
Less true 1 2 3 4 5 6 7 More true

54. Before I study new course material thoroughly, I often skim it to see how it is organized.
Less true 1 2 3 4 5 6 7 More true
55. I ask myself questions to make sure I understand the material I have been studying in this class.
   Less true 1 2 3 4 5 6 7 More true

56. I try to change the way I study in order to fit the course requirements and the instructor’s style of teaching.
   Less true 1 2 3 4 5 6 7 More true

57. I often find that I have been reading the textbook for this class but I don’t know what it was all about.
   Less true 1 2 3 4 5 6 7 More true

58. I ask the instructor to clarify concepts I don’t understand in class, after class or during office hours.
   Less true 1 2 3 4 5 6 7 More true

59. I memorize key words to remind me of important concepts in this class.
   Less true 1 2 3 4 5 6 7 More true

60. When course work is difficult, I either give up or only study the easy parts.
   Less true 1 2 3 4 5 6 7 More true

61. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for this course.
   Less true 1 2 3 4 5 6 7 More true

62. I try to relate ideas in this subject to those in other courses whenever possible.
   Less true 1 2 3 4 5 6 7 More true

63. When I study for this course, I go over my class notes and make an outline of important concepts.
   Less true 1 2 3 4 5 6 7 More true

64. When reading for this class, I try to relate the material to what I already know.
   Less true 1 2 3 4 5 6 7 More true

65. I have a regular place set aside for studying.
   Less true 1 2 3 4 5 6 7 More true

66. I try to play around with ideas of my own related to what I am learning in this course.
   Less true 1 2 3 4 5 6 7 More true

67. When I study for this course, I write brief summaries of the main ideas from the textbook and my class notes.
   Less true 1 2 3 4 5 6 7 More true

68. When I can’t understand the material in this course, I ask another student in this class for help.
   Less true 1 2 3 4 5 6 7 More true
69. I try to understand the material in this class by making connections between the textbook readings and the concepts from the lectures.
Less true 1 2 3 4 5 6 7 More true

70. I make sure I keep up with the weekly reading and assignments for this course.
Less true 1 2 3 4 5 6 7 More true

71. Whenever I read or hear an assertion (a statement of fact) or conclusion in this class, I think about possible alternatives.
Less true 1 2 3 4 5 6 7 More true

72. I make lists of important items for this course and memorize the lists.
Less true 1 2 3 4 5 6 7 More true

73. I attend this class regularly.
Less true 1 2 3 4 5 6 7 More true

74. Even when the course material is dull and uninteresting, I manage to keep working until I finish.
Less true 1 2 3 4 5 6 7 More true

75. I try to identify students in this class whom I can ask for help if necessary.
Less true 1 2 3 4 5 6 7 More true

76. When studying for this course, I try to determine which concepts I don’t understand well.
Less true 1 2 3 4 5 6 7 More true

77. I often find that I don’t spend very much time on this course because of other activities.
Less true 1 2 3 4 5 6 7 More true

78. When I study for this class, I set goals for myself in order to direct my activities in each study period.
Less true 1 2 3 4 5 6 7 More true

79. If I get confused taking notes in class, I make sure to sort it out afterwards.
Less true 1 2 3 4 5 6 7 More true

80. I rarely find time to review my notes or textbook before an exam.
Less true 1 2 3 4 5 6 7 More true

81. I try to apply ideas from textbook readings in other class activities such as lectures or labs.
Less true 1 2 3 4 5 6 7 More true
REFERENCES


Teaching Electrical Circuits Using a Virtual Lab

Md Zahidur Rahman
Mathematics, Engineering, and Computer Science

Abstract
This paper describes an engineering professor’s first attempt at designing and implementing a scholarship of teaching and learning (SoTL) study in a basic electrical circuits course at LaGuardia Community College. Inspired by his understanding of Lee Shulman’s (2005) concept of “signature pedagogy” and Eric Mazur’s emphasis on student-centered approaches (2009, November 12), and aware that his students did not always understand the electrical theories and concepts presented in class, the author decided to change his pedagogy. He explains his efforts to train his students to think as engineers, first by making them more “visible” and “accountable” in the classroom, and second, by offering them hands-on practice through the use of Multisim, a free and open source simulation software. The implications for the teaching of the basic electrical circuits course are offered as well as the author’s reflection on his own growth as a teacher and his developing understanding of the scholarship of teaching and learning.

Keywords: Multisim, simulation, software, engineering, and electrical circuits

Introduction
In the early 1990s, when I studied for my Bachelor of Science in Electrical Engineering at Bangladesh University of Engineering and Technology (BUET), Dhaka, most of the electrical engineering courses included a 1- or 2- credit laboratory. These labs in courses such as Electrical Circuits, Electronics, Electrical Machines, and Electrical Measurement and Instrumentation complemented the 3-credit lecture in electrical theories and concepts. Instructors usually discussed theories and presented some problems and solutions; they also gave us problems to work on in class and circulated around the room as we worked independently. In the lab, we performed hands-on experiments to test and verify the theories and concepts we had learned in class. Working in groups of two or three students, we performed experiments using authentic electrical tools such as voltmeters, ammeters, multimeters, and rheostats to design, build, and test electrical circuits.
I came to the United States in 1999 to continue my studies in engineering. I was surprised to find that professors did not provide many opportunities for the hands-on experimenting and independent problem-solving that I had experienced in Bangladesh. Instead, they primarily lectured and demonstrated solutions to problems on the blackboard, a pedagogical approach I adopted as a teacher at City College, and later at LaGuardia Community College. Standing at the blackboard, I lectured and wrote out solutions to problems, stopping periodically to ask my students if they had any questions. They rarely did, and I assumed they understood what I was doing. Occasionally, I gave students a problem to solve independently in class. I walked around the room observing students as they worked, but I did not interact with them very much.

I joined LaGuardia Community College’s Carnegie Seminar on the Scholarship of Teaching and Learning (SoTL) seminar because I wanted to improve my teaching and my knowledge of SoTL. During our discussions of Lee Shulman’s article, “Signature Pedagogies in the Professions” (2005), I reflected upon my own experiences in Bangladesh and in the United States. Shulman, an educational psychologist and past president of the Carnegie Foundation for the Advancement of Teaching, describes a typical engineering class as follows:

Although the teacher faces his class when he introduces the day’s topic at the beginning of the session, soon he has turned to the blackboard, his back to the students. The focal point of the pedagogy is clearly mathematical representations of physical processes. He is furiously writing equations on the board, looking back over his shoulder in the direction of the students as he asks, of no one in particular, “Are you with me?” A couple of affirmative grunts are sufficient to encourage him to continue (p. 53).

Shulman’s description sounded a lot like my experience as a student in the United States and the classes I was teaching, but I was no longer sure this approach was effective. Shulman also notes that in lecture-based teaching, there is “almost no reference to the challenges of practice … [and] little sense of the tension between knowing and doing” (p. 54). Shulman’s critique of the typical engineering class helped me to
see that I was not meeting the goal of preparing my students to become professionals. Engineers must not only understand theories and concepts, but also devise solutions to real-life problems, test their solutions, and troubleshoot those that do not work.

Furthermore, after viewing a video of Eric Mazur (2009, November 12) engaging Harvard students in the study of physics, I realized that I needed to change the dynamic in my classes. Instead of asking “Are you with me?” and turning back to the board while students passively watched me derive solutions to problems, I learned to build in more opportunities for them to solve problems themselves during our class sessions. Now, rather than simply observing as students work and waiting for them to ask me questions, I have begun to move around the class, crouching so I can see their work, understand where they are stuck, and ask questions that help in the discovery of the solution. Additionally, I call individual students up to the board as I sit among the others. I urge them not to be afraid to try; the other students and I will help them as needed. Using these methods, I can detect confusion more clearly and offer help more quickly.

But even with these changes, I felt that my pedagogy was not adequate to prepare students for a career in engineering. “Professional education is not education for understanding alone;” writes Shulman, “it is preparation for accomplished and responsible practice in the service of others” (p. 53). In order to more fully address my pedagogical goals, I needed to provide my classes with more hands-on experiences similar to those I had had as an undergraduate student in Bangladesh.

Electrical Circuits (MAE213) is a 3-credit course required for all civil, mechanical, or electrical engineering majors. Unfortunately, this foundational course does not include a lab hour. Furthermore, due to space and financial constraints, LaGuardia students currently do not have access to an equipped electrical engineering hardware lab. Therefore, our Engineering faculty are exploring simulation software. Such “virtual labs” engage students in realistic problem-solving activities that require the application of theories and concepts learned in the classroom.

Virtual labs offer many advantages, among them powerful processing and simulation facilities, ease of use, and accuracy. Where physical labs are not available, virtual labs can provide students with useful experience (Hackworth & Stanley, 2001; Hall, 2000; Lee, Li, & Cheung, 2002). Moure, Valdés, Salaverría, & Mandado (2004), Butz,
Duarte, & Miller (2006), and Swayne (2012) all note that virtual laboratories also have potential for helping students understand theoretical principles. Kollöffel and Jong (2013) studied groups of vocational engineering high school students to assess their understanding of electrical theories and concepts, and found that adding virtual lab experiences to the traditional lecture and hardware lab approach helped students learn theoretical concepts. Their research revealed that students might face some difficulties and need more time to construct, design, analyze, and verify the electrical circuits assignments using real hardware labs. Kollöffel and Jong suggest that virtual labs enable students to perform these tasks more quickly.

MATLAB and Multisim are the two simulation software packages in use at LaGuardia. Utilized for numerical computation and programming, MATLAB is a sophisticated and expensive software package often employed by professional electrical engineers. Multisim, on the other hand, is a free and comprehensive circuit analysis program that allows for the design, analysis, visualization, and simulation of electrical and electronic circuits. In addition to an extremely realistic interface, Multisim allows students to use a mouse and graphics options to create schematic diagrams. Fraga, Castro, Alves, and Franchin (2006) studied groups of college engineering students in an electrical circuits class. Using two computer simulation software programs, PSpice and Multisim, the researchers found that Multisim provided students an environment closest to a real lab. With Multisim, students can use virtual oscilloscopes, multimeters, and ammeters to develop their knowledge of electrical behavior.

Multisim engages students in realistic problem-solving; they can build simulated circuits, learn how to construct complex circuits with various components, and verify the circuit design. After building their simulated circuit, students “turn on the electricity” using Multisim’s virtual “switch.” With this last step, students can immediately see if the circuit they have designed will function as they planned. If it doesn’t, they can continue working on the problem, and utilize their knowledge of electrical theories and concepts to troubleshoot design issues and create alternatives until they arrive at the correct solution to the problem.

The Electrical Circuits course proved to be an ideal environment in which to begin exploring the pedagogical advantages of Multisim. The curriculum focuses on basic components of electrical theory and
practice such as resistors, capacitors, and inductors, and reinforces fundamental mathematical and electrical concepts needed for designing and analyzing electrical circuits. Using Multisim allows my students to put their knowledge of theory into practice using a realistic, albeit simulated, environment.

Preliminary Investigation of Multisim
In the informal study of my Spring I 2013 Electrical Circuits course described below, I examined the extent to which Multisim helped 17 undergraduate students (15 male and 2 female students) solve engineering problems. Three students were Civil Engineering majors, ten were Electrical Engineering majors and four were Mechanical Engineering majors. I divided the students into two groups of equal size. For the first half of the semester, the students in Group 1 worked on one project, performing all calculations and solving all circuit design problems by hand without verifying their answers or testing their solutions with Multisim. Group 2 students worked on the same assignment, but used Multisim to verify the accuracy of their calculations and test the viability of their design solutions. In the second half of the semester, the groups switched: Group 1 completed two projects using Multisim, while Group 2 completed the same two projects without using Multisim. This arrangement assured that all students would experience solving problems both ways:

1. Using only hand calculations and hand-drawn circuit designs.
2. Performing hand calculations, and then using Multisim to design, build, test, verify, and troubleshoot their solutions.

As indicated in the Project Scores table below, the median scores revealed that students who used Multisim did slightly better than students who did not.

<table>
<thead>
<tr>
<th></th>
<th>Group 1 Median Score</th>
<th>Group 2 Median Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multisim</td>
<td>91.5</td>
<td>91.5</td>
</tr>
<tr>
<td>Hand calculations only</td>
<td>88.5</td>
<td>89.0</td>
</tr>
<tr>
<td>Percentage increase</td>
<td>3.4%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

Table 1: Project Scores: Hand Calculation or Multisim
In an effort to get a better picture of students’ interactions with the software, I also asked students to respond to these three questions at the end of the semester:

1. Which topics or projects were most difficult for you?
2. Which method (hand calculation only or hand calculations and Multisim verification) better reinforced electrical theories and concepts?
3. What assignments or activities were most effective?

Eleven students concurred that using Multisim was the most difficult part of the projects. Twelve students agreed that performing the assignments with the simulation software is a better way of reinforcing electrical theories and concepts, three students believed that performing hand calculations only is more effective, and two students thought there was no difference between the two. Clearly, the majority of the students considered the mixture of hand calculation and software simulation the most effective way to complete projects and homework assignments.

Although this experiment was conducted with a small sample of 17 students, the results suggest that students do indeed benefit from the use of Multisim. In a short reflection at the end of their projects, one student commented, “With the help of Multisim I was able to verify my answers and correct the one that I had wrong.” Another student observed, “By doing this project I learned how to use Multisim to solve circuit problems, I also learned how beneficial it is to use Multisim. It is a very simple and quick way to check your answers for any mistakes.”

Ideally, LaGuardia’s engineering students should be able to test their designs of electrical circuits using authentic equipment in a well-furnished electrical engineering lab such as the one I used in Bangladesh. Based on the results of my Spring I 2013 experiment, I believe that Multisim offers a next-best solution to the problem of lack of access to realistic environments in which students can test their designs. This necessary hands-on experience brings me closer to a principal component of engineering’s signature pedagogy and addresses Shulman’s reminders about the importance of preparing students for their professional lives. In future semesters, I hope to continue my efforts to analyze and report upon the effect of using Multisim to help students master electrical engineering theories and concepts.
Notes

1. Both of the female students reported that using Multisim was the most difficult part of the class and noted that, for them, performing the hand calculations was more helpful in fostering understanding of electrical circuit theories and concepts, while the male students noted that Multisim provided a better way to understand the electrical theories and concepts of this course. This difference can potentially be ascribed to the assumption that males usually have more experience in dealing with various software tools and are not as intimidated by having to use software to simulate the circuit.

References


Improving Student Performance

Implementing Active Learning Strategies to Increase Retention in Human Anatomy and Physiology

Maria Entezari, Natural Sciences

Abstract
This study examines the impact of group work and discussions, “clicker questions,” partial outlines, and one-minute papers on the exam performance of LaGuardia Community College students in Human Anatomy and Physiology I (A&P) during Fall I 2012 and Spring I 2013 semesters, as well as students’ overall satisfaction with the course. A&P is a key course requirement for candidacy in health science majors at LaGuardia. Assessments consisted of a comparison of exam performance in treatment and control groups and a survey of student attitudes. The data analysis indicates statistically significant improvement in exam performance among the students who had active learning instruction. The results of the attitude survey, in which the students rated the efficacy of active learning strategies on a five-point Likert scale, indicate that the majority of students strongly preferred active learning activities and were satisfied with their experience in the course. A substantial majority of students indicated that the active learning strategies helped them to learn the material important to their future career goals. This study thus suggests that active learning strategies improve LaGuardia students’ experience of and performance in Human Anatomy and Physiology I.

Keywords: Student-centered, active learning, motivation, performance, anatomy and physiology, undergraduate.

Introduction
Human Anatomy and Physiology I (A&P), a gateway course for LaGuardia’s health science and psychology majors, has high dropout rates, following national trends. Health Science faculty at LaGuardia feel that successful completion of A&P with a C+ or better gives promise that candidates will achieve positive results in key courses in the major such as Human Anatomy and Physiology II and clinical courses. However, in practice, students need an “A” if they wish to be accepted into LaGuardia’s highly competitive programs in Nursing, Physical Therapy, or Occupational Therapy. Therefore, A&P faculty are frequently in search of pedagogical interventions that improve grades,
increase course retention rates, and gear students toward graduation and transfer. But deciding upon successful interventions is a challenging task. As documented across diverse disciplines (see Defining Active Learning below), the incorporation of active learning is one approach that can increase student learning, motivation, and success.

Throughout my life as a student in Iran, I wanted to be a teacher. Even in middle school, I observed my teachers’ methods, becoming more and more inspired as I evaluated what I liked and didn’t like. Yet in my first year as a professor at LaGuardia, I realized with dismay that nearly 40% of my students dropped my class after only a few sessions. Of those who stayed, just 50% completed the course successfully. At first, I assumed that my students simply lacked the motivation to study well, a perception that was in conflict with my knowledge that most worked hard and for many hours outside of class to support themselves and their families.

Zhai and Monzon (2001) reported that students withdraw from courses and subsequently from pursuing degrees at community colleges for several reasons, including conflicts with work schedules, personal reasons, parking issues, family obligations, financial difficulties, boredom with classroom activities and teaching styles, and low motivation. It is doubtful that we can eliminate all the factors that cause students to withdraw from their courses. However, educators might be able to influence some conditions that relate to student retention, especially fear of failure and lack of motivation.

While I could not identify the causes of withdrawal and failure from my A&P class, the rates were alarming and demanded immediate solutions: I increased my office hours, added more review classes before each quiz, and offered two sessions of online discussion board per week. These additional supports had some effect, raising the number of students who passed to 60%. Yet the percentage of withdrawals from my classes did not budge. If initially I had been excited by pedagogical challenges, now I was anxious, frustrated, and discouraged. I began to accept that if my students were to be better learners, I had to become a better teacher. Beyond offering more office hours, I had to rethink my pedagogy.

During this period of exploring strategies, the first step in my own remediation was to participate in LaGuardia’s Carnegie Seminar on the Scholarship of Teaching and Learning. With the goal of changing my entire approach to Human Anatomy and Physiology I, I launched a
two-year investigation of my methods with a series of questions: **What was my teaching philosophy?** **What previous classroom experiences had inspired me as a student?** **What had I done before in my classes?** **What had worked well and what had not?**

Reflecting on these questions, I thought back to Iran and the professor of embryology who encouraged my enthusiasm to teach biology. His methods were hands-on and collaborative: We formed the multiple stages of a frog’s development in clay, labeled its diverse parts, and tested each other to confirm that our models accurately incorporated every element of the frog’s physiology. With this embryology professor, we actually *experienced* biology in ways that reflected the well-known Chinese proverb, “Tell me and I forget. Show me and I remember. Involve me and I understand.” For us, his techniques were unique; we loved being in embryology lab, and none of us wanted to miss his class. I wanted my LaGuardia students to share the enthusiasm instilled in me by my professor, and I wanted to teach them as my professor had taught me, by actively engaging them in Human Anatomy and Physiology I, a course that could make or break their hopes for life-changing careers in the health sciences.

**Defining Active Learning**

Numerous research studies show the value and effectiveness of active learning strategies in improving student success, especially among minorities and at-risk students (Kagan, 1994). Schargel and Smink (2001) identified 15 effective strategies to decrease dropout rates from courses and subsequently from college. Among those most relevant to my Carnegie Seminar investigation were professional development, mentoring/tutoring, individualized instruction, and active learning; the focus of this paper is restricted to active learning strategies. Designated as one of “seven principles” for effective undergraduate education (Chickering & Gamson, 1991), “[a]ctive learning provides opportunities for students to talk and listen, read, write, and reflect as they approach course content through problem-solving exercises, informal small groups, simulations, case studies, role playing, and other activities – all of which requires students to apply what they are learning” (Meyers & Jones 1993; xi). A methodology that places students’ needs at the center of a learning environment, active learning is designed to generate discussion of concepts, posing of questions, and clarification
of misconceptions. In sum, active learning contrasts with traditional lecture courses in which students are expected merely to listen and absorb information transmitted by their instructors.

Active learning covers a wide range of strategies, and most studies show that, regardless of type, active learning has a positive effect on students’ learning and performance. A study by Springer, Stanne, and Donovan (1998) showed that implementing various forms of small group learning improved attitude and persistence in STEM courses. Similarly, collaborative work and group discussion significantly increased students’ learning and conceptual understanding in an upper-level biology course (Knight & Wood, 2005). Bojinova and Oigara (2011) reported that clickers appear to increase student engagement; however, they observed no significant difference in the scores of students who used clickers and those who did not. Another example of active learning strategies is the one-minute paper assigned at the end of class; students write about what they learned and what most confused them, a technique found to improve students’ exam scores (Stowe, 2010).

In traditional pedagogy, a substantial amount of material can be covered in lecture. However, students are often overwhelmed by the content. They struggle to make connections among facts and to build upon prior knowledge. In a traditional classroom, students may not have the opportunity to discuss their ideas and misconceptions and there is often little interaction among students or with their instructors. A number of studies found that these deficits are the primary reasons for attrition in science courses and subsequently for dropping out of school (Wilke, 2003). It has been shown that active learning strategies can improve student performance and attitude (Johnson, Johnson, & Smith, 1998). Active learning strategies increase student interaction with their peers and with their instructors, encourage students to connect new knowledge to prior knowledge, and provide opportunities for students to reflect on their learning process (Yager, 1991).

In contrast, some studies have shown that active learning strategies have no impact on student achievement at all (Huang & Carroll, 1997). These discrepancies might be attributed to differences in course content or student populations. It is, therefore, important to consider different courses with different populations of students if the positive effect of active learning strategies on student performance is to be confirmed. This study describes the development and implementation of
an instructional design that integrated multiple forms of active learning and student-centered pedagogies into a traditional lecture-based course in Human Anatomy and Physiology. The study was guided by the hypothesis that implementing different active learning strategies synergistically – using group work and discussion, “clickers” (personal response cards), partial outlines, and one-minute papers – would improve students’ exam performance, deepen conceptual understanding, and increase satisfaction and retention in A&P at LaGuardia Community College.

To test this hypothesis, I compared a traditional lecture-based environment to an active learning and student-centered environment. In both classes, I measured student performance on exams and a variety of student behaviors, such as the levels of their interest and motivation.

Method

Participants

Participants in this study (N=66) were students enrolled in two sections of Human Anatomy and Physiology I (A&P) in 12-week sessions of LaGuardia’s Fall 2012 and Spring 2013 semesters. All health science majors are required to take this 4-credit course to enter programs in Nursing, Physical Therapy Assistant, Occupational Therapy Assistant, Radiologic Technology, and Veterinary Technology. Participants were concurrently enrolled in a laboratory course that met once a week for 3 hours. The lab component of the course was not changed. LaGuardia’s Institutional Review Board approved the research study protocol (IRB Approval number 446331-1), and all students were informed that participation in the study was voluntary; opting out would not affect their grades.

This study was conducted in four 3-hour class sessions held during the semester. A&P covers the following topics: basic chemistry, the cells and tissues, a general introduction to the structure and function of human organs, the integumentary system, the skeletal system, the muscular system, the cardiovascular system, the respiratory system, the lymphatic and immune systems, and the maintenance of normal functions in the whole organism.
Experimental Design and Procedure
The research methodology was a quasi-experimental design with two conditions. The control condition was a traditional lecture-based approach to teaching the course; the intervention condition incorporated active learning strategies. The content material, the order of the lectures, the syllabus, and the exam schedule were the same for both groups. For both the control and treated groups, all materials required for the lecture (including outlines, notes, PowerPoint slides, and animations) were posted online one week before each class using the Blackboard course management system. For the control group (students taught in Fall I 2012), course topics were introduced by lecture; in-class discussion was minimal. In the treated group (students taught in Spring I 2013), lectures were punctuated, at twenty-minute intervals, by at least one type of active learning technique incorporated into the class.

Interventions
Based on the learning objectives, complexity of the task, and period of available time, one or two activities were chosen for each session. For example, I used group work and discussion activities to give students more time to understand the complexity of certain topics such as the concepts of chemistry included in the A & P curriculum. Personal response “clicker questions” were used to check quickly on the extent to which student comprehended the material. The partial outline activity helped students learn and remember definitions and facts.

Group work and discussion
During group work, four students worked together. Chairs were arranged in a semicircle to permit easy interaction with the instructor and other students. Several times in each group work session, the instructor posed two or three questions (Figure 1). While the students attended to these, the instructor circulated, listening to their discussions, answering questions, and offering comments. After 5 or 10 minutes, one or two groups presented their responses to the class.
Personal response “clicker questions”

Two to four “clicker questions” were presented as multiple-choice questions on a PowerPoint slide. Instead of electronic clickers, students used colored index cards to show their responses to these questions. Based on students’ answers the instructor could see what students understood and what they were still struggling with, and provide clarification as needed. (Figure 2).

Figure 1: Sample group work questions

The following figure is a diagram of an atom. Complete this exercise by responding to the questions that follow, referring to the atom in this figure. Insert your answers in the answer blanks provided.

1. What is the atomic number of this atom? __________________
2. If the atomic mass of this atom is 23, what is the number of neutrons? Show your work. __________________________

________________________________________________

________________________________________________

3. What is the electron configuration of this atom? ___________
4. How many electrons are in the valence shell? ______________
5. How many electrons would be needed to fill its outer (valence) shell? __________________________________________
6. What is the net charge of this atom? _____________________
7. Is this atom chemically active or inert? __________________
Partial outline
After a 15-minute minilecture, students worked in pairs to complete fill-in-the-blank prompts keyed to definitions and facts directly related to the minilecture (Figure 3).

Figure 3: Sample fill-in-the-blank prompts

1. Responsiveness means ______________.
2. Evolution means ______________.
3. Metabolism means ______________.
4. Thermoregulation is an example of ______________ because the body respond ______________ the original change.
5. Most of the feedback loops in our body are ______________ feedback loops.
6. ______________ feedback enforces the changes.
7. ______________ feedback is not always useful such as ______________.

One minute papers
Toward the end of each class, students were asked to write down the most important things they had learned, and to identify their needs for any additional information or clarification. After class, the instructor
Data Collection
To measure the effect of active learning strategies on student performance, I compared the scores of the same three out of six multiple-choice exams given to the treated group (Spring I 2013, N=32) and the control group (Fall I 2012, N=34). Based on Bloom’s taxonomy, answers were categorized as easy (knowledge), medium (comprehension and application), or difficult (analysis and synthesis). In addition, students in the treated group responded to a five-point Likert-scale survey of their attitudes toward active learning strategies and the course as a whole (questionnaire reproduced in Appendix B below).

Statistical Analysis and Results
Student Performance
As shown below (Figure 4), students in the treated group performed significantly better on Exams 1 and 2; on Exam 3, although students in the treated group performed better, the difference was not found to be statistically significant.1

---

Figure 4: Average scores on each exam

<table>
<thead>
<tr>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>50</td>
<td>60</td>
<td>50</td>
</tr>
</tbody>
</table>

---

1. The difference was not found to be statistically significant.
The average of scores on all three exams showed that students in the treated group achieved an average score of 76.8, significantly better than students in the control group whose scores on the three exams averaged 67.8. These scores are represented below (Figure 5):

Figure 5: **Overall average test scores**

![Mean performance chart](image)

Control Group – Non-Active Learning  
Treatment Group – Active Learning

The analysis of student responses to exam questions revealed that students exposed to active learning strategies were better able to answer questions in all three of the hierarchical learning categories (Easy, Medium, Difficult). Figure 6 shows that in each category the mean score was higher for students in the treated group.

Figure 6: **Average scores on exam questions grouped by hierarchical learning category**

![Average scores chart](image)

Easy  
Medium  
Difficult  

Control Group – Non-Active Learning  
Treatment Group – Active Learning
Student Attitudes and Retention
As Table 1 indicates, the majority of students in the treated group scored all survey questions about active learning satisfaction as “strongly agree.” Indeed, 90% of the students preferred active learning over traditional methods.

Table 1: **Student-reported attitudes toward active learning in Human Anatomy and Physiology I**

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree nor disagree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL improved my learning in A&amp;P</td>
<td>73.88%</td>
<td>17.70%</td>
<td>1.20%</td>
<td>7.20%</td>
<td>0%</td>
</tr>
<tr>
<td>AL increased my interest in the course</td>
<td>66.35%</td>
<td>19.15%</td>
<td>2.60%</td>
<td>10.40%</td>
<td>1.50%</td>
</tr>
<tr>
<td>AL improved my grade in the course</td>
<td>68.56%</td>
<td>16.66%</td>
<td>5.48%</td>
<td>9.3%</td>
<td>0%</td>
</tr>
<tr>
<td>I am glad I took A&amp;P with AL activities</td>
<td>81.50%</td>
<td>13.33%</td>
<td>5.17%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>In the future, I would prefer AL to lecture-based courses</td>
<td>90.05%</td>
<td>7.60%</td>
<td>1.10%</td>
<td>1.20%</td>
<td>0%</td>
</tr>
<tr>
<td>A&amp;P is relevant to my career goals</td>
<td>79.77%</td>
<td>13.30%</td>
<td>5.00%</td>
<td>2.00%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Discussion

*Student Performance*

The present study shows that incorporating some active learning activities in a content-intensive course such as A&P offers students an opportunity to engage with their peers and reflect on their own thinking process in the classroom. Consistent with studies that show the benefits of active learning strategies (Walker, Cotner, Baepler, & Decker, 2008), the A&P data, as shown in Figure 4, indicate a positive correlation between improvement of student grades and incorporation of active learning methods in the classroom. Also observed in Spring I 2013 (Figure 6) was significant improvement in the mean (p<0.001), indicating students’ ability to answer more questions at the Medium and Difficult levels of learning. These results suggest that implementing active learning strategies in this course improved academic performance and increased students’ problem-solving skills, and helped students identify strategies for enhancing their own learning. Extensive investigations suggested that metacognitive awareness is one of the crucial factors.
for student success (Bransford, Brown, & Cocking, 2000), preparing them for more advanced courses and independent learning (Armbruster, Patel, Johnson, & Weiss, 2009).

Four different active learning strategies were incorporated to improve student learning in the treated group. Small-group discussions and other group work encouraged students to debate different solutions and approaches to problems; these small-group activities worked especially well for shy students who might be reluctant to ask their questions in class. These methods also have the benefit of providing immediate feedback to the instructor about students’ understanding and/or misconceptions.

A second strategy tested was the use of personal response cards (surrogates for clickers). Results were consistent with Crouch and Mazur’s study, which found that using clicker questions improved student learning and performance (2001). Clickers are particularly effective as an immediate gauge of students’ understanding of specific topics. Based on their responses, the instructor can give students appropriate feedback and correction; students can also anticipate the format and depth of the questions that will appear on their exams. Clicker questions also stimulate in-class peer instruction, which is important for the process of student learning (Smith et al., 2009).

Third, partial outlines helped students to deepen their understanding of topics and retention of facts, and increased students’ participation. Students were motivated to ask more questions, which in turn helped to improve comprehension. Student responses on the questionnaire showed that they find this strategy useful, since it enabled them to make “a whole story” out of the various elements presented in class. Finally, the one-minute papers helped students to summarize what they had learned and identify areas of confusion.

Student Attitudes
Many science and nonscience majors believe that science courses are boring and even irrelevant (Rigden & Tobias, 1991). Some have had negative experiences in science courses before and come to class with poor attitudes. Most students are apprehensive about the prospect of performing badly in a science course (Hemenway, Straits, Wilke, & Hufnagel, 2002). In the present study, the incorporation of active learning strategies permitted students to discuss their thoughts in a
risk-free environment. Here, interaction between students and instructor mitigated anxieties about contributing to the class discussion and commenting on the work of peers. As shown in Table 1, 66.35% of the students “strongly agreed” that active learning activities increased their interest in the course content. Previous studies show that increased interest improves learning and can lead to better performance in a course (Svinicki, 2004).

Table 1 also shows that 81.5% of the students “strongly agreed” that they were glad they had taken the active learning enhanced course; 73.88% “strongly” believed that active learning strategies facilitated their learning, and 68.56% “strongly” believed that these strategies had helped them earn a better grade. Incorporating active learning activities in class enables students to become more familiar with the content, to connect various elements of the course, and subsequently, to come closer to their career goals. A substantial majority of the students (79.77%) indicated that they “strongly” believed that the A&P course material was relevant to their future career. These survey results show strong student satisfaction with the course and seem to confirm the positive effect of active learning strategies on students’ motivation and attitude. Active learning activities resulted in improved social interaction among the students. Some realized that study groups outside of the classroom could help them to better understand the course material. In one instance, a group of students attended the instructor’s office hours together.

Conclusion and Future Directions

This study investigated the effects of incorporating active learning and student-centered pedagogy into what was previously a traditional lecture-based Human Anatomy and Physiology I course. The results show a correlation between these strategies, improved student performance, and positive student attitudes toward the active learning enhanced course; furthermore, survey responses indicate that students enjoy active learning. Providing preliminary data and a model for incorporating active learning strategies in a content-intensive course, the study demonstrates the importance of revising traditional pedagogies in order to increase both the effectiveness of teaching and student motivation.

In the future, by disseminating these results, we can encourage the use of active learning methods by faculty, especially those in the sciences or similar disciplines, who have previously hesitated. This
study suggests that learning objectives and teaching methods in science courses should be reconsidered and reconceived to include activities that focus on active and collaborative learning. Such activities are crucial in improving student performance and guiding understanding of the relevance of course material to student career goals. An additional benefit of more class interaction is the possible gain in students’ abilities to communicate ideas and understanding. The process of reconsidering teaching and learning is, of course, time-consuming and requires extensive and close collaboration between faculty and academic administrators. Yet it is through openness and cooperation that all partners in teaching and learning will find productive ways to implement strategies that maximize the realization of student potential.

Notes
1. See Appendix A for details on statistical processes utilized for this study.
APPENDIX A

Data was compiled using Microsoft Excel 2010. All tests were scored using a 100-point scale. The average test scores achieved in each group were compared. A post-hoc test was performed to determine which means were statistically different. Mean scores, standard error (SE) and p-values are reflected in the chart below:

Table A1: **Mean scores, standard error (SE) and p-values**

<table>
<thead>
<tr>
<th></th>
<th>Exam 1 (Mean ± SE) p &lt; 0.05</th>
<th>Exam 2 (Mean ± SE) p &lt; 0.05</th>
<th>Exam 3 (Mean ± SE) p = 0.15</th>
<th>Overall Average (Mean ± SE) p &lt; 0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated group</td>
<td>79.13 ± 3.05</td>
<td>77.00 ± 3.17</td>
<td>74.25 ± 3.63</td>
<td>76.80 ± 1.89</td>
</tr>
<tr>
<td>Control group</td>
<td>69.06 ± 3.60</td>
<td>67.06 ± 3.05</td>
<td>67.27 ± 3.22</td>
<td>67.80 ± 1.88</td>
</tr>
</tbody>
</table>

Student performance on each of three hierarchical levels of comprehension was tested using one-way ANOVA to compare the means of correct answers in each category (see Figure 6 above).
APPENDIX B

Questionnaire used to assess student motivation and attitudes

Your class was the first section of SCB203 lecture to incorporate active learning activities. Therefore, I highly value your honest feedback to improve the structure of this teaching style to help serve future students. In addition, your comments will help improve the course overall and also help me assess my teaching to be more effective in working with future students.

This survey is completely anonymous. So don’t worry about anything and just feel free to write your opinion.
Thank you very much!

1. The material covered in Anatomy and Physiology I is relevant to my long term goals and future career.
   - Strongly disagree
   - Neither agree nor disagree
   - Strongly agree

2. Interaction with my classmates and professor in class through active learning strategies increased the level of my interest in anatomy and physiology.
   - Strongly disagree
   - Neither agree nor disagree
   - Strongly agree

3. Overall, taking SCB203 incorporated with active learning activities instead of the lecture-based teaching facilitated and improved my learning in anatomy and physiology.
   - Strongly disagree
   - Neither agree nor disagree
   - Strongly agree

4. Overall, taking SCB203 infused with active learning activities instead of the lecture-based teaching improved my grade in anatomy and physiology.
   - Strongly disagree
   - Neither agree nor disagree
   - Strongly agree

5. I am glad that I took SCB203 infused with active learning activities instead of the lecture-based teaching class.
   - Strongly disagree
   - Neither agree nor disagree
   - Strongly agree

6. In the future I would prefer to take courses that contain active learning activities.
   - Strongly disagree
   - Neither agree nor disagree
   - Strongly agree
7. Please rank each of the following elements of the lecture portion of this course according to how helpful you found them to be in terms of your learning. (1 = not helpful, 5 = extremely helpful)

- Group discussion: 1 2 3 4 5
- Clicker questions: 1 2 3 4 5
- Partial Outline: 1 2 3 4 5
- One minute paper: 1 2 3 4 5

8. Please rank each of the following elements of the lecture portion of this course according to how helpful you found them to be in terms of preparing you for exams. (1 = not helpful, 5 = extremely helpful)

- Group discussion: 1 2 3 4 5
- Clicker questions: 1 2 3 4 5
- Partial outline: 1 2 3 4 5
- One minute paper: 1 2 3 4 5
REFERENCES


It’s About Time!

Applying “Flipped Classroom” Pedagogy to Teaching and Learning Elementary Algebra

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Mathematics, Engineering, and Computer Science

Abstract
This paper explores a practice-based approach to improve pass rates in Elementary Algebra (MAT096), the second of two developmental math courses at LaGuardia Community College. The study investigates the impact of implementing a modified flipped classroom focused on in-class practice and instant feedback on student performance. To measure the impact of this pedagogy, the study compares the scores on two departmental exams with the exam scores on all the other MAT096 sections taught in Spring I 2013. The results provide statistical evidence that a modified flipped classroom approach helps students master the course material gradually and improves their academic performance.

Keywords: practice-based learning, flipped classroom, remedial math, pass rates.

Introduction
According to the Carnegie Foundation for the Advancement of Teaching, more than 60% of the nation’s community college students must take at least one course in developmental math, and an alarming 70% of these students do not complete those courses and, therefore, cannot proceed to college-level work (Carnegie). The causes of low achievement in math are well known – curricula and methods of instruction that are incompatible, lack of adequate student preparation in fundamental concepts, and insufficient time to review and practice. However familiar and varied these causes, the effects of failure in math are devastating: Inability to complete developmental math usually means that a student simply cannot graduate from college. By 2020, 67% of all New York jobs will require a college degree or career certificate (Complete College America, 2014, p. 1). Failure to graduate severely limits employment opportunities and salaries, also impeding personal and professional growth.
LaGuardia Community College of the City University of New York (CUNY) follows national community college trends identified by the Carnegie Foundation: In Fall 2012, 76% of students in the entering class placed into developmental math (LaGuardia Community College, Office of Institutional Research, 2013, p. 25). That same semester, the failure rate for students registered in Elementary Algebra (MAT096), the developmental math course discussed in this article, was 58% (J. Zhu, personal communication, January 15, 2014). Bahr’s extensive study (2008) of developmental math students in California public community colleges revealed that “three out of four (75.4%) remedial math students do not remediate successfully” (p. 442) and “more than four in five (81.5%) do not complete a credential and do not transfer” (p. 444). In a similar vein, the report of LaGuardia’s 2013 Periodic Program Review (PPR) of Developmental Math states that by Fall 2012, of the 934 students who had placed in MAT096 in Fall 2006, 53% had dropped out and only 41% had graduated or transferred (Developmental Math, p. 6). While the authors of the Developmental Math PPR note that further study is underway to identify variables that may affect the retention rate of developmental math students, the data analyzed thus far suggests that reducing the dropout rate of students in developmental math courses would improve the 6-year overall graduation rate (p. 6).

Within LaGuardia’s department of Mathematics, Engineering, and Computer Science (MEC), faculty teaching developmental math have participated in initiatives designed to help students pass developmental math courses and advance in their degree studies. For example, in Project Quantum Leap (PQL), over a 6-year period, 55 math faculty explored student-centered approaches such as collaborative learning, think-alouds, and structured problem-solving, all strategies applicable to the teaching of basic skills math (LaGuardia Center for Teaching and Learning [CTL], 2009). Math faculty are also piloting strategies such as modular classes and Academic Peer Instruction (API) tutoring support in class. MEC has also made extra tutoring, special workshops, and exam prep available to day and evening students. Implicit in these initiatives is the view that gains in student success will be achieved through pedagogies that include interaction and collaboration, combined with in-class and cocurricular tutorial support. However, even with such support, I believe that faculty and students require more time in class for supervised math practice and feedback. If students are to master
the course material, they must do so gradually, consistently practicing and assessing their grasp of each concept, and they must be assured of faculty feedback during each class session. To many teachers of developmental math, it often seems that there is so much material to cover that students do not have the time necessary to master course content. Too often, our students fall behind from assignment to assignment, their confidence and motivation faltering as the semester continues. This paper explores my effort to make time for in-class practice and feedback despite the constraints imposed by the MAT096 curriculum.

The Developmental Math Course at LaGuardia
LaGuardia Community College offers a sequence of two noncredit math courses, Introduction to Algebra (MAT095) and Elementary Algebra (MAT096), both designed to provide basic understanding of the arithmetical and algebraic concepts required for successful completion of the credit classes that form part of graduation requirements. Both MAT095 and MAT096 are scheduled for a total of 6 hours each week (4 hours of lecture, 1 hour of faculty-supervised time in a computer lab, and 1 tutorial hour). The curricula utilize EducoSoft, a web-based course management system that provides tutorials, practice tests, lecture notes, review materials, and course and department exams (Educo, 2008). Supplementing both courses are context-based quantitative reasoning projects using the environment as context in Introduction to Algebra, and health in Elementary Algebra.

As mandated by the MEC department, a 12-week semester in MAT096 begins with a review of fractions, decimals, and percentages and moves on to cover factoring, polynomial equations, scientific notation, graphing, and quadratic expressions. There are two departmental exams in Week 4 and Week 8 respectively, as well as two quantitative reasoning projects assigned during Week 3, Week 5, and/or Week 10. At the conclusion of the course, if students are to complete CUNY’s developmental math requirement and advance to the courses required for their major, they must also pass CUNY’s Common Elementary Algebra Final Exam (CEAFE), which counts for 35% of the final grade.

Almost every MAT096 class session introduces a new topic. Thus, very little or no time remains for students to practice solving problems in class or for the instructor to review student work and provide feedback. In agreement that practice is essential to developing
an understanding of math concepts, most teachers assign homework as the conventional means of mastering content. But homework and practice require time, and, for our students, time is in short supply. Many work, some commute long distances, often after long hours at work, and others work, commute, and take care of their school-age children. A recent random survey of 650 LaGuardia students revealed that 70% are employed; of these, over 60% work more than 20 hours per week (Dickmeyer, 2012, slide 33). Just under half of our students support themselves, 18% work to cover tuition and college expenses, and 8% to support their parents (Dickmeyer, 2012, slide 32). Students also reported that they spend 6 to 10 hours per week commuting to and from the college (Dickmeyer, 2012, slide 38). Faculty, too, are short on time. The density of the curriculum, the pressure of the CUNY test, and the lack of time to help students practice all make it difficult for developmental math faculty to cover the material and prepare students for their tests within the 12-week time frame.

The “Flipped Classroom” Model
To address this shortage of time, educators are currently exploring pedagogies inspired by the “flipped classroom” model. Sams and Bergmann, who began using a “flipped classroom” in 2006 (“Why,” 2012), explain the concept as follows:

Instead of coming to class to watch the teacher lecture and then going home to practice what they learned – thus the word homework – students watch the lecture at home and then come to class to practice what they learned – that is, they’re now doing homework in class. Freed from delivering whole-class instruction during that hour or so, the teacher can deliver targeted instruction to students one-on-one or in small groups, help those who struggle, and challenge those who have mastered the content. (“Flip,” 2013).

Although the verb “to flip” is recent in this context, various forms of this approach have been used by several educators in the past decade and have shown evidence of significant learning gains (Brame). Recently, Deslauriers, Schelew, & Wieman (2011) studied the effect of using flipped classroom techniques in a physics class. The results of their
study comparing the flipped classroom to a traditional lecture-based classroom showed increases in student attendance, engagement, and subject learning.

In LaGuardia’s MAT096 course, EducoSoft can be employed in a manner that supports a “flipped” classroom. To illustrate, students could use EducoSoft tutorials, independently and at their own pace, to review, practice, and clarify concepts introduced in class, freeing up time for more in-class practice and instructor feedback. But with limited time available, the working student or working parent or caretaker who does not always use EducoSoft effectively needs time to practice in class. In addition, the experience of learning material on their own, merely by reading through online tutorials, is perhaps not as motivating to students as solving problems with peers in class. Furthermore, without the instructor’s immediate feedback, students have only vague insight into how well they are mastering the course material as they review it at home. As Guskey (2005) notes, providing students with feedback on formative assessments and following these with corrective instructions and reassessment are essential elements of mastery learning and can have exceptionally positive effects on student learning. Certainly, a teaching approach that involves supervised practice in class with immediate feedback from the instructor helps students learn better and master the material gradually, avoiding the problems that result when students encounter difficulties learning independently.

Prior to the study described below, I did not set aside class time for my MAT096 students to practice. Instead, I lectured and wrote illustrative examples on the board while students listened for the entire hour. Occasionally, I asked if they were following the lesson. In the rare cases when students asked questions, I provided additional information. For homework, students completed sets of problems using EducoSoft, and in the subsequent class, I allocated approximately 5 minutes to address any questions they raised about the homework. However, I was dissatisfied with my classroom approach, always lecturing and constantly rushing through the syllabus, all the while aware that the students, not having done their homework, were not keeping pace.

While participating in The Carnegie Seminar on the Scholarship of Teaching and Learning offered by the LaGuardia Center for Teaching and Learning, I became aware of Eric Mazur’s flipped classroom pedagogy (2009). Intrigued by what I saw him doing with his physics
students, I decided to reallocate classroom time and tasks with the purpose of increasing interaction among students and with me, and encouraging a head-start on homework and an accompanying motivation to complete it. Most especially, I wanted to create an environment of engagement in which the instructor was at hand to give quick feedback and students were equally ready to identify and untangle their confusion.

Method
Thirty students enrolled in my Spring I 2013 MAT096 class participated in the study described below.¹ My classroom intervention consisted of four parts: preclass online exposure to new material, a shortened lecture, time allocated for in-class practice, and immediate feedback. Using this approach, I taught quadratic equations following the steps below:

**Part I: Online preclass exposure to the material (EducoSoft)**
I posted worksheets, and a quiz on the topic to be covered in class about one to three days ahead of time. (Note that the students get 24-hour access to all of the course materials in EducoSoft, including tutorials and lecture notes.)

**Part II: In-class review and minilecture (35 minutes)**
At the beginning of the class hour, I reviewed the homework for approximately 5 minutes. Then, for the next half hour, I explained quadratic equations. I gave examples of both quadratic and nonquadratic equations. Next, I explained the procedure used to solve quadratic equations, and provided a few examples. Although lecturing is essential to introduce concepts and definitions, using fewer examples and reducing the time spent on theoretical concepts allowed me to shorten the lecture time by half.

**Part III: In-class practice (20 minutes)**
Instead of explaining and solving many quadratic equations while asking students if they followed the lesson, I distributed worksheets consisting of five problems. Unlike the EducoSoft homework, which presents students with a miscellaneous assortment of problems related to a larger theme, my worksheets focused only on the concept covered in the lecture. Furthermore, EducoSoft homework assignments provide
students with the step by step solution to a sample problem; in contrast, my worksheets contained only carefully chosen hints. Given my experience teaching MAT096, I knew where students usually had trouble applying a concept, and I constructed my hints to supply students with just the right amount of information they would need to move on and solve the problem independently. While students worked individually, in pairs, or in small groups, I circulated around the classroom, answering questions and interacting with students individually. Whenever I noticed that many students made the same mistake, I gathered everyone into a large group and provided clues to point students towards the solution. I supervised students’ work and assisted them in completing the worksheet.

**Part IV: Instant feedback (5 minutes)**

At the end of the class, I wrote one quadratic equation on the board and gave students 2 to 4 minutes to solve it. After asking students whether they had been able to solve the problem, I wrote the answer on the board, and assigned the homework for the following lesson. I usually gave the students about one week to complete 2 to 4 online homework assignments.

**Measures, Results, and Discussion**

To evaluate the effectiveness of this approach, I compared the median scores achieved by students in my Spring I 2013 MAT096 section on both of the departmental exams they took with the median scores attained by students in all other Spring I 2013 MAT096 sections on the same exams. For each departmental exam, two samples were considered:

- **Sample 1** is the set of scores for all MAT096 students registered in Spring I 2013 who did not receive the intervention.
- **Sample 2** is the set of scores for the students who were exposed to the flipped classroom experience.
Table 1 presents the sample sizes and the median scores achieved on the two departmental exams.

<table>
<thead>
<tr>
<th>MAT096 – Spring I 2013</th>
<th>Exam 1-N</th>
<th>Median Score</th>
<th>Exam 2-N</th>
<th>Median Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1: General Population of MAT096 students</td>
<td>955</td>
<td>73.33</td>
<td>838</td>
<td>86.67</td>
</tr>
<tr>
<td>Sample 2: Flipped classroom experience</td>
<td>14</td>
<td>83.34</td>
<td>14</td>
<td>93.33</td>
</tr>
</tbody>
</table>

On both exams, the median score was higher for students in the flipped classroom, providing evidence for the effectiveness of this practice-based learning approach. To assess the validity of the sample and the intervention, statistical tests were performed at 5% significance level.²

This study suggests that making time for in-class practice using the flipped classroom approach can help students succeed. Students seem to have benefited from the class practice and daily assessment. Providing immediate feedback, clarifications, and explanations in class may have increased students’ ability to complete their homework and to prepare for departmental exams with more confidence and in less time. I noticed that during review of the homework, students asked fewer questions about the problems in EducoSoft suggesting that it was easier for them to complete the assigned homework. Students could also ask me questions during class, which saved them time since they did not have to arrange to meet with me outside of class. In the future, I would like to study the impact of this intervention on a larger population of LaGuardia’s developmental math students, and use qualitative measures as well as more extensive quantitative data to document the benefits of using a modified flipped classroom approach to help students succeed.
Acknowledgements

The author is deeply grateful to the editors of InTransit for their support and guidance throughout the writing of this article, and to Dr. Milena Cuellar, Department of Mathematics, Engineering, and Computer Science, for her expertise in statistical analysis, without which this paper would be incomplete. The author is also indebted to The Carnegie Seminar participants for their invaluable suggestions and encouragement.

Notes

1. 22 students took the exams, but only 14 students signed the Institutional Review Board (IRB) consent form; only the scores of those 14 students are reported.

2. In that analysis, a series of Mann-Whitney hypothesis tests (Mann & Whitney, 1947) is set up for bootstrapped samples. Details on this study are available from the author upon request.

References


Multiply or Divide?
The Problem with Word Problems

Reem Jaafar
Mathematics, Engineering, and Computer Science

Abstract
Word problems constitute an impediment to students’ progress in remedial math courses. A study of basic math skills at LaGuardia Community College revealed that students perform better when the context of the problems relates to areas of student interest. Furthermore, when given opportunities to discuss word problems in class with their peers, students are more successful in solving similar problems assigned for homework.

Keywords: Cooperative learning, mathematics anxiety, word problems, remedial mathematics pedagogy.

Introduction
“How much ground beef would be in each hamburger if 6 pounds of ground beef were used to make 13 hamburgers?” When faced with such a word problem, students in the developmental course Introduction to Algebra (MAT095) often ask, “Should I multiply or divide?” Despite understanding the procedures of multiplication and division, students become confused by word problems that require the correct choice and application of one or the other of these operations; in fact, “confusing” was the most frequent response students gave to a question about their attitudes toward word problems on a survey administered during Spring I 2012 (Appendix A; see also “Results” section below). In addition, I have observed that students visiting the math tutoring center often skipped the word problems that appeared in EducoSoft, the online learning platform used for all remedial math classes. One LaGuardia student remarked that she finds understanding word problems difficult because “there’s all that stuff at the beginning, and you have to get through that before finally seeing the question at the end. So, you don’t know what the point is till you get to the end. That’s hard.”

While the structure may be challenging, many researchers have found that students also have difficulty simply reading and understanding word problems (Barwell, 2001, 2003; Short & Spanos, 1989; Wiest,
If we can encourage our students to read carefully and patiently, they will not immediately assume that all word problems are “confusing” and may persist longer in their efforts to solve them. Exacerbating the anxiety experienced by many students toward reading and math in general, word problems in particular impede advancement and success in both developmental and college-level math courses.

For the country’s community college students, the road to college-level math and beyond is arduous. Students who do not pass developmental math cannot succeed in college studies, a condition that severely hampers their efforts to realize educational and career goals. Over 60% of community college students register for remedial math courses, yet only 30% achieve success (Carnegie). LaGuardia students follow a similar pattern of failed attempts. The 2012 Institutional Profile reported that approximately 70% of entering students place into developmental math courses (LaGuardia, p. 24). Before ever enrolling in a college-level math course required for graduation, a student placed in MAT095 must pass the course, and then complete the follow-up developmental course, MAT096. Finally, she or he must prepare for and pass the CUNY Elementary Algebra Final Exam (CEAFE). Obstacles like these often cause students to give up on college studies.

As noted in a recent study of CUNY retention rates, “entering freshmen who failed the math basic skills tests were less likely than students who were math proficient to re-enroll one year after entry” (CUNY, 2006, p. 23). In other words, failing developmental math often means that students do not graduate and therefore never attain their educational and career goals. Merseth (2011) quotes the president of the Carnegie Foundation for the Advancement of Teaching, Anthony S. Bryk, who noted that for diverse groups of students who see community college as an educational and economic lifeline, “developmental mathematics courses represent the graveyard of dreams and aspirations” (p. 32).

At LaGuardia, the first semester of the developmental math syllabus covers arithmetic (signed numbers, fractions, decimals, percents), elementary algebra (first-degree equations and inequalities, rules of exponents, equations of lines), and basic geometry (area and perimeter), as well as numeracy (estimation and unit analysis). Students must understand and perform calculations, but they must also be able to apply those calculations in context, most often in the form of word problems. Word problems constitute 20% of the first exam, 40% of the second
exam, and 33% of the final exam, and are, for many students – including those enrolled in MAT095 – the major hurdle to clear (Barwell, 2001, 2003; McNeil, Uttal, Jarvin, & Sternberg, 2009; Renninger, Ewen, & Lasher, 2002). Unfortunately, if students cannot learn to solve word problems at the start of the course, they will continue to misunderstand these problems throughout the semester. In the end, passing the exams and, thus, the course becomes less and less likely.

But what is it about word problems that creates confusion for developmental math students? Barwell (2003) provides a useful description of word problems, noting that they usually have four elements: “named characters, a scenario, items of numerical information and a question or task to be carried out” (p. 6). As in the example that introduces this paper, word problem information is not always “relevant” to students’ experiences or understanding of the situation described in the problem (Barwell, 2003, p. 6). That is, usually we want to know how many hamburgers we can make with a given amount of meat, not the other way around. Further, the context may be ambiguous or indirectly stated. For example, in the hamburger case, there are no named characters; we don’t know who or what the hamburgers are for. When Barwell (2003) listened to third-graders creating their own word problems, he discovered that math learners required narratives and that if they could relate the story to their personal experience, they were better able to understand the mathematical structure of the problem.

In a study of fourth-grade students’ ability to solve word problems, Bates and Wiest (2004) examined the effect of adding a personal dimension to the problem context. Participating students solved two sets of 10 problems each within a two-week period. Half of the problems were copied straight from the course textbook. The researchers “personalized” the remaining problems by substituting the names of students’ favorite toys, cars, friends, etc. in the scenarios provided in the textbook. Bates & Wiest compared the accuracy of student solutions to the textbook problems vs. the personalized problems, and found that students with low reading ability did “slightly” better on the personalized problems (p. 22). Although the improvement was not statistically significant, the students did exhibit more interest in working the personalized problems. This study points the way to further research: What conditions will alleviate the difficulties students have with word problems?
As a participant in the LaGuardia Center for Teaching and Learning’s Carnegie Seminar on the Scholarship of Teaching and Learning (2011–2013), I had an opportunity to frame preliminary questions about students’ difficulties with word problems, a process of research and inquiry that unfolded over two semesters and a summer. In Spring I 2012, I surveyed student attitudes toward word problems. During the following summer, I devised a new approach to teaching word problems in MAT 095 which I introduced to students in Fall I 2012. Guiding the initial framing of the inquiry was the hypothesis that a.) student success would increase if word problems were contextualized, focusing on their personal interests; providing contextualized word problems would help students to apply growing math knowledge to diverse situations in their lives; and b.) heightened success would lessen anxiety and increase willingness to practice math; growing competence could make math more appealing to at-risk students placed in remedial courses. Finally, I wished to observe whether working in groups would have any effect on students’ perceptions of their ability to solve word problems.

Literature Review

Despite student difficulties with word problems, Staub and Reusser (1995) emphasize that such problems allow students to utilize their knowledge of the world in combination with language and arithmetic skills. Further, De Corte, Verschaffel, & Greer (2000) note that word problems help students understand “when and how to use their mathematical knowledge for approaching and solving problems in practical situations” (p. 63). However, researchers agree that the scenarios usually written to depict such practical situations have a direct effect on student ability to understand and solve the problem, or to recognize that the problem has no solution (Barwell, 2001, 2003; Renninger et al., 2002, Verschaffel & De Corte, 1997; Wiest, 2002).

After researching the connection between students’ solutions to word problems and the context of the problems, Verschaffel and De Corte (1997) observed that students often “suspend” their ability to make sense of things. That is, they do not utilize their knowledge of the real world when they work on word problems. Verschaffel and De Corte cite studies conducted in the 1970s and 1980s in which elementary school students were given sets of exercises that contained “absurd” word problems that had no solution, for example, “There are 26 sheep
and 10 goats on a ship. How old is the captain?” Half of the students “solved” such problems by adding the numbers without understanding that the question and their solutions were meaningless (p. 578). In a similar study conducted by Reusser & Stebler (1997), 112 secondary school students were given two sets of 10 problems. Half of the problems in each set could not result in a “realistic” answer, for example, “Grandfather gives his 4 grandchildren a box containing 18 balloons which they share equally. How many balloons does each grandchild get?” The “nonrealistic” answer students gave was 4.5. On all similar types of problems, 50% of the students provided nonrealistic answers, even when they had been advised repeatedly to read the problems carefully and thoughtfully.

In addition to a realistic context, Renninger et al. (2002) and Wiest (2002) explored the extent to which students’ ability to solve word problems is affected by the degree to which they are interested in the problem scenario or context. In an intensive study of three students, Renninger et al. (2002) first interviewed the students to determine their level of interest in a variety of areas such as sports and television. Then, they gave the students sets of word problems focused on their “well-developed” interest defined as interest “characterized by the likelihood of re-engagement with specific classes of subject content” (p. 469). Renninger et al. concluded that students who were weak in math performed more successfully on word problems that had contexts in which they were interested. Studies concur that students will solve word problems more successfully if the context is realistic, interesting to them, and, as Wyndhamn and Säljö showed in their 1997 study, if they are engaged with other students. Although most of the research on word problems has been done with K−12 students, it seems likely that these findings apply to community college developmental math students as well; the research described below was an attempt to confirm that assumption.

Method
Participants
Twenty-eight students who took MAT 095 during Fall I 2012 participated in the study. Data from LaGuardia’s Office of Institutional Research indicated that about 32% of the students enrolled in the class were Hispanic, 39% were black, 4% Asian, 11% white, and 14% from other ethnicities. The class had a predominantly female population
In Transit

(68% versus 32%). Fifty percent of the students had a cumulative GPA of 2.0 or higher.

**Procedure and Measures**
The study consisted of three elements:

*Questionnaire:* At the beginning of Spring I 2012, I administered a questionnaire (Appendix A) asking students to describe their attitudes toward word problems, whether they had encountered them before, and how difficult they perceived word problems to be. On the questionnaire, students also identified one of the following topics as an area of interest to them: baseball/sports, money/finance, the environment, or health. Although the rest of this study focused on a Fall I 2012 class, the demographics of the later class were sufficiently similar to that of the Spring I 2012 class that the survey results could be applied to both.

*Online EducoSoft homework assignments:* Over the course of the semester, students completed seven EducoSoft online homework assignments devoted primarily to word problems. Each EducoSoft homework assignment includes an average of 11 word problems, arranged in sets of two to four problems devoted to particular curricular topics (decimals, fractions, percents, etc.). The first problem of each set serves as an example and is always presented with a solution so that students can see the process for solving it; the remaining problems in the set have a structure similar to the first, but students do not have access to the solution and must arrive at the answer independently. The first four EducoSoft homework assignments, requiring students to solve word problems using single-step multiplication, division, addition, or subtraction, were assigned in September and early October. From mid-October through the end of the semester, students worked on the last three EducoSoft assignments. The problems in these later homework assignments included more sophisticated multi-step processes that called for students to calculate proportion and percentages, and use percentages to calculate prices and discounts.

Students are usually assigned EducoSoft problems as online homework, but, for the purposes of this study, examples of EducoSoft word problems were given out as a handout in class. The class was divided into three groups according to students’ areas of interest; a leader was designated for each group. The role of the leader, always a student who had done well on prior homework assignments, was to discuss the
problems in the group and help others understand and correct their mistakes. First, students completed a survey asking them to read and score the difficulty of each problem on a scale of 1 to 5 with 5 representing the highest level of difficulty. Then, the students solved the problems in their groups while I circulated among them offering feedback and suggestions. After the discussion, students again rated the difficulty of the problems (Appendix B). Since the worksheet consisted of EducoSoft problems, students could discuss a problem in class with their peers and under my supervision, and then solve it again online at home, an approach that allowed them to practice independently what they had learned in class.

Homework worksheets: I created two worksheets for each area of interest. The first of these targeted worksheets had two problems for students to solve; the second had between two and four problems, depending on students’ area of interest. In addition, I drew on EducoSoft examples to compile another three general worksheets, with an average of four problems each. When assigning these worksheets, I alternated between general problems drawn from EducoSoft, and the problems that I had created which were targeted to student interests. Thus, I gave the assignments according to the following schedule:

Set 1 (general word problems) – early October
Set 2 (targeted word problems) – late October
Set 3 (general word problems) – early November
Set 4 (targeted word problems) – late November
Set 5 (general word problems) – end of semester.

Whether the assignment contained general or targeted problems, students were required to solve the problems in writing and show all their calculations. Worksheets were due by the next class session.

To assess the effectiveness of the use of word problems targeted to student interests, I compared students’ scores on the targeted written homework versus their scores on the general written homework. Additionally, I compared student scores on the online EducoSoft homework with scores achieved by my MAT095 students in the three previous semesters.

Results

Questionnaire: At the beginning of the Spring I 2012 semester, 100% of the 28 students surveyed said they had encountered word problems before. When asked to describe word problems, 55% of the students
used the word “confusing” or “confused,” 15% used the word “complicated,” 30% used the words “fun,” “tricky,” or “like.” With regard to the choice of topics, 48% selected money and finance, 30% health, and 22% sports and baseball; none of the students selected the environment. When asked whether they liked or disliked word problems (on a scale of 1 to 5 where 1 means “Strongly Dislike” and 5 means “Strongly Like”), a total of 74% of the students gave scores ranging from 1 to 3; 26% gave a score of 4 or 5.

**Online EducoSoft homework assignments given in class:** Students scored their perception of the level of difficulty of the EducoSoft problems both before and after they discussed the problems in their small groups. I compared the pre- and post-discussion scores to see if students’ perception of the level of difficulty changed. Averaging the results for all seven lessons revealed that 59% did not change their perception of the level of difficulty; however, over 80% of the students correctly answered questions on the EducoSoft homework online. This difference revealed the importance of drawing a distinction between students’ perceptions and students’ abilities. Students might perceive a problem as difficult, but once the problem becomes familiar to them, their anxiety is alleviated and they do well on similar problems given as online homework.

As shown by the average homework scores represented in Table 1, students participating in the study achieved higher scores on the online EducoSoft homework assignments than students in previous semesters. This data suggests that the small group discussions in class helped students complete the online assignments more successfully than their peers in prior semesters.

**Table 1: Comparison of students’ scores on online homework in four semesters**

<table>
<thead>
<tr>
<th></th>
<th>Lessons 1 through 4</th>
<th>Lessons 5 through 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average homework scores in the three semesters prior to the study</td>
<td>85.37%</td>
<td>78.88%</td>
</tr>
<tr>
<td>Average homework scores in Fall I 2012 study</td>
<td>92.46%</td>
<td>84.36%</td>
</tr>
</tbody>
</table>
Average scores on the last three homework assignments (5 though 7) were about 8% lower than the average score on the first four; this difference is to be expected since the last three assignments cover more material and require more skill to complete accurately.

**Homework worksheets:** The scores students achieved on the general (G) vs. the targeted (T) written word problems solved at home are presented in Table 2. On average, students scored 77.79% on the word problems targeted to their interests; the average for the general set of word problems was 60.86%, markedly less.

### Table 2: **Class average for the general (G) and the targeted (T) word problems homework**

<table>
<thead>
<tr>
<th>HW 1(G)</th>
<th>HW 2(T)</th>
<th>HW 3(G)</th>
<th>HW 4(T)</th>
<th>HW 5(G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late September</td>
<td>Mid-October</td>
<td>Early November</td>
<td>Mid-November</td>
<td>Early December</td>
</tr>
<tr>
<td>Average Class Score</td>
<td>63.52%</td>
<td>85.83%</td>
<td>52.32%</td>
<td>69.75%</td>
</tr>
</tbody>
</table>

**Conclusions and Future Directions**

This study was designed to investigate two strategies for improving students’ ability to solve word problems: 1) situate problems in a scenario of interest to the students, and 2) give students time to work with their peers in class on homework that they normally encounter only individually online. Data collected over the course of the Fall I 2012 semester suggests that students’ ability to solve word problems does improve when they work on problems of interest to them and when they work together with their peers.

To expand on this study, one could further investigate the extent to which students’ perception of the difficulty of a word problem may affect their ability to solve those problems. As Wiest (2002) and Barwell (2001, 2003), and others note, we must also come to a better understanding of how lack of language skills and reading ability causes students to struggle with word problems. Surely, methodologies that help students analyze the parts of a word problem (scenario, information, question) would help students recognize patterns and apply the critical thinking skills which would enable them to recognize “absurd” problems or those which have unrealistic solutions. Several studies have recommended that if students write their own word problems, their
comprehension and ability to solve them would be enhanced (Barwell, 2001, 2003; Short & Spanos, 1989). This practice could help students read problems more carefully, and arrive at a better understanding of how to derive the solution.

Our goal is to prepare students to succeed in upper-level mathematics courses regardless of their major. For example, a student interested in nursing should be well prepared to tackle medical dosages in upper-level courses after taking remedial mathematics. A student interested in humanities should be ready to take a statistics course. Even if students do not intend to take very advanced courses, they should be able to understand and utilize math and number sense as needed in daily life. Finally, they should be independent thinkers capable of deciding whether they need to “multiply or divide.” After all, we have a moral obligation to transform remedial math from “the graveyard of dreams and aspirations” to the gateway to students’ dreams and career aspirations.

Notes
1. Both MAT095 and MAT096 consist of 4 lecture hours, one EducoSoft lab hour supervised by the instructor, and one class hour supervised by a math tutor in the math lab.

2. Students completed an average of three EducoSoft assignments online every week, but only seven of these assignments were entirely devoted to word problems.
APPENDIX A

Questionnaire: Student Attitudes toward Word Problems

1. Have you ever seen word problems in Math before? (Here is an example of a word problem: Anna spent $40 less on food this week than Emily did. If Emily spent $93 this week, how much did Anna spend?)

2. How much do you like or dislike word problems? (Answer on a scale from 1 to 5 where 5 means you like them a lot, and 1 means you dislike them a lot.)

   1  2  3  4  5

3. How many word problems would you like to see on an exam if the exam consisted of 10 questions?

4. Name the MOST important reason why you Like or Dislike word problems.

5. If you happen to dislike word problem, can you tell me what might make you like them?

6. Circle ONE topic that is of GREAT interest to you:
   Baseball/Other sports  Money/Finances
   Environment            Health
APPENDIX B

Sample Word Problems with Likert Scales for Ranking Perceptions of Difficulty

1. Find the LCM of 150, 200, 450 and 600.

Before solving the problem, rank how difficult you think it is:
(1 is very easy; 5 is very hard)
1 2 3 4 5

After solving and discussing the problem in class (with the professor and your peers), rank how difficult you find it: (1 is very easy; 5 is very hard)
1 2 3 4 5

2. Candies are packed in four different sized packets containing 150, 200, 450 or 600 candies respectively. Find the smallest number of candies needed to make an exact number of packets of each size. Find the number of packets of each kind that will be made from each particular number.

Before solving the problem, rank how difficult you think it is:
(1 is very easy; 5 is very hard)
1 2 3 4 5

After solving and discussing the problem in class (with the professor and your peers), rank how difficult you find it: (1 is very easy; 5 is very hard)
1 2 3 4 5
REFERENCES


Anatomy via Adagio
Preliminary Thoughts on the Pedagogical Value of Music in a Biology Lab Class

Dennis Aguirre, *Natural Sciences*

**Abstract**

This paper describes the effect of playing classical music in a Human Anatomy & Physiology II lab course. The instructor noted that students preparing to take a high-stakes exam were more focused and less anxious when music was played. A comparison of quiz results revealed that students scored higher on the quizzes that covered aspects of the human body and organ systems that they had explored in lab when music was played.

*Keywords:* *Anatomy and physiology, classical music, lab classes*

One morning, while walking past the Fine Arts studios at LaGuardia Community College, I noticed students sculpting as music played in the background. They appeared relaxed, yet thoroughly involved in their work. Students in my Human Anatomy and Physiology I lab also worked with their hands, creating and modifying clay models of anatomical structures. Would their abilities to remember and understand body parts and their functions improve if I, too, played classical music as they worked? In September 2012, following the example of the Fine Arts studio, I decided to bring music into my laboratory, streaming it over the Internet.

Almost immediately, I observed that when the music was playing, students completed their work more quickly and efficiently. Eager to work with their clay models, they added more personal touches, Mohawks, for example, or tattoos, to their models than students had in prior classes. Most important, when there was music in the lab, the students seemed to learn the muscles and structures covered in the Human Anatomy and Physiology I curriculum with greater ease. After several semesters of positive feedback from students in Human Anatomy and Physiology I, I decided to incorporate music in the Human Anatomy and Physiology II lab classroom.

Required for health science and biology majors, Human Anatomy and Physiology II covers the brain, eye, physiology, senses (auditory
anatomy, integumentary, olfactory, gustatory), human somatic and autonomic reflexes, digestion anatomy and histology, digestive physiology, urinary system anatomy, histology, physiology, reproductive anatomy, physiology of reproduction, meiosis and fertilization, embryonic development, and genetics of the human body. To pass the lab component of the course, students must score 60 or above on two timed practical lab exams, both of which require the accurate location and identification of 50 of the 500 anatomical structures covered in the syllabus. For example, they must recognize not only the kidney, but also the pelvis of the kidney, pyramids, collecting ducts, nephrons, tubules, and blood vessels. Most students are understandably anxious about these tests; if they do not pass this course, they cannot continue in their chosen major in the health sciences, which for so many of our students lays the foundation of professional and economic security for their entire families. My hope was that by listening to classical music during the lab sessions, students would diminish their anxiety, increase their receptivity to information and its organization, and improve exam scores.

During the session in which they take the 4-credit Human Anatomy and Physiology II course, students typically carry between 7 and 10 credits, and most students have completed 45 or more credits. In the 12-week sessions, the class meets twice each week, 3 hours in a lecture class and 3 hours in the lab; in the Fall II and Spring II 6-week sessions, the weekly lecture and lab hours are doubled to allow faculty to cover the same material as in the longer session. The lecture segment of Human Anatomy and Physiology II focuses on the physiology, or function, of organ systems, while the lab hours focus on identifying the body parts. For example, in a typical 3-hour lab session about the brain, for the first 60 minutes faculty discuss the parts of the brain and demonstrate how these parts work together; students listen and take notes, using their illustrated lab manuals to follow the lecture. In the following 45 to 60-minute lab segment, small groups of students examine and manipulate plastic models of the brain, working on recognizing the shape and placement of its different parts and increasing their ability to identify those parts. In the last hour, students solidify their knowledge by dissecting a sheep brain. This pattern of lecture and hands-on practice in the lab structures the study of all organs in the Human Anatomy and Physiology II curriculum. Working with the plastic models and dissecting organ specimens are the two modes of hands-on instruction
that enable students to use their senses of touch and sight to learn the location, purpose, and names of over 500 parts of the body.

Studies demonstrate that stimulating even one sense, such as sight, results in greater learning; still greater benefit occurs when multiple senses are stimulated. For example, Dzubak found that students are less likely to be distracted when engaged in multisensory learning (2007). In my lab classes, students were already using their senses of sight and touch to examine and manipulate the movable parts of the plastic models. Sometimes, when dissecting specimens, students cut the intestine by mistake, releasing odors that engage their sense of smell. Playing music in the lab class would invoke a fourth sense, hearing.

In his review of studies on the impact of listening to music, Schellenberg (2005, p. 317) writes that music can also affect “mood, which, in turn, affect[s] cognitive performance.” As a teacher of a high-stakes stress-producing discipline, my goal was to strengthen student performance on quizzes and exams by lowering their anxiety and sharpening their ability to recall large amounts of material.

I began by selecting the six lab classes that were most appropriate for observing students working while classical music played in the background. The topics covered in the selected lab classes included the nervous system, special senses, gametogenesis, and the digestive, urinary, and reproductive systems. The lab classes were organized as follows: After a brief lecture students worked independently or with partners at their lab tables, examining and manipulating plastic models and then dissecting lab animals (rats) or mammalian organs (sheep brains, etc.). Students worked for approximately 45 to 60 minutes, and during this time classical music streamed from an Internet site through the lab’s speakers. The volume was adjusted so that the music could not be heard beyond the lab.

To my eye, while the music was playing, students appeared less anxious; they took fewer breaks and were more focused on the anatomy tasks at hand. As a result, I noticed, they always completed tasks by the end of the lab class when the music played; such was not always true of those lab classes when there was no music. At the end of the lab, the music was turned off, students returned lab items to their designated places, cleaned up their work areas, and took a 10-minute review quiz. During each quiz, I used a pointer to indicate ten anatomical parts of the organs students had studied during the lab hours, and asked
students to write down the name of the indicated part. These quizzes were not counted in course grades; however, students used their quizzes to review material, gauge progress, and identify areas of weakness. The “point-and-identify” format of the timed quiz helped students to prepare for the two 40-minute exams, consisting of 50 questions each. Quizzes were collected and answers discussed briefly before the class ended. My records indicate (Table I, below) that the average quiz scores were higher when classical music was played.

As a result of this preliminary investigation, I have concluded that classical music can help establish an environment that decreases student anxiety and enhances learning in the Human Anatomy and Physiology II lab class. Over the course of the two sessions, verbal feedback from students corroborated my impression that the music helped to reduce their stress levels and, thereby, helped them to learn more effectively; this feedback has encouraged me to continue to investigate the effect of playing music during lab sessions. In the future, guided feedback will provide clearer evidence of students’ learning experiences as the music is played. Future plans include formal explorations of multisensory stimulation to better understand student learning and ability to memorize anatomical structures.

<table>
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<th>Lab Section</th>
<th>Fall I 2012 SCB204.1751</th>
<th>Fall I 2012 SCB204.1752</th>
<th>Fall II 2012 SCB204.7728</th>
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<tr>
<td>Number Enrolled/Completed</td>
<td>22/22</td>
<td>22/18</td>
<td>23/23</td>
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<td>No</td>
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<tr>
<td>Average Scores</td>
<td>59%</td>
<td>54%</td>
<td>70%</td>
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Notes

1. LaGuardia’s academic calendar includes two semesters annually, Fall and Spring. Each semester consists of two sessions, the first of which (e.g., Fall I) lasts for 12 weeks and the second (e.g., Fall II) for 6 weeks. The preliminary experiment described here took place in both the Fall I and Fall II 2012 sessions.

References


Memoirs of Mathematicians and Scientists
4 OUT OF 3 PEOPLE STRUGGLE WITH MATH

As Easy As
3.1415926535897932384626
433832795028841971693993
751058209749445923078164
062862089886280348253421
1706798214808651328230664

MATHCOUNTS

This is what a mathematician looks like

Weapons Of Math Destruction
MY FRIENDS KEEP SAYING THEORY WHEN THEY SHOULD BE SAYING HYPOTHESIS

Facts are not science — as the dictionary is not literature.

TECHNICALLY the glass is always full! 50% air 50% water

Scientific Method
- Question
- Hypothesis
- Prediction
- Experimentation
- Replication
- Publication
- Knowledge
I grew up with two contrasting educations, distinct enough that “school” and “study” were for a long time separate experiences. School was Indianola Elementary, a brick structure near the sprawling Ohio State University campus where my father and mother taught mathematics. School was where I discovered watercolors and ink-drawing, where a blond-ringleted girl named Lori taught me how to immortalize my handprints in glue, and where, during recess, my best friend Anne Caswell and I chased boys in an ongoing competition of athletic prowess. School introduced me to exotic customs and expectations, pondered over at home with my equally puzzled immigrant parents. For example, in France and Yugoslavia, my mother’s and father’s respective countries, it would have been inconceivable for pupils to address teachers by their first names. As the first of their four children, it was I who convinced them that the use of first names was in fact acceptable and even customary in America, and also that a “sloppy joe” really was something to eat.

On the other hand, study was reserved for literature and math, lessons written in French and mailed by the Centre National d’Enseignement à Distance to the children of expatriates. Among my earliest and fondest memories are those afternoon and weekend hours spent studying Verlaine, Rimbaud, and excerpts from Balzac, and completing exercises in arithmetic, geometry, and algebra, all the work carefully reviewed and returned to France for evaluation and correction.

Years later, while cleaning out my parents’ basement, I came upon a stack of these childhood math assignments. Their precision and clarity surprised me. Every exercise required two separate boxes, one labeled Solution and the other Operations. In the Solution box, I set down my math reasoning in words: Since each kilo of oranges cost 1.66 francs, three kilos would amount to $3 \times 1.66 = 4.98$, while eight apples at 0.32 francs each would cost $8 \times 0.32 = 2.56$, yielding a total grocery bill of $4.98 + 2.56 = 7.54$ francs. Then, in Operations, I displayed the
arithmetic that had yielded the numbers. Sometimes a teacher’s red mark identified an error in computation, but the written explanation in the Solution box underscored the greater importance of reaching conclusions through reasoning.

In those years, homework led to many discoveries. For example, with the study of place-values came the realization that I could count in bases other than base 10. Before then, letters and digits appeared to behave in the same way, that is, as signs whose combinations yielded different “words” – chocolate, for example, or 728. But with the discovery of place-values, I began to see that letters and numbers behaved differently. While language could develop dynamically and even chaotically over time, in base ten, 728 would always denote a sum of specific groupings – seven groups of 100, two of 10, and eight ones. But why not group in powers of 5, or 3? To a young girl, this notion presented exciting possibilities! If I decided to count in base five, my 8-year-old self would instantly mature to 13 – 1 group of five years, and 3 ones. Even better, in base three, my age would translate to 2 groups of three, and 2 ones, making me a 22-year old woman!

So systematic was this number-naming that I was surprised I hadn’t perceived its logic before. Now I could use different bases to encode numerical communications for our sibling “Spy Club!” (That the Spy Club had never yet been called upon to use secret codes did not stop us from devising new ones.) The fun only increased when I ran into a problem for bases greater than 10: If I wanted to group in powers of 13, say, what single “digits” would be used to denote a group of ten, or eleven, or twelve? My mother suggested I “just make some up,” and so the Spy Club members set about creating our own memorable designs, finally settling on a flag-like symbol to denote a grouping of 10, crossed by a single bar for 11, and by two bars for 12.

At the age of 10 (a grouping of one!), I left Indianola Elementary for middle school. In those hazy prepubescent years, math made only incidental appearances but those few sightings provoked curiosity and thought, as on the day our social studies teacher introduced us to Zeno’s paradox. If an arrow were shot toward a tree, to reach the tree it would first have to cover half the distance to its target, then half of the remaining distance, and so on, so that the arrow would never reach its target. The class sat perplexed as our teacher, representing the trajectory of the arrow, took one large step that brought her halfway closer to the
wall, then a smaller step that bridged half the remaining distance, and so on. I realized that our teacher’s representation was misleading – by taking the same amount of time for each step, each covering smaller and smaller distances, she was constantly slowing down and so (unlike an actual arrow traveling at a constant velocity) would never reach the wall. I was intrigued. If any whole could be subdivided into infinitely many successive halves, then:

\[
1 = \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \frac{1}{64} + \ldots
\]

In other words, the infinite sum on the right yielded a finite number, but how could I compute it without knowing the result in advance?

To demonstrate that the equality held, I had to show that the sum of all fraction terms after \(\frac{1}{2}\) was itself equal to \(\frac{1}{2}\). After multiplication by 2, this would return my original equation, which at first made me feel I was going in circles – until I realized that multiplication by 2 provided just the trick I needed! If my infinite sum was a number \(x\), then multiplication by two would double the number, yielding \(2x\):

\[
\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \frac{1}{64} + \ldots = x
\]

\[
1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \ldots = 2x
\]

Now aligning identical terms in each infinite sum made it clear that \(2x\) was just 1 more than \(x\) – in other words, \(x\) indeed had to be 1!

The trick that I had found to compute the total \(x\) of an infinite sum pleased me, and I was equally pleased by the unexpected pattern revealed when I computed sums of successive thirds, fourths, etc. But it did not occur to me that I could pursue this puzzle as a subject of formalized study, nor did anyone around me suggest that I do so. Although I was the daughter of mathematicians, I never felt pressed to exert any particular efforts in that direction. Math was entertaining and even fascinating, but other activities were equally absorbing, like writing a poem, or learning a piano piece, or planning an elaborate joke for April Fool’s Day.

For a long time, math remained divided into separate domains: a place of school lessons and barely remembered tests versus a thrilling
realm of private curiosity and solitary exploration. It was not until finishing my undergraduate degree in comparative literature and working as a mathematics tutor that I realized I could connect school to study. One summer morning, as I reviewed some university math books in my usual spot on the terrace of a Paris café, my waiter cheerfully exclaimed, “Exams are over, take a break!” Laughing, I explained that I was preparing lessons for my own students. “Then your students should take a break,” he insisted. “It’s time for vacation!” When I revealed that my students had already departed for the summer, he eyed me, baffled: “So, wait, you’re not here studying for school or work? C’est juste pour vous distraire?”

Scribbled in my notebook were topology theorems and solutions, material that far surpassed my obligations as a tutor. “I guess that’s true,” I admitted, and laughed again at his raised eyebrows. But in that moment I understood that I could pursue a degree in math for pleasure. That fall, my decision to pursue a graduate degree in math led me to where I am now. Since then, in my classes and in math events across LaGuardia, I try to bridge school and study. Too often my students see math as confined to school, nothing more than a requirement for a major or graduation. But as their teacher, my first aim is to reveal the other space that math opens – a space for play, for free exploration, and for the occasional, magical surprise of finding the key to a mystery.
One of my first memories of school is the sound of rain. Not the sound of real rain but the sound of tiny balls of modeling clay, softened by the hands of 4 and 5-year-olds and bounced upon the faux leather placemats that covered our schoolroom tables. The clay balls were as big as our little palms, and as cold as early morning dew. Warming them up took a long time, but the bouncing tick-tack, loud and unsynchronized, was a child’s pleasure. I was entranced by the sound of the up and down movements of the bouncing balls, and with an uncontrollable and unconscious reflex, I counted the tick-tacks with the lost and forgotten number system used by very young children.

I grew up in Bogotá, Colombia, a big city whose elevation of 2,625 meters is proclaimed inaccurately in the city’s motto as “2,600 meters closer to the stars.” To tourism advertisers, the number 2,600 is presumably catchier than 2,625. But whatever! For many, those numbers are close enough; to a mathematician, however, those 25 meters are not insignificant. To us, precision matters. I can tell you that Bogotá sits high in the Andes, surrounded by mountains, at 4° north of the Equator, thus offering the enjoyable weather of an eternal autumn. It was there, in the early 1980s and 2,625 meters above sea level, that I had the good fortune to be educated at Sagrado Corázon de Jesús, an excellent Catholic school.

Strict and challenging, Sagrado Corázon de Jesús was at the time considered a progressive school for its “Personalized System of Instruction,” a method that made us independent learners from an early age, not because it was individually customized but because we were responsible for working mainly on our own. In each subject, we received “the guide,” a biweekly assignment listing the topics to be researched in our classroom library. At the end of the two-week cycle, we presented and shared our findings in a “put-in-common” round-table discussion led by our teacher. Afterwards, we handed in our notes for grading.
and received the next guide. In most subjects, we learned together in groups; if we had questions, we put these to other students first, and only later to our teacher. Best of all, we completed our work entirely in class during school hours, which meant no homework unless we had wasted our time at school.

But there were exceptions to the system. In Colombia, instruction in mathematics and science is mainly a recitation of recipes for how to solve what, and which procedure to follow when. The mathematics and science guides required that we practice huge numbers of exercises, and practice them again, and practice even more, just in case. Posing as an elite possessing knowledge accessed by a special few, the teachers presented the math “recipes” and they did not encourage questions. For students, this approach generated anxiety, frustration, and the false belief that math could not be learned by everyone. Perhaps these teachers did not deeply understand mathematics; unfortunately, they too were products of the same vicious learning cycle. This attitude – I have the power, you don’t know what I know, I make you believe that I know what you don’t (although I actually don’t), I feel frustrated, you feel frustrated, etc. – perpetuated an anxiety that grows deeper in the next generation of learners. Because I saw something very different in math and science, I was lucky, very lucky, to escape the cycle, but I saw it trap others.

During my late childhood and adolescent years, I was a very conflicted, rebellious, and bad-tempered girl. I was only eleven when the Mother Superior of my school pointed me out as a negative leader, a bad influence, because I did not always follow instructions. For many years, this label affected my self-image and the image my family had of me. Even my parents began to think that I would not graduate from high school. But in the repetition of the interminable exercises required by the math and science guides, I experienced peace and confidence. I became good at math; practice was not a trap but a safety net that I held on to. In algebra, the rules were clear, unchangeable, and unambiguous. Math brought me joy; it was like meditating, repeating a mantra, my own mantra. To solve a problem, I did not need to think, I just had to perform one (of many!) sets of steps. Math was a game of translation, converting the problem into simpler, familiar procedures to be used again and again. Many times, I was nearly expelled from school, but because I was “so good” at math and science, my teachers looked
the other way. Eventually, my math-meditations brought me popularity in school and confidence at home; I stood up and left behind the conflicted, rebellious, and bad-tempered adolescent. Since then, I have used my inner math-world of peace and joy whenever possible to help myself, my colleagues, and my students.

These experiences have contributed immensely to my teaching philosophy, a philosophy shaped by the never-ending practice of my Colombia school days, transformed by the freedom and responsibility of a single annual exam required by graduate school in the United Kingdom, and further modified in the United States, where math fear is everywhere. As I encounter different types of students, move to different countries, change disciplines of study, and grow older, I always try to explain things to others as I wanted someone to explain things to me those many years ago. I make the effort to remember how I learned something, and I try to remember the experiences that made learning difficult.

Sometimes, remembering my past school days, I imagine how to improve those learning experiences of my youth. In my imagination, I am observing my present self teaching my past self. At the same time, I keep in mind my present students: They are in front of me, looking into my eyes, waiting. These memories and images accompany me into all my classes, where I hope to pass on the peace, passion, and joy I feel in mathematics. I want to share the feeling of being empowered by skill and knowledge accessible to all through work that is both hard and enjoyable. I hope, too, that my teaching will break self-imposed stereotypes. Most of all, I hope to teach students who believe themselves to be “math disabled” to push past their limits to a more peaceful and less anxious math clearing where they will thrive.
Магический Цвет Математики
The Magic Color of Math

Marina Dedlovskaya
Mathematics, Engineering, and Computer Science
Over the years, I learn about different types of equations, different approaches to solving equations, and various ways to use equations. Equations are convenient tools, and with them I resolve many problems in many different fields of study. In college, I discover that the way I was taught math throughout my school years is thrown out the window!  

After finishing my formal education, I continue my math studies for three reasons: First, whether studying for an exam or preparing to teach, I find pleasure in math. Second, to me math seems easier to study than any other subject. After all, everything in math is logically connected, there is not much to memorize. All I need to remember is the starting point and the nature of the connections among facts.

Experience confirms that the field of math is the right choice for my professional career. I meet a woman whose dissertation research in the economy of the German Democratic Republic came to an abrupt end in 1990 when the GDR ceased to exist. In graduate school, I learn about different aspects of math. It turns out that I can pursue my professional interests and be a mathematician out of love. For this, I am ever grateful.

In the late eighties, in Orenburg State Pedagogical University, because of the draft for the war in Afghanistan, most students were girls. Not far from the School for Military Cadets, the school of Math and Physics became known as the “school for girls.” Very frequently, the cadets come calling for dates, but first they must study, they must prepare. A math professor of the cadets likes to talk to his students: “What are you going to talk to your girlfriend about if you don’t understand double integral notation?”

In my earliest memories, my grandfather holds my hand as I walk with trepidation through the misty mangroves of our ancestral home in Kerala, South India. My grandmother’s house had been in her family for more than twenty generations, and it was there that I spent my long-awaited summers. My Kerala home was a haven and a mysterious treasure trove of creaky teak floors, deep almirahs filled with sour lime pickles, and long eerie corridors lined with moth-eaten portraits of generations past. Much as I loved this great house, on most days I was outside on the vast verandahs tracking red-ant trails or exploring the Malabar mangroves. A surgeon by profession, my grandfather came with me on all my mangrove expeditions. At the crack of dawn every morning, we put on our boots and, catching net and binoculars in hand, waded through ankle-deep waters. In those fleeting summers of sudden sightings of brown-winged kingfishers and river otters, I fell in love with the natural world.

In middle school and high school, I wasn’t the best at academics. My interests were too varied: I played lots of cricket and participated in numerous art contests and exhibitions. After summer months in the mangroves with my grandfather, I was bored by the confines of a classroom with teachers who orated text straight off the page. The exception was my biology teacher who took us around campus to tell us about the living world. I became her “lab assistant,” a role that required catching tadpoles for our metamorphosis experiments, dissecting cockroaches for the study of the nervous system, and planning field trips to observe birds in the Madras Sanctuary. I loved every bit of her class. Looking back, I see that the single force motivating my school years was the anticipation of learning new scientific concepts.

Fourteen years after that biology class, I had to decide upon a premed program. As I come from a family of doctors, I wasn’t asked if I wanted to study medicine; rather, my family simply assumed that I would join the medical clan. However, whilst choosing among schools, I found myself drawn towards an undergraduate program in zoology at
Madras University. Before I knew it, I had recalculated my prerequisites and researched prospective doctoral programs in Animal Behavior! It took a bit of coaxing, but eventually my family gave me permission to follow my dream of becoming a scientist. I had finally found my true place, and as I studied science, I realized the difference between being passionate and talented. Yes, I had talent in sports and in the creative arts, but I lacked the passion necessary to sustain a career in these fields. On the other hand, the study of biology was entirely different: For this discipline, I possessed both talent and passion.

Upon the completion of my undergraduate degree in biology, I felt that I had mastered the animal kingdom, at least at the level of the organism. But there was a void in my knowledge of how things functioned at the mechanistic, molecular level. For instance, a defining characteristic of animal behavior is the response to environmental change by switching from one behavioral state to another. Ants, for example, have morphologically and behaviorally distinct major and minor workers within a colony. The physically larger majors are predisposed to defend the ant nest, whereas the smaller minors are the foragers. Despite this predisposition, majors will shift to foraging if the needs of the colony so require. I was curious about the molecular underpinnings of these behavioral shifts and wanted to understand how the environment mediates the ultimate cause. In other words, I wanted to discern the brain chemistry that underpins behavioral displays. If behaviors were chemically controlled, which genes would trigger the production of chemicals and how? These questions led me to graduate study in biotechnology and to deeper investigation of the world of molecular genetics, genetic engineering, and bioinformatics.

Graduate study severely tested my relationship to biology. Our class hours were long and lab hours longer. I passed most nights alone in the library, surrounded by massive textbooks that I could not afford to buy. Reading until dawn between large glass windows in the soft glow of a flickering desk lamp, I made my own notes to take home and study. In those years, I cultivated my study skills, learned efficient note taking, and ruminated on problems and scientific concepts on my 45-minute walk home through monsoon rains.

That time is marked by a memory of my mother, somber and silent, walking into my exam hall as I finished my last final. Only I knew the meaning of her smudged khol-rimmed eyes and her hurriedly wrapped
sari. After a brief illness, my beloved grandfather had suddenly been admitted to the intensive care unit with organ failure. Wordless, my mother and I drove to the hospital in an autorickshaw. I held my grandfather’s hands as he drifted away from me. His passing brought me infinite sadness, but also a new sense of being. After his death, my family encouraged my plans to accept admission to a doctoral program for which I had received a fully funded international scholarship.

My scholarship took me to Australia and a cornucopia of late nights watching fruit flies mate, midafternoon surf trips to Bondi Beach, and early morning breakfasts of Vegemite and toast with my Aussie flat-mates. Most important, as a student at Macquarie University, I conducted research in insect behavior at the Centre for Brain, Behaviour and Evolution. My research site also served as a rehabilitation facility for injured wallabies and kangaroos, one that gave me endless opportunities to play with rambunctious marsupials. And it was in Australia that I met the love of my life, had a big fat Indian wedding, and defended my thesis. But those experiences form another saga! In this part of my saga, my husband and I transferred to the University of Central Florida, where I conducted research for two years before arriving in New York to teach and direct my own research group at LaGuardia Community College.

As I write this memoir, I review all the major events in my life: my discovery of the natural world under the guidance of my grandfather, a life-changing career choice, and the passionate search for knowledge that took me far from my ancestral home and my grandfather’s love. My path to biology and teaching was hard; I was wrong in my choices more than once, and more than once, I squandered my creative potential. But I have learned that passion for our life’s work needs nurturing and commitment, qualities that emerge only with self-knowledge. In reflecting upon the perseverance necessary for my own self-discovery, I hold close the words of the renowned educator, Sir Ken Robinson: “Human resources are like natural resources; they’re often buried deep. You have to go looking for them. They’re not just lying around on the surface.”
How I Met My Mathematical Self

Bill Rosenthal
Mathematics, Engineering, and Computer Science

1. Conception through Junior High
I was but 1.5 years old when my parents traded our East Flatbush apartment for a ranch house in a suburb without numbered streets and avenues. From then until early adolescence, I exhibited neither interest in nor aptitude for quantitative matters. My mother boasted to her dying day that her only child started reading *The New York Times* at age 3. When it became developmentally appropriate to be sarcastic, I would rejoin that as I was *still* reading *The New York Times*, there had been no progress in all those years.

During one of my innumerable detentions in seventh grade, my mathematics teacher made me write the numeral for “one followed by a hundred zeros” one hundred times on the chalkboard. If only I had known that $10^{100}$ is an abbreviation for this number! (Nowadays I use this episode to introduce exponents and scientific notation to MAT095 and 096 students.) On the last day of eighth grade, the mathematics teacher publicly told each student his recommendation for the next year’s class. Mr. Perea put me in the regular track that commenced with ninth-grade algebra; on occasion, I caught myself looking ahead in the textbook, mildly pleased when a complicated calculation worked out properly.

It was in ninth-grade algebra that I first enjoyed a mathematical topic. The square-root algorithm felt similar to the long-division process – yet more sophisticated and more challenging by just the right amount. Carrying out a square-root extraction made me feel a shade more adult. Hapless with hammers, wrenches, and other markers of masculinity, I wielded the square-root implement with dash and aplomb.¹

2. High School
My tenth-grade geometry teacher was fresh out of college and endearingly geeky. No one will ever know whether Mr. Hulsaver’s interest in me was due to or in spite of my lifelong ineptitude at visualizing geometric objects. The June 1969 geometry Regents was so difficult that
the scores were curved upward. Mine wound up as an 88. Mr. Hulsaver is the earliest of my mentors to be acknowledged in my dissertation.

Eleventh grade found me chugging along the regular track with Mr. Ferraro in that era’s equivalent of the present-day Algebra 2, aka College Algebra with Trigonometry. One day, Mr. Ferraro introduced me to the “New Math.” A riot of abstraction that failed miserably, the New Math involved teaching arithmetic to children based on axioms of set theory and formal logic. It was breathing its last as the next big thing in school mathematics when Mr. Ferraro conjectured that it would appeal to me. How right he was! There was something surgically sharp and whistle-clean about this approach to mathematics – austere, forbidding, in and of a world entirely its own. I found myself being drawn into this world.

Off school grounds, I requested and received from my parents an upscale slide rule for my fifteenth birthday. A Dover paperback on recreational mathematics grew grimy with my thumbprints. So too a copy of the Time-Life mathematics book – until I turned to the facing pages with hundreds upon hundreds of digits of the decimal expansion of \( \pi \) printed in a long unbroken string. I screamed, dropped the book, and never opened it again.

Mr. Ferraro suggested I take calculus concurrently with precalculus during my senior year. He did me the solid of enabling me to advance my schooling, putting paid to the myth that mathematical knowledge is a stepladder whose rungs must be climbed one at a time. Precalculus and calculus brought me my first tremors of mathematical joy. Reciting the first twenty-five digits of the decimal expansion of \( e \) felt like G-d’s recompense for forbidding me to go on dates. Compelling the two different-looking sides of an alleged trigonometric identity to become equal to one another shooed the insecurity and anxiety away from my synapses for a few minutes. Then there were the words, oh, the words. Trigonometric! Abscissa! Interpolation! Antidifferentiation! And my favorite, the Gudermannian! Unlike the unfortunate trumpet I sonically abused during fifth grade, the precalculus-calculus register made exotic music I could understand and play – and, perhaps, someday conduct.
3. College

Just after I turned seventeen, I started linear algebra, a gateway course to the mathematics major. When I opened the famously severe textbook to do the first assignment, the gate suddenly looked like an electrified fence decorated with foot-long barbed wire and extending to the heavens. This was the big time, and I felt infinitesimally small. Soon I was engaged in long-distance sobbing, kvetching to my parents, “There are Chinese kids in the class!” The “Chinese kids” were the first persons of Asian heritage I had encountered outside of restaurants. My absorption of the model-minority myth escalated the fear resulting from the vertiginous difficulty of the mathematics. With the Schaum’s Outline Series book as my security blanket, I persisted. By the first robin’s song of the Buffalo spring, I had grown to enjoy cutting my mathematical teeth on the little miniproofs that had had me at sixes and sevens in midwinter.

Linear algebra was followed by abstract algebra. True story: Some MAT095 students recently asked about my doctoral research. I told them that I did work in a field named abstract algebra. The students’ unorchestrated quasichoral response: “Isn’t all algebra abstract?” Got that right, people. How I revealed in abstractness during my sophomore year! I would spend eight, ten, twelve consecutive hours at a carrel in the music library, oblivious to anyone and everything other than the glyphs populating number systems in which $2 + 2 = 0$ and the algebraic laws I had held to be sacrosanct were violated with gleeful abandon so as to give birth to infinitudes of new systems.

When in March of 1973 I lost my first serious girlfriend, I compensated by losing myself wholeheartedly in abstract algebra’s abstractions. It was fortuitous that shortly after the relationship ended, Galois theory entered my life. I had never seen anything so lovely — nay, anything with the quality of loveliness manifested by the fundamental theorem of Galois theory. Don’t ask, please. Forty years down the pike and I’m still trying to make sense of this cognitive-aesthetic phenomenon.

My collegiate mathematical activity was conducted in isolation as complete as that of the inmate sentenced to solitary confinement on an asteroid in the Twilight Zone episode “The Lonely.” I shunned all contact with mathematics majors so as not to perturb an illusion of grandeur that formed an ever-larger proper fraction of my self-concept. You see, I was soon to become the World’s Greatest Mathematician (WGM). Of all time. Including the infinite future.
Entering my final undergraduate semester, I had to decide between student teaching and the second halves of Introduction to Topology and Introduction to Complex Analysis. It wasn’t much of a contest. The education minor for which I had amassed twelve credits had never been more than a fallback response to the question, “So what can you do with a math major?” By January 1975, my mathematical ardor was sufficiently intense that even my parents were no longer dissatisfied with the answer, “Go to graduate school.”

The previous semester’s struggles in the first halves of both topology and complex analysis had taken me by surprise. Facing up to my difficulties would have threatened the veracity of the fantasy of my inevitable anointment as the WGM. I ignored, externalized, and wished into the cornfield the nagging discomfort emanating from my insufficient understandings of certain mathematical objects and the curves of reasoning terminating in truths about them. After all, I had received an A in both Topology I and Complex Analysis I. My grandiosity thus survived its first dust-up with reality, permitting me to play with Weierstrass’s mind-blowing infinite products in Complex Analysis II. Best of all, topology’s second semester dealt with *algebraic* topology. This cross-breeding of mathematical subdisciplines snatched topology from the realm of the spatial senses, referring questions of the shape and composition of tangible objects to the lawbreaking number systems that had bedazzled me two years earlier. A few weeks before graduating, I was transfixed by the Seifert-van Kampen theorem, which made me shiver like nothing had since my first date with the fundamental theorem of Galois theory. I was unaware at the time that these shudders prefigured my dissertation research. I was, however, fully conscious of my status and stature as the WGM-in-Waiting.

Graduate School and the Unimaginable Beyond
Our time is nearly up for this installment of “How I Met My Mathematical Self.” Thank you for tuning in, and even more for not tuning out. We’ll see you next time, when our (mostly) reliable narrator will address:

⊕ Whence *teaching* in the development of my mathematical self?
⊕ Whatever became of that WGM dude?
⊕ How did my mathematical self become a historical being?
⊕ Why am I still working on a calculus problem I started 30 years ago?
⊕ How did my participation in a women’s studies reading group change everything about my mathematical self?
⊕ Any questions you’d like answered. Those are the most important ones.

...and the most most-important question is one that the editors politely yet firmly requested me to address: “Please write a bit about the women’s studies reading group.” The setting was Ursinus College in the deliciously named Collegeville, Pennsylvania during the Spring 1988 semester. I was in the second year of my second post-PhD position. The reading group’s charge was to be the campus vanguard for integrating issues of gender, race, and class into the curriculum. My invitation to the group stemmed from an enthusiastic response to the previous semester’s workshop led by Peggy McIntosh, author of “Interactive Phases of Curricular Re-vision: A Feminist Perspective.” This enthusiasm, in turn, was conditioned by my just having read Susan Griffin’s book Pornography and Silence for the interdisciplinary senior symposium I was teaching.

I can’t completely account for the earthquake that shook my soul when I read Pornography and Silence. But surely its cause has something to do with my being the son of a man whom I questioned (in life) for not being a “real” man and thanked (posthumously) for the culturally feminine qualities I now value in myself. After the earthquake, nothing would be the same. The centerpiece of the reading group to which Pornography and Silence and Peggy McIntosh delivered me was Women’s Ways of Knowing: The Development of Self, Voice, and Mind. If you have read the book, you will understand the essence of my transformation. If you haven’t read the book, please consider doing so.

As evidence of the depth and breadth of the subsequent re-vision of all sectors of my selves – mathematical and otherwise – I offer:
1. My first published paper in education is titled, “Women’s Ways of Knowing and Humanistic Mathematics: A Partnership.”
2. In 1994, the feminist science educator Elaine V. Howes and I gave the conference presentation “Reconceptualizing the Infinite: An Intersubjective Feminist Critique of Mathematics.”
3. In 1995, Elaine V. Howes and I gave the conference presentation “Infinity (Continued): What’s Gender Got to Do with It?”
5. In 2013, Elaine V. Howes and I celebrated our thirteenth wedding anniversary.

Notes
1. The ubiquity of electronic calculators soon booted the extraction of square roots out of school mathematics. Some say that the same fate should befall long division.
“Math Is Everywhere,” Photograph by Paul West
Multiplying Disparities

Paul West
Mathematics, Engineering, and Computer Science

The analysis of the 2013 GSAT results further exposes the disparity in the quality of education that students at the primary level are receiving in public schools compared to private institutions across the island.

The majority of the primary, all-age, and junior-high schools are lagging behind preparatory schools, which are generally populated by students from higher-income households.

– The Gleaner, February 10, 2014

Today, as I sit outside the gates of Kingston’s Duhaney Park Primary School, I am thinking of the changes that I want to see in Jamaica. Before me, the mural “Math is Everywhere” combines images and words to relate mathematics to science, economics, and engineering. But in one very real sense, math isn’t everywhere: Every year, both at the primary and secondary level, standardized tests show dismal results in mathematics in Jamaica’s poorest schools. As I write, school children mill about, reminding me that this is the time of year when exam results come out. These days will bring joy to some, and to others, sadness.

My own school days were idyllic, full of personal advantage. I grew up in a family of educators on the northeast coast of Jamaica in the small vacation town of Port Antonio. In primary and middle school, my friends and I received the solid fundamentals of English, mathematics and science, all compulsory core subjects. Our teachers were well trained, curricula were structured, and the emphasis on good manners, discipline, and tradition was unwaveringly strict. Early on, I understood the importance of being educated and being an educator. My mother graduated from Teachers College, taught English and mathematics, and became a primary school principal; my father was a university professor of pharmacology. Consequently, I was a good student, consistently working hard in class and attending endless extra lessons and enrichment programs organized by my mother and her colleagues. With regard to my future, my mother limited her instructions to exclusionary rules. For example, being a lawyer was not an option – they told too
many lies. More direct, my father pointed me towards medicine. But if I was a good student, I was also a rebellious preadolescent, acutely aware of my lack of interest in either profession.

After middle school, my friends and I moved on to high school, a straightforward transition at that time. Across the island, all public and prep school students sat for the annual Common Entrance Examination (CEE), established in the United Kingdom in 1904. For our efforts, we received a pass or fail on the exam, and up to the age of 12, those of us who failed could take it again. Once we passed our exams, we selected our high school, a choice usually based on neighborhoods, sports, and family traditions as well as academics.

I went to Jamaica College, a gold standard, traditional high school (“traditional” as in British colonial history and influence). At this time in Jamaica, education was free up to university level, and everyone had access to supplemental lessons at no cost. Public school or prep school, rich or poor: these differences didn’t matter. As long as we passed the pass/fail Common Entrance Exam and if space was available, any of us could attend Jamaica College. In those days, then, the mixture of students was diverse and the playing field more level.

For me, life was good; school was fun and struggle was elsewhere. In my world, high school was the best time of life. Sports and proms balanced homework; and though I easily accepted academic challenges, adult responsibilities were at a distance. Outside of high school, my days were filled with soccer, skateboarding, bike riding, horseback riding, and going to the beach. Unknown to me were the burdens of psychological, economic, emotional or physical trauma.

It is with this happy recollection of my school life that I present to you a situation that now exists on the island of Jamaica. In 1999, the Grade Six Achievement Test (GSAT) replaced the CEE. Let me count the ways in which these two exams differ. First, the GSAT is not pass or fail. Instead, a student is scored on his or her performance in English (including comprehension), Social Studies, Science, Arithmetic, and Communication Task. Second, students may take the test once only. Third, the choice of school option is dependent on the GSAT score. In other words, students who once mixed easily and equally are now sorted into categories of GSAT scores, each corresponding to specific schools ranked from high to low, academic to vocational. For example, an 88% GSAT average prevents entrance into a school with an academic rank
of 90% and above. Everything that friends have in common is now insignificant; your score is now your identity. And the visible symbol of that identity is your new school uniform, its colors indicating GSAT success or failure. Until graduation from high school, the community will judge you on the basis of these uniforms. Thus are communities of friends divided, segregated, and reduced by GSAT scores.

The way many students master the GSAT curriculum and enhance their chances to attain entrance into preferred or high ranking schools like Campion College depends on access to resources, mostly in the form of extra or supplemental lessons. If the best school admission = highest GSAT, then access to the best extra lessons = the highest GSAT. And of course, the best extra lessons = $$$. Thus, the “best” schools end up with the “best” students, typically from similar social backgrounds. In other words, to a large degree the GSAT model caters to the student who can afford the required resources and supports, i.e., private extra lessons. For private educational companies, “extra lessons” are a lucrative business, their promises beyond the reach of most students. Unless inequity and segregation are addressed, disparity in options and resources will continue into the next five years and beyond. A child with dreams of Campion is relegated to the realities of Papine High, schools less than 2 miles apart but at opposite ends to the academic spectrum.

As a Jamaican empowered my whole life by mathematics, I am contributing my skills to train math teachers in the use of digital media. In addition, I am in partnership with Junior Achievement Jamaica, the Digital Yard Foundation, and the Jamaica Business Development Corporation to develop young minds in math and science through an interactive, hands-on approach, utilizing LEGO blocks, robotics and computer aided design (CAD). Such programs encourage students to form mock companies and design projects with mentors from industry and academics. Our programs also support initiatives aimed at raising awareness and motivation in STEM disciplines, and we assist low-income schools with donations of books, geometry sets, and academic workshops. In these small ways, Jamaicans can dispel fear and increase understanding of how math relates to the world of a young person.

I know the pivotal impact teachers can have on a young person. In my own life, my zeal for math was deepened by a teacher’s attention and encouragement. As a budding soccer star, I was fascinated by the mechanics of striking a soccer ball and how that relates to its landing
location – the perfect lob pass, if you will. As I progressed to applied mathematics, my exposure to projectile motion, motion along a curved path under the action of gravity, fueled my fascination. Projectile motion describes the exact trajectory of an object under the action of a single force applied at the beginning of the trajectory after which there is no interference apart from gravity. The resultant of vertical and horizontal vector components of the induced object velocity has the potential to identify the exact landing location. While I cannot know with equal certainty the trajectories of the children of Duhaney Park Primary School, I am too aware of the multiple economic, social, and emotional forces that may upend the hopes of their young lives.

Despite the challenges of poverty and unequal opportunity, I am committed to my goal of leveling the educational playing field in math and science. I believe that independent of socioeconomics or neighborhood, children K through 12 must have access to STEM programs that, aligned with entrepreneurial development, will stimulate the aspirations of Jamaican youth across all social classes. We must provide the conditions and resources that inspire young minds to explore diverse areas of science innovation and technology. If we Jamaicans commit to a fairer distribution of our intellectual, educational, and entrepreneurial resources, then we will build solid foundations for the economic and intellectual development of our country. If we are to succeed in building this foundation, then math must be everywhere.
Reflecting on my journey in science from childhood to the present, I am filled with memories. Early on, science presented me with so many questions about nature: Why are both the sky and the sea blue? Why are there so many colors in a rainbow? Why do some foods taste sweet and others bitter? From primary grades through high school, I sought answers to these questions. There were very limited resources in my small Caribbean island of St. Kitts. Fortunately, good teachers nurtured my curiosity and inquiries. In response to my science and nonscience questions, they offered their books and personal experiences.

After high school, I decided to attend the University of Alabama (UA) in Tuscaloosa. I knew very little about American universities, and campus visits from my home town of Basseterre were out of the question. At that time, I wanted to be a doctor, and UA had a good medical school and a warm climate. I had been accepted by universities in the northeast, but it was cold there, and the scientist in me did not want to investigate snow.

Of course, I had heard the stereotypes about the American South, but did not give much thought to how these might impact my studies. Overall, my time at UA was challenging, educational, and eye-opening. I lived and spent most of my time with other international students in the campus Rotary House, a residence on UA’s Fraternity Row. A whole other story could be written about the interactions between the residents of the Rotary House and the white men – and yes, all the men were white – in the fraternities surrounding the Rotary House. As one might imagine, my greatest challenge was the shock of coming from a country where the majority of the population is black to live in Alabama, where the majority is white.

A few weeks after arriving in Tuscaloosa, I needed a haircut. I entered the barber shop, sat down, and waited about an hour for the first open seat. It didn’t seem strange to me that I was the only black person in the barber shop, and I didn’t really notice the glances from the white customers. After about an hour, the barber approached me,
leaned over, and very apologetically said, “I’m sorry, but I have never cut a black person’s hair before. I would not know how to cut your hair.” Speechless, shocked, and embarrassed, I was also angry that the barber hadn’t told me this when I first arrived, but the racist implications did not strike me until much later.

A similarly memorable moment occurred after my first exam in an advanced biology class. While handing the exams back, the professor, an elderly white gentleman, announced to the class, “I don’t believe that blacks or women can succeed in the sciences. They definitely cannot succeed in my class.” I dropped that class right away. And this time the racism struck me immediately. Both incidents forced me to confront Alabama’s racial history, and strengthened my resolve to succeed not only at the University of Alabama, but especially in science.

For a native Caribbean, being the only black person in a class of 30 or 40 students was certainly unusual. However, most instructors and classmates were helpful, supportive, and friendly. I was invited to participate in research by a chemistry professor who was world famous, though I did not know that at the time. He took the time to talk to me about chemistry and science, inspiring me to explore the questions about nature that had stayed with me from childhood. These conversations and the opportunities to do research in his lab and to talk with other chemistry professors were key reasons for switching my major to chemistry.

Besides the academic opportunities, an unanticipated benefit of my time in Alabama was gaining greater appreciation for and sensitivity to race and ethnic relationships in the United States. In history class in St. Kitts, I had learned about Southern segregation and the fight for civil rights, and I had seen TV shows and movies that reinforced negative stereotypes about the South. But actually living and studying in the South opened my eyes to experiences that still haunt this country. Had I attended a college in the North or Midwest, my perspective on race would have developed, but perhaps not as starkly. To be honest, I also did not appreciate back then how these negative stereotypes might affect my life. Tuscaloosa taught me that the field of science, despite its emphasis on facts and logic, does not exist in a vacuum. Science is really about people.

After graduation, I carefully considered the question of where I would do graduate work. Having realized that environment was as
important as the quality of the education, I was determined to pursue doctoral studies in a diverse urban area. I chose Wayne State University (WSU) in Detroit, which, in 2000, was 82.8% black.

An amazing city, Detroit proved to be an excellent choice for me. As I worked toward finishing my graduate degree, faculty, staff, and my fellow students at WSU provided great academic and personal support. Nevertheless, once again, life in America surprised me. In Detroit, there were also challenges to success, especially when it came to focusing on studying. Unlike Tuscaloosa, Detroit was a city filled with so many things to do, so many distractions for a young black man. But as in Tuscaloosa, I also discovered stereotypes of blacks. Gathering with friends in a mall or at a club, or walking into an elevator, or driving around certain neighborhoods produced reactions just like those I had experienced in Tuscaloosa. Women clutched their purses closer to their bodies. Or, “Uh oh, here come those thugs. Let’s move to that other table.” However, far outweighing these experiences were the comforts offered by a city that valued diversity. Detroit struggled with questions and assumptions about race and ethnicity in ways that were less apparent in Tuscaloosa.

As a graduate teaching assistant in Detroit, I learned things most unusual for a native Caribbean. For example, in St. Kitts, I never had to think about how minority students might perceive their teachers. I had grown up in a country in which the individuals who taught me looked like me, and like me, had come of age in a shared culture. However, while teaching and talking with black students at WSU, I realized how unusual it was for them to be in a college level science class, taught by someone who, though from a Third World country, nevertheless looked like them. It was during those years that I realized how important it is to go beyond the science course content, and talk with my students and colleagues about my experiences and perceptions. Even at LaGuardia, I have found that we underestimate the need for connection in students who look to us for the inspiration to persevere in their studies.

It is impossible in a brief memoir to describe all the experiences that have marked my journey from a tiny Caribbean island with a population of only 30,000 people to teaching in the largest city in the United States and in the largest urban university system in America. But along the way, I have learned that students (and the general public) view science as cold, difficult, impersonal, and in no way related to their
personal lives. And this perception extends to their science teachers, whom they believe to be cold, difficult, and impersonal. I want our students to realize that science is not undertaken in isolation by robots. I believe that if my students are to understand and appreciate science, I must reveal its personal side, the personal side of myself as a scientist, my passions, struggles, triumphs, and perseverance.

LaGuardia faculty are aware that our students come from very difficult backgrounds beset with obstacles. However, among our diverse faculty are those who rose from similarly difficult backgrounds to overcome many of the same obstacles. I believe that if we can allow our students to see where we came from and share the journeys that brought us to where we are now, they will do much better in science. Ultimately, they will be better students, better people, because they can relate to the struggle to succeed. If we can connect to our students with empathy and humanity, we may inspire in them an appreciation of science that moves them to ask for themselves my long-ago questions about the sky and the sea and the tastes of bitter and sweet.
I am a Chinese woman born in mainland China. When people learn that I am also a mathematician, they invariably make certain assumptions: that at an early age I sat in a large classroom, an abacus on my desk, rapidly mastering arithmetic. That quite unlike the educational experience of most Americans, multiplication tables were drilled into me in endless days (and nights) of repetition. That the pressure to succeed, score high on exams, and rise to the top was obligatory. To the contrary, my own education was quite untraditional and school had little to do with my becoming a mathematician. The true explanation involves a unique upbringing, a few inspiring teachers, and the right information at the right time.

I grew up in a remote, mountainous region of northwest China. Before I was born, my father’s outspoken politics had forced my parents to flee their village in Hunan to Xinjiang, where they settled near the borders of Kazakhstan, Russia, and Mongolia, an area of Altaics, Russians, Kazaks, Mongols, and nomads. Our home did not have electricity, nor did our school, a primitive mud structure. My father had grown up very poor with only three years in a classroom; my mother was born into a wealthy family of scholars. In fact, her father had built a school in the village in Hunan. But when Mao’s Liberation Army took power, her father was killed – publicly executed as a visible representation of wealth. And my mother was denied a formal education.

Because both my parents had hardly any schooling, they were determined to give their children a proper education. In our home in Xinjiang, though toys were few, my brother and I played with puzzle books, educational magazines, a deck of cards. Before I started school, my father taught me how to multiply and how to use an abacus. He also invited teachers to eat with us, usually fish he had caught in the river, berries, and herbs he’d gathered from the mountainside, and vegetables from our garden. At one of these meals, my brother’s teacher, Xiao Fang
Guo, a stocky man passionate about knowledge, told a transformative story about the great mathematical prodigy, Carl Friedrich Gauss.

As Guo related the tale, the five year-old Gauss and his classmates were punished for misbehaving. Kept at school, the children were told that they could leave only after adding together all the numbers in sequence from 1 to 100. His pals set to work, pens in hands, adding $1 + 2 + 3 + 4$, etc. Gauss thought for a few seconds, and then offered the solution. Skeptical that the boy could have added 100 numbers so quickly, the teacher asked for an explanation: How had he arrived at the answer before even putting pen to paper? Gauss responded that symmetrical pairs of numbers added up to 101. 1 plus 100 added up to 101. So did 2 plus 99, 3 plus 98, 4 plus 97, etc. Therefore, one simply multiplied 101 by 50 to get an answer of 5050. Astonished, the teacher allowed Gauss to head home.

As a 7-year-old, I was immediately awed and delighted by this story. To me, Gauss’s quick, clever, but simple solution was like a magic trick, one that I remember wishing I could do. Seeking to exercise my wits in a similar fashion, I soon found my chance in a field covered with piles of logs cut from the forest. There were no cars in that part of our settlement, but once every autumn a convoy of trucks came to haul the logs away. Hearing the sound of approaching motors, all the children rushed into the dirt road, clapping and cheering, “A car is coming, a car is coming.” For us, the log piles were a happy place to play, one that held the promise of novelty.

Running about the field one hot summer day not long after hearing the story about Gauss, my friends and I decided to climb the neatly stacked logs. Arriving at the top, I saw that the workers had arranged them in symmetrical trapezoids (though I didn’t yet know that word). As a game, we counted the number of logs in each pile, and it was then that I had my first mathematical “Aha!” moment. I realized that if you imagined another, identical trapezoid upside down and next to the actual pile, each row would be the same length! The composite shape would form a parallelogram of logs (though I didn’t yet know that word, either). All I had to do was count the top layer and the bottom layer and add them together. Then I multiplied that sum by half the number of layers.
I was thrilled! Just like Gauss, I had found my own quick solution to a seemingly tedious problem! From then on, I was hooked on numbers, though it was a long time before I would learn that mathematics is not only about numbers. In those years, math was always something to play with, never a chore. Instead, every problem presented an opportunity to find a faster, more efficient, more clever and interesting solution. Later that year, when my teacher asked me what I wanted to be when I grew up, I responded unhesitatingly and with pride, “A mathematician.” I can’t say that I really knew what mathematicians were. I knew only that Gauss was one, and that mathematicians pursued things that sounded unearthly, pure, and even cool: theorems.

Not until I met Zeng YiRu in 7th grade did I understand that math was a codified, academic discipline, that all my ideas could be put into a formal language. An inspiring and captivating teacher, YiRu helped me stretch my mathematical imagination. She pushed me to become more than a tinkerer with numbers and mathematical concepts, and she was as important to my career in mathematics as Xiao Fang Guo had been with his story of Gauss.
YiRu taught me how to crystallize my thinking, how to communicate in the language of math, and how to write proofs. But I’ve never left behind the childlike delight in simple cleverness, the joy of solving puzzles. I am often surprised that a seemingly obvious game can lead one to think about deep mathematical problems and even generate important questions.

To enjoy math, you needn’t be a mathematician. Above all else, I hope to impart to my students the sense that math is to be played with, that it is not tedious and boring, a task to be shirked, ignored, or completed as soon as possible. Rather, math offers the same kinds of challenges and pleasures as a game of chess or a crossword puzzle. I don’t expect to recreate my own experience in my students nor do I expect, or want, all my students to become mathematicians. But I do hope that if I can turn their attention, or the angle of their attention, to the side of math that is filled with cleverness and intellectual “toys,” they will find their way to a richer, more pleasurable understanding of the discipline.
From Math Phobia to Math Philia

We will prove this by the method of prolonged staring.

– Joel Franklin
From Math Phobia to Math Philia

Hugo Fernandez, Humanities
Math used to be easy for me, or should I say easy enough. But then came geometry, and after a series of unfortunate events, I flunked and lived in fear of ever taking another math class. I was fortunate to be taken under the wing of Professor Bob Blitzer, who prepped me for entrance exams to prove that I knew enough mathematics to transfer from a community college to a university. Professor Blitzer showed me not only what to expect on the test, but also how to see the unity and clarity of math. I actually contemplated changing majors from photography to mathematics.

Now I read books about astrophysics, and numbers like Zero and Phi. As a photographer, I use the Pythagorean theorem to figure out the normal lens for any film format; and I apply the inverse square law to calculate film exposure when using artificial lights. Maybe someday I’ll go back and re-take that geometry class, just as I repeated Spanish. I’ve come to discover that learning higher math is like practicing a beautiful language that I don’t know how to speak well, or coming to understand a poem that at first seems incomprehensible. Through repetition and close attention, clarity emerges.

Naomi Schubin Greenberg, Health Sciences
It was my first semester in college and the day we got the results of our first math exam. I felt devastated. My score was 54. My mind was racing back toward what could have led to such a poor result. At my high school graduation I received an award for the highest math score. My report card showed 100’s in each marking period for math; well, maybe one 98. Had I been over confident in registering for solid analytic geometry without ever having taken solid geometry or analytic geometry?

Sitting near the top of the University of Michigan’s huge amphitheater, I slowly gathered my courage to walk down the stairs to show my paper to my instructor. His positive response quieted my anxieties. “That’s fine. You got more than half right. Just continue what you’re doing and you’ll pass.” And I did. I still pursue math puzzles and buy math related books for leisure reading, but the moment has stayed with me.
Louis Lucca, Humanities
His name was Mr. Piccione. Nicholas Piccione. He was very tall and reed-thin, with an aquiline nose. He was all nose, really. Mr. Piccione, “Peach” to his students, was my junior-year high school Trigonometry teacher. He was, in fact, quite dour and far from peachy. At some point during that year I began to have trouble seeing the yellow chalk on the green blackboard. Numbers were harder to make out than letters. Mr. Piccione made me sit in the front row and constantly made reference to my inability to see the board by referring to my ‘blindness.’ He reported me to the Principal who, in turn, called for a meeting with me and my parents. From that day on, I was forced to wear glasses. Although I could see the board clearly, I became blind to math. I have hated glasses, and math of any kind, ever since.

Deborah Nibot, Enrollment Services Center
Math represents ZEN to me, or the pathway to it. Afflicted with Math anxiety at my junior college experience, I released my stress by meditating, tapping into my mind and letting go of so many things. My method was to step to the back of the classroom, sit in position and meditate for 20 minutes before taking the test. In the end, I earned an A on the final.

My dad was battling cancer at the time, and my inability to do math seems related to my inability to save him. You see, as a young man my father was stripped of his inheritance and pushed into poverty. An inner-city child of two immigrant parents, I avoided numbers, which, for me, represented money and the lack of it. In our family, money was always a negative number. Today I am in a better place, thanks to a “Math Anxiety Focus Group” offered by New York City College of Technology’s Developmental Skills department. I had been looking for an alternate view of math and I found it in meditation. If we can learn to slow down and control the mind’s reactions to what we fear, we can unlock our potential for accomplishment.

Roslyn Orgel, CTL
In elementary school, I saw the point of adding, subtracting, multiplying and dividing, and if my answers were incorrect, I understood my mistakes. Algebra, though, was different. What was the meaning of all those X’s and Y’s, and speedboats coming from opposite directions?
When would the skills necessary to solve these problems be used in my everyday life? In junior high, I exclaimed to Ms. Fornoff, “But all numbers are irrational!” Until recently, I had no idea that the word “irrational” as applied to numbers had to do with ratios, and not absurdity. Twenty years later, a friend asked me “Why is it acceptable to say we can’t do math when few of us would admit to being illiterate?” In her question I recognized myself and the illogic of my math avoidance.

Still, I did nothing to overcome my math phobia until, as co-facilitator of the PQL seminar, I worked closely with math faculty, many of whom were dismayed by the intensity of students’ math hatred and fear. If we didn’t always agree about pedagogy, I admired the PQL participants’ commitment to helping students overcome their fears, and I came to appreciate the challenge of teaching an overly-packed curriculum to reluctant learners. As math faculty discussed the beauty and ubiquity of math, I began to wonder: What beauty? What have I been missing? What can they see that I don’t see? One day, Gordon Crandall, a PQL co-leader and devoted reader, directed me to Mathematics and Democracy: The Case for Quantitative Reasoning (2001), a collection of articles edited by Lynn Steen. Several of the authors argue that in an increasingly data-driven society, it is our civic responsibility to understand the numbers and statistics informed by public policy. Convinced, I decided it was time to come to terms with my math phobia.

On many occasions, I shared my experiences and questions with Michele Piso, colleague and editor of In Transit. In response, she described her vision of a LaGuardia-wide Math Happiness project (aka Math Philia!). Comparable to LaGuardia’s Common Reading program, Math Happiness would encourage math-challenged staff and faculty to take math classes together with LaGuardia students. She imagined a campus of faculty/student study groups and elevator conversations about math problems and homework struggles. If we could ask each other about what we were reading, why not ask students about what they were studying in math class? In Spring 2013 I took up the challenge and entered MAT095. By the third class, I had study-mates. We rode the subway home with our math notebooks open on our laps, and we went to the Math lab after class to get a head start on homework. Perhaps most importantly, we encouraged each other not to be afraid to ask questions in class. Reader, I passed the course. In Fall I moved up to MAT096, sitting in the course at night, and meeting almost every
weekend with my fellow student study partner. Over plenty of coffee and hot chocolate at an East Village cafe, we factored our polynomials, solved quadratic equations, and prepared for the final CUNY exam. Success! We both earned high final grades! Had I been alone with my math problems, I’m almost certain I would have given up.

My next step is Statistics and Math in the Everyday World. As an active reader and former English major, I know that I am literate; my new hope is to be numerate. If I am successful, it will be because of my study partners, and, most especially, the LaGuardia math faculty who have welcomed me into their classes. With patience, they have shown me the way out of math phobia toward math happiness. Please note: Math Happiness is available to all. If interested, contact MH founding members, Michele Piso, Roslyn Orgel, and Patricia Sokolski.

Bernetta Parson, Office of Transfer Services

Math is humbling. Anything that has only one answer is humbling because you are either right or wrong. In math, I’m more wrong than right. I don’t know when my math phobia began, but certainly my aversion started sometime in elementary school. I got gold stars and certificates and praise from my teachers for my writing. I won spelling bees and short story contests. I was good at my timetables and fractions but I don’t remember being acknowledged for those abilities. I gravitated toward the subjects (Language Arts in middle school, and English later) for which I received recognition, both personal and academic. In middle school, math was just something to get through, and by the time I entered high school, the only pleasure math offered me was in measuring bolts of fabrics and figuring out seam allowances. I could get by with very basic algebra, but beyond that, everything else was a blank. My brain didn’t seem to be wired for math; moreover, in class there was no attempt to apply math to practical situations. Where once there had been a tenuous connection, for example to multiplication in middle school or measurements in sewing class, now higher math made no sense at all to me. So rather than continuing to feel like an idiot, I simply avoided math, until the GRE. It wasn’t pretty, but having to battle quadratic equations and isosceles triangles helped to conquer some of the old fear.
John Piper, Development Office

I was a teenage math dummy – or at least I thought I was. In my first year of high school, I got a grand total of 46% in algebra for the entire year, and in a sweltering term of summer school, I barely squeaked by. Consequently, I was banned from ever taking math again. My best friend in school scored 10% on his final: 5% for correctly getting his first name and another 5% for his last name. That was it. In college, I got minimal grades for a couple of required math courses, but stellar marks everywhere else.

In more recent years, I became a professor in an Ability-to-Benefit program, teaching college-level material to incoming high-school dropouts. My specialty was supposed to be language skills, but a math component was also included. I mentioned my lack of math expertise, but the retort was, “Don’t worry, we’ll send you to math class.” They did, and the result was an epiphany during a lecture, when in a flash it seemed that the entire mathematical universe made complete sense.

I think that the key to resolving my outsider math status was realizing that when I flunked so badly I was only fourteen-years-old, in a much different time and living under totally different circumstances. As a mature grownup, I convinced myself that I could learn math, and thus remove the ban.

Meanwhile, my friend – the one who got 10% on his final for at least getting his name right – had started college in his forties, thinking he’d major in music. He had to take the required math courses and found he was really good at it. It took him some time to graduate going at night, but he did – graduating with a degree in mathematics, with honors.

So, here I was, attempting to teach math to students who were, at times, very surly, and the results started coming in. My students were succeeding in numbers that raised eyebrows. Pretty soon, I became lead math teacher for the department, not only teaching my classes, but holding seminars for our faculty as well. And if there were particularly difficult classes or situations I was called in to teach those, too. Eventually I picked up a nickname, “The Math Marine,” as in “send in the Marines,” the watchword when my skills were needed. I always prefaced my classes with my own high-school experience, however, and that of my friend, telling my students, “I’ve been there.”
I am satisfied to have successfully introduced so many students to college, yet there is one downside: When I’m with friends in a restaurant, nobody bothers to fumble with their calculators to divide the check and figure out the tip. My friends simply turn to me because I’m the only one who can figure it out in my head.

Michael Rodriguez, Humanities
I clearly remember early in elementary school taking a math quiz and thinking how easy it was. When I got the quiz back every answer was wrong. I do not recall what type of logic I devised to solve the problems but I remember feeling very disappointed. That was the beginning of my self image as someone who was not especially proficient at math. At the same time it was already obvious that I could draw really well. Even in kindergarten I felt like I was the best artist in class. The identity of someone who excelled at art but could not do math stuck with me all the way through the beginning of college. Now I think it was detrimental that almost everyone from my parents to my teachers nurtured this negative image.

In college I thought that passing or not passing my math courses was going to be a decisive moment in my life. That is, if I did not pass these courses, my college career would be over. So, I announced to my friends that I had to stop partying and going out on weekends, an uncharacteristic moment of maturity for a 21 year old in the early 80s in Miami, Florida.

As I got deeper into my art studies, I began to read more philosophy and logic and I especially remember reading Gary Zukav’s The Dancing Wu Li Masters which connects mysticism and physics in a really compelling way. So while I may not be able to perform the equations that result in string theory or the big bang theory, I really enjoy, for example, reading about quantum mechanics. I guess the point is that I sometimes regret that I did not explore mathematics on a deeper level. I have always felt that children are not challenged enough in all subjects, especially math. As the father of a six-year old girl in kindergarten, I am interested in figuring out how we as a family navigate her future math studies. My hope is that by high school age she will be teaching me algebra and trigonometry all over again.
Professional Development in Quantitative Reasoning

Mathematics, in the common lay view, is a static discipline based on formulas...But outside the public view, mathematics continues to grow at a rapid rate...the guide to this growth is not calculation and formulas, but an open ended search for pattern.”

Recalculating a Core Competency

New Approaches to Quantitative Reasoning at LaGuardia Community College

Justin Rogers-Cooper, *English*

When the modern revolution in Writing Across the Curriculum (WAC) began to spread along with the pedagogical theories of James Britton and Janet Emig in the mid- to late 1970s (Emig, 1977), it took a couple of decades for the message to move into colleges and universities throughout the country. When that first wave hit, though, LaGuardia Community College was at the forefront of innovation: We opened our Writing Center in 1974, just three years after the College opened, and since 1999, faculty have participated in LaGuardia’s year-long Writing in the Disciplines (WID) professional development seminar. With risk-taking institutions like LaGuardia quickly absorbing new ideas and leading the way, today we find that fully half of the nation’s colleges have a WAC-type program, and writing centers are even more ubiquitous – and perceived as utterly necessary (Thaiss & Porter, 2010).

We should keep this institutional legacy of innovation and agility in mind as we contemplate a new movement spreading throughout the country. Like the WAC movement of the 1970s, this movement requires faculty from multiple disciplines to rethink traditional priorities about pedagogy, particularly those that separate what happens in one subject area from what happens in another. The “Numeracy Movement,” which focuses on what is called quantitative reasoning (QR), seeks not just to certify that every last student can solve basic math equations, but also to create “quantitatively literate individual[s] . . . able [to] engage in mathematics and solve quantitative problems from a wide array of authentic contexts and everyday life situations” (Getz, 2011). In other words, our students need to think about the meaning of numbers in all of our classrooms, not just in their math classes. In fact, it may be that only by situating numbers in real-life contexts will students be able to grasp fully the importance of math, both as a subject and, in the words of the Carnegie Foundation for the Advancement of Teaching, as “a habit of mind” (Getz, 2011).
Just as the WAC movement demonstrated the need for “writing-to-learn” strategies in a variety of fields, the push for numeracy has strengthened into a wholesale recalculation about the importance of quantitative reasoning for student success, in both education and in daily life. Guidelines set forth by the Quantitative Literacy Subcommittee of the Committee on the Undergraduate Program in Mathematics (CUPM) did not appear until 1996, a full generation after writing centers. The National Numeracy Network (NNN) appeared in 2000 to unite disparate innovations into one concerted effort to spread the need for reform and to spearhead future initiatives. In 2006, the American Mathematical Association of Two-Year Colleges (AMATYC) again echoed WAC of a generation earlier and recommended that “faculty in other disciplines . . . integrate quantitative literacy into coursework across all disciplines” (Getz, 2011).

Suddenly, a new era began for community colleges trying to offer students the best kind of general education. When LaGuardia created its “core competencies” or set of outcome skills that the College assesses to measure the success of its general education, Quantitative Reasoning joined the list that included Critical Literacies, Oral Communication, Research and Information Literacy, and Technological Literacy. As in implementing the other core competencies, LaGuardia responded to the need to assess quantitative reasoning by tasking its faculty and the Center for Teaching and Learning (CTL) to find creative ways to integrate the new competency into disciplines, especially those outside math.

In response to this mandate, the CTL offered Quantitative Reasoning mini-seminars in 2010/11 and 2011/12. Led by Dr. Sreedevi Ande (Mathematics, Engineering, and Computer Science), Ros Orgel (CTL) and Carolyn Henner-Stanchina (College Now), fourteen faculty from across the disciplines read articles about the need for quantitative reasoning and created low-stakes assignments to help students build skills in this area. Although faculty evaluations of the mini-seminar attested to its value, participants also recognized that a few meetings over the course of a single semester did not provide enough time to learn about quantitative reasoning, investigate resources available on the Internet, and devise, test, refine, and report on assignments and student progress.

Therefore, during the 2012/13 academic year, LaGuardia took another step into the QR era. It should not surprise anyone to learn that instead of simply copying best practices from around the country and...
injecting them into its classrooms, LaGuardia decided to pilot a new faculty-led seminar, Strengthening Core Learning, designed to define, test, deploy, and assess activities focused on helping students develop general education competencies. Seminar participants joined one of four strands, each focused on a different competency (Critical Thinking, Research, Reading, and QR). Under the enthusiastic co-leadership of Yelena Baishanski (Mathematics, Engineering, and Computer Science), Justin Rogers-Cooper (English), and Ros Orgel (CTL), each faculty member in the QR strand revised one of their classes using the precepts of QR-infused assignments.

We inherited the seminar structure from LaGuardia’s Writing in the Disciplines model, another clear nod to the ways that WAC-pioneered teaching innovations have rooted the current drive to redistribute competencies into general education. To deepen the point, the Strengthening Core Learning seminar adopted John C. Bean’s famous “writing-to-learn” textbook, Engaging Ideas (2011), a staple of the WID seminar at LaGuardia and a beloved reference for faculty developing new assignments. In addition, one of the WID Writing Fellows, Graduate Center student Daniel Harris, participated in the QR strand’s organization and seminar activities.

Blending Bean’s advice with the Numeracy Movement was not easy by any means, but our strand discovered that Bean’s goals could help inform the creation of QR-focused assignments. For example, “low stakes” assignments that relied on in-class student discussion and “writing-to-learn” activities could be useful strategies for working through a conversation about a graph or chart. Creating time in the classroom to summarize data in a graph brought students one step closer to integrating that data to support claims for a thesis-driven argument. Figuring out the ways that graphs distort information through scale, metrics, or captions also allows students to develop critiques of data, data which can inform counter-arguments in more sophisticated essays.

The seminar leaders worked hard to achieve two parallel goals: introducing QR as a competency and integrating Bean’s ideas. As with all pilots, and perhaps all CTL seminars, one of the most valuable aspects of our communication grew out of faculty sharing with each other about their classroom experiences. History professor Timothy Coogan, Education professor Angela Cornelius, Philosophy professor Michael Kilivris, Mathematics professor Mahdi Majidi-Zolbanin,
English professor Noam Scheindlin, and Humanities professor Joni Schwartz each incorporated quantitative information into their respective fields, often through data-driven tables or text, or via classic data visualizations in charts and graphs. Professor Coogan created an assignment that engaged students in looking at New York City riots from a quantitative perspective, such as examining the numbers of people who participated and contrasting that data with qualitative descriptions of riot experiences and their aftermath. Working through Professor Cornelius’s assignment, education students explained the meaning of statistics related to childhood education, such as the relative number of words children learned as they grew older. Professor Kilivris challenged his philosophy class to debate the meaning of “the good life” by placing canonical texts by Greek philosophers next to recent polls about happiness. Professor Majidi-Zolbanin’s Introduction to Algebra students wrote up how they would explain some math rules and practices to other students and provided examples and written explanations of how similar problems should be solved. Poetry students in Professor Scheindlin’s class examined the work of the widely-admired Georges Perec, a writer who explored his art using numerically derived “constraints” based on complex idiosyncratic formulas. Ethnographic studies of New York neighborhoods conducted by Professor Schwartz’s Intercultural Communication students incorporated statistics, graphs, and charts. Each faculty member emphasized one of the key goals of a QR-infused class: “Numeracy” for LaGuardia students would be indicated by their ease in summarizing, interpreting, critiquing, and integrating the meaning of numerical information.

As with every other aspect of our work at LaGuardia, one of the challenges for our strand was to determine how to assess and measure the effectiveness of student development of QR skills over the semester. We developed a simple rubric on a 1-to-3 scale to trace how students responded to a basic graph with the skills mentioned above: summary, interpretation, critiquing, and integrating numerical information into claims about a topic. We gave students opportunities to respond to a basic graph at the beginning and end of the semester. In my class, I noticed that students initially found it more difficult to explain the meaning of a graph, although most could report its basic content. As with many other subjects, however, their greater success at the end of the semester could not be explained simply by the additional time spent
in class on QR. The context for graphs matters too, and I discovered that my students were able to translate data with more ease in part because they had more knowledge about the subject that the data purported to address. In my English composition class, part of a Liberal Arts Learning Community on “Race and Culture,” for instance, most of my students proved able to decipher the deeper meaning of information on drug arrests and prison sentencing after reading book excerpts and essays on institutional racism. To me, this means that “interpreting” the numbers cannot happen in a vacuum; excelling at QR will mean that students are growing holistically in the other competencies, too – in this case, especially critical literacy.

I left the QR strand of the Strengthening Core Learning seminar with a renewed sense of respect for the charts, graphs, and statistics I see filling up the various screens and papers in my professional and personal life. As we continue to address QR skills development, we should remember a few points that could apply to any college. First, it took the WAC movement several decades to achieve the success that we now take for granted. Second, it took time to convince faculty from many disciplines about the value of a new practice. Third, the WAC movement worked because it got results: Students who write more often perform better on other measures of competency. For the QR movement to achieve similar results, faculty will need to see how it improves student performance in their disciplines. Finally, no amount of budding student achievement in quantitative reasoning can make a real difference until it becomes universal – and that will mean bringing part-time faculty into the conversation.

Duplicating the success of WAC will take time. Yet we should feel genuine excitement to be at the beginning of the QR movement. There are new opportunities to be seized by those willing to do the work. Furthermore, history tells us that LaGuardia Community College will be leading the charge, working with students, and getting the job done.

*The author would like to extend a special thanks to Dr. Yelena Baishanski for her help with this report.*
REFERENCES


To address LaGuardia students’ 60% failure rate in developmental math courses,1 Provost Paul Arcario designed Project Quantum Leap (PQL) in 2006. The grant proposal was accepted by the Fund for the Improvement of Post-Secondary Education (FIPSE). Initially a three-year project, Project Quantum Leap was extended via additional grants from both the U.S. Department of Education (Title V) and the City University of New York (CUNY), and ran for six years, from 2006/07 through 2011/12, culminating in a year-long seminar for adjunct Math faculty. Fifty-four LaGuardia faculty participated in the professional development seminars, nearly half of them for more than one year.

PQL was informed and inspired by the Science Education for New Civic Engagements and Responsibilities (SENCER) approach to teaching math and science in “compelling contexts” that had been successful in high-level courses at four-year colleges. Through a process of intensive faculty development and curricular revision, project leaders2 sought to increase completion and pass rates in three LaGuardia math courses, two of them developmental (MAT095 and MAT096), and the third an introductory college-level course (MAT115).

By rooting the study and practice of math in real-world and compelling contexts, we hoped that students would not only succeed in these courses, but also acquire a greater awareness of the place of math in understanding and solving civic problems. For example, utilizing the revised curriculum, students in Introduction to Algebra (MAT095) would apply principles and practices of arithmetic and rudimentary algebra as they learned about the environment, pollution, and global warming. Investigating the long-term effects of the overuse of energy might encourage students to take an active role in cutting down on their own use of appliances. Similarly, Elementary Algebra (MAT096) students could explore ways to use algebraic principles in the investigation of the causes and results of health problems. Using linear equations, students would learn about the dangers of obesity and the
importance of exercise and good nutrition. Further, Algebra and Trigonometry (MAT115) students who learned to use advanced algebraic formulations to understand business and finance might become more cognizant of the dangers of debt and modify their own spending patterns accordingly.

Seminar participants studied the SENCER approach and discussed ways to integrate even more content into an already overloaded syllabus. While we all knew that students needed extensive practice with mathematical operations, the PQL approach also required math students to read articles about the compelling context and then apply the math principles they were learning to the issue in question. Math faculty would not only have to check students’ math calculations, but also look at what students wrote about how they solved problems and what they understood about the content of an article they had read. PQL required students to reflect upon their math learning and think about the impact of what they had learned on their own behaviors.

We quickly realized that in order to create meaningful contexts and realistic activities, Math faculty needed help. Obliging colleagues from Environmental Engineering, Health Sciences, and Business joined the seminar and provided participants with much needed expertise, content knowledge, and referrals to appropriate materials. Using those resources in the first two years, faculty developed activities that often took two or more weeks of class to complete. Realizing that the focus on a single lengthy activity would not give students sufficient exposure to the compelling context, faculty in subsequent years utilized shorter readings, activities, and practice exercises designed to engage students in the context and provide more opportunities to practice the math. Thus far, participants have contributed 35 activities to the PQL Sampler, a work that will remain “in progress” as we add new lessons and materials.3

In addition to developing activities and considering how best to revise syllabi to incorporate PQL work, seminar meetings focused on student-centered pedagogies, i.e., examining not just what we teach, but also how we teach it. We examined and experimented with the “discovery method” that utilizes a carefully scripted questioning technique leading students to figure out mathematical solutions for themselves instead of relying on lectures. We discussed and practiced effective group work in a math class as well as ways to give meaningful and constructive feedback to students. We incorporated inquiry assignments
and multimedia into PQL activities. Humanities faculty collaborated with Mathematics faculty to select and design contextual themes for paired courses. An example of integrative teaching and learning, these collaborations provided time to engage students with the contexts through discussions and reflection in the Humanities courses while shared assignments gave the Math faculty time to work on difficult math content. More experienced faculty mentored newcomers on PQL methodologies, and, in monthly seminars, we continued to share practices, revise assignments, and explore effective ways to balance the extra time needed for student-centered approaches with the pressures of preparing students for LaGuardia and CUNY exams.

All three of the target courses now have revised curricula. Each semester, student pass rates were analyzed and compared to the baseline rate established prior to the PQL project. Although, overall, there was steady improvement in MAT095, results for MAT096 and MAT115 were more erratic. Various factors affected outcomes: For example, students taught by faculty more experienced with PQL methodologies achieved higher pass and retention rates. Students in paired courses passed math courses at higher rates than students in comparison courses. Changes to the CUNY COMPASS exit exam, initially required but later abolished, may have skewed these results.

We also analyzed the effect of PQL approaches on students’ attitudes toward learning math. Survey data gathered from 2006/07 through 2011/12 indicated that students in PQL classes agreed with the statement, “Currently I’m interested in applying math to real world issues,” at a rate higher than students in comparison classes. Gains were seen on responses to statements such as, “Currently I’m interested in reading about social issues where math is involved,” and “I can think critically about math-related issues I read about or hear about in the media.” Students also reported taking ownership of their learning, experiencing reduction in math anxiety, and engaging to a greater extent in higher levels of integrative thinking as they began to see the role of mathematics in advancing their overall educational success.

Participation in PQL also resulted in changes for faculty. In their final reports, PQL faculty replied to the question: “How has the PQL experience affected your understanding of yourself as a teacher and what you do with students?” During the first year of the project, we saw comments such as “More and more I realize that students should not
learn only to pass a test” and “Contextualizing math really motivates our students.” By the end of the project, those who were involved with PQL for at least two years answered with more sophisticated thinking about pedagogy, for example, “Now I know that I have to understand my students’ issues and vary my teaching style (in my math class) to accommodate the learning style of the entire class” and “Instead of explaining why math is important, it’s more powerful and meaningful to make students realize it for themselves.”

Although the funding that supported PQL ended in 2011, Math faculty and the leadership team continue to discuss what could be done more effectively if the project were refunded. For example, teaching math in “compelling contexts” can help students learn, but we have realized that having only one such context per course can be limiting for both faculty and students. Further, although the intensive activities collected in the PQL Sampler are useful, developing them consumed seminar time that might have been used more effectively for additional discussion and practicing of student-centered pedagogies. We also realized that faculty benefit from watching their peers teach; a future PQL seminar would therefore include more opportunities for peer observations.

While there is always room for improvement, we have found that PQL encouraged faculty to experiment, and to share and critique their teaching practices. Participants have presented their work at national conferences (SENCER, YouthBuild, New York State Mathematics Association of Two-Year Colleges, and others) and written articles for both In Transit and peer-reviewed journals such as the New York State Mathematics Teachers Journal and Science Education and Civic Engagement: An International Journal. All sections of MAT095, MAT096, and MAT115 now incorporate exercises and activities developed in PQL, and adjuncts and tutors have been trained in PQL approaches. Math faculty continue to address the core problem of how to help students succeed. We believe that by providing time and a safe space for faculty to collaborate and explore effective approaches to helping students learn math, PQL has informed curricular improvements and invigorated Math faculty at LaGuardia.
Notes

2. PQL was led by Provost Paul Arcario, Associate Dean Bret Eynon, Professors Prabha Betne, Gordon Crandall, Marina Dedlovskaya, Yasser Hassebo, Rudy Meangru, Frank Wang, and Shenglan Yuan, from the Mathematics, Engineering, and Computer Science department, and Ros Orgel and Judit Török from the LaGuardia Center for Teaching and Learning.

3. The current version of the PQL Sampler is available in print from the LaGuardia Center for Teaching and Learning, and electronically at http://www.laguardia.edu/ctl/Project_Quantum_Leap_Sampler.aspx


5. The final evaluation report, submitted to FIPSE on March 31, 2011, provides an in-depth examination of outcomes data. Contact Bret Eynon or Judit Török for a copy of the report.
My husband measured the world in numbers; my world is measured by words. A master of the Middle Eastern oud, he also learned to repair this beautiful fretless instrument. With the tools of his trade, he measured the frequencies of vibrations, the gauges of strings, the hairline cracks along the oud’s spruce face, ebony neck, and rosewood back. Left behind in his workshop are Japanese devices with tiny delicate hands indicating pressure, glass tubes regulating temperature and humidity, calipers and clamps of multiple sizes, slender gold cylinders to weigh strings, and scales for grams of pigment and fish glue. Along the sides, bottoms and bridges of each Arabic and Turkish oud are series of numbers for string action or tuning written in a hand that can only be described as musical: 40%, 112; 35 (9.3) 8f, 27.2 (6.8) 4½f, 22.8 (43) 5f, 30.5, 29, 24, 22.7; 48, 36.4, 29.4, 24.2. In Indian ragas, Balkan folk dance, and microtonal Turkish makams, he heard cycles elusive to other ears: It’s a 32: listen; it’s a 7/16, a 12/8, he’d say, with a soft clap to the time. Though he was proficient up to trigonometry, all those numbers didn’t make him a mathematician, they simply made him numeric. Dyslectic, he read very little that wasn’t technical; with obsessive brilliance, he preferred numeric exactness over ambiguity. The patterns of music and not metaphor kept his world ordered, precise, certain. Perhaps numbers made sense of a life disordered by the Armenian deaths and diaspora: so many relatives lost, displaced. In the everyday world, my husband wanted facts not metaphor; and when he performed, numbers became feeling free of words.

But not everyone finds comfort in numbers. For me, as a young person who read early, the decomposition of words into letters that formed incomprehensible mathematical formulae was just painful, and I felt betrayed. What happened to the sentences? How could one arrangement of letters reveal and interpret the world, and the other present itself as detached, indecipherable? The women in my Pittsburgh housing project didn’t use numbers to gossip or explain poverty, divorce, sex, violence or love, their meanings shouted or whispered in song, prayer, memories,
or reprimands. Even in church, it was *logos*, the word, and not numbers that animated the spirit. Words multiplied and made metaphors, allowed for ambiguity and offered ways to understand others. I hated math for what I perceived as its coldness, its stillness and impenetrability; I hated its precision, abstraction and tyrannical absoluteness, and I was hostile to the way most math teachers spoke. When they spoke their math language, the whole world vanished, and along with it all humanity.

Now I recognize the shortcomings of my perceptions. I witness the enduring efforts of the good math teachers at LaGuardia daily confronted by students who harbor feelings similar to those of my young self. Somehow our teachers maintain their humor, a trait, it seems, of mathematicians and musicians. And of course I know that numbers possess an aesthetic power present in great architecture, in poetry, and in the rhythms and formal structures of the music that until recently filled our home. But how many of our students are similar to me? Do they enter class and wonder what those formulae have to do with the conditions that have shaped their precarious lives, and do they question the power of those formulae to affect social equations that seem unalterable: poverty, inequity, displacement? Many of our students are rich in language; they can talk poetic, multi-layered circles around those with doctorates in English, philosophy, and the social sciences. With the facility of the most fluent deconstructionist, they can see through false constructs. So my question is: how can we bridge the gap between their worlds and math? What sentences can we speak that will make formulae meaningful to them?
Contributors

Leslie A. Aarons is an Assistant Professor of Philosophy in the Humanities Department at LaGuardia Community College. Her research interests and publications focus on environmental ethics, public philosophy, and social and political philosophy. She organized and moderated college-wide conference events in Public Health and Environmental Ethics at LaGuardia in 2007, 2008, 2012, and 2013. She is the president and conference organizer of the Long Island Philosophical Society (LIPS).

Altai Eru Irving Abrams was born in New York City and is currently in the second grade. A fun-loving girl, she spends the greater portion of each day in the vivid imaginary worlds she creates for herself (and her sister). The author of Coco the Dog and My Visit with Grandma and Grandpa, she is now working on mastering her multiplication tables.

Dennis Aguirre received his MD diploma from the Medical School of Universidad México Americana del Norte (UMAN) in Reynosa, Mexico. He was awarded the license of Doctor of Medicine, Surgery, Obstetrics by Mexico’s National Secretariat of Health in 2003. He has taught Anatomy and Physiology I and II and Principles of Biology for LaGuardia’s Natural Sciences Department since 2004.

Yelena Baishanski is an Associate Professor in the Mathematics, Engineering, and Computer Science Department, now in her fourth year at LaGuardia. She completed her PhD in Mathematics at the CUNY Graduate Center in 2010, having previously graduated from Université de Paris VII with a Licence de Mathématiques. She cofounded the LaGuardia Student Math Society, and has shared her work in developmental mathematics in peer-reviewed journals and at the 2012 International Congress on Mathematical Education held in Seoul, Korea.

Milena C. Cuellar received a MS degree in Physics from Universidad de Los Andes, Bogotá, Colombia in 2001, and a PhD in Statistics from the London School of Economics in 2006. She has been an Assistant Professor in the Mathematics, Engineering, and Computer Science Department at LaGuardia since Fall 2012, and continues to serve as an Academic Research Visitor at the Center for the Analysis of Time Series (CATS) of the London School of Economics.
Marina Dedlovskaya, Associate Professor in the Mathematics, Engineering, and Computer Science Department, earned her PhD in 1997 from Moscow State Pedagogical University. Her research interest is in Abstract Algebra and Math Pedagogy. Dr. Dedlovskaya joined LaGuardia Community College in 2004. Since then, she has taught mathematics at different levels from developmental to advanced. Currently, she is actively involved in exploring new approaches to improving the teaching of basic mathematics courses.

Maria Entezari received her Bachelor’s degree in Biology, and her Master’s and PhD degrees in Anatomical Sciences from the Medical University of Tehran, Iran. She has been teaching at LaGuardia since 2008. Now an Associate Professor, she teaches Human Anatomy and Physiology I and II, General Biology for science majors, and Topics in Biology for non-science majors. Dr. Entezari’s research is in the field of oxidative stress and macrophages functions with an emphasis on sepsis and Alzheimer’s disease.

Hugo Fernandez, Assistant Professor in the Visual Arts and Photography areas of the Humanities Department has an M.F.A. in fine art photography from the Yale School of Art, and is also a graduate of Florida International University and Miami Dade Community College. He has taught photography in the Humanities Department at LaGuardia since 1994, including courses in beginning and advanced black and white, color, studio photography and photojournalism. His work focuses on large-scale panoramas and intimate portraiture.

Naomi Schubin Greenberg, professor in the Health Sciences Department and Global Learning Committee member, started LaGuardia’s first health career program, Occupational Therapy Assistant, forty years ago. Her broad interests have led to research, presentations and publications on topics ranging from travel to culture. She earned a PhD in Gerontology from Columbia Pacific University, and a Master of Public Health in Health Care Administration and a Bachelor of Science in Occupational Therapy from Columbia University.
Reem Jaafar joined LaGuardia Community College in 2010 and is currently an Associate Professor in the Mathematics, Engineering, and Computer Science Department. Dr. Jaafar cofounded the LaGuardia Student Math Society in 2011 to engage students in mathematics, and has trained LaGuardia students to compete in national and regional competitions. She co-organizes Pi Day, a College-wide event to celebrate mathematics and student achievement, and is currently organizing multidisciplinary STEM talks.

Mangala R. Kothari is an Associate Professor in the Mathematics, Engineering, and Computer Science Department at LaGuardia Community College. She earned her PhD in mathematics from the Indian Institute of Technology, Mumbai, India in 1990. Her research interests are in the areas of operator theory and functional analysis. She has taught a variety of mathematics courses in India as well as in the USA and has been teaching at LaGuardia since 2008. Her current research interest lies in exploring best practices in teaching basic mathematics.

Louis A. Lucca, CMP, is the Director of Communication Studies for the Humanities Department. He teaches a variety of courses in the major, including Mass Communication and Society, Introduction to Mass Communication, and Interpersonal Communication. Dr. Lucca holds a Certificate in Math Phobia.

Dionne Miller has been an Assistant Professor of Chemistry at LaGuardia Community College since 2009. Prior to that, she was an adjunct professor at the City College of New York and Bronx Community College and a lecturer in Chemistry, Chemical Technology, and Environmental Studies at the University of Technology (UTech), Jamaica. She received her PhD in Chemistry from the CUNY Graduate Center and holds a Diploma in Technical Education from UTech. Her research interests are in the optical properties of nanoparticles as well as the use of flipped classroom strategies in science education.
Deborah Nibot has been an employee of CUNY for 28 years. Beginning as a College Assistant in 1986, she has held multiple positions and is now the Director of Student General Services at LaGuardia. In this capacity, she assists students with both their Registrar and Financial Aid needs. Deborah also teaches Communication Studies courses in the Humanities Department.

Roslyn Orgel is Associate Director for Technology, Pedagogy, and ePortfolio Projects at LaGuardia Community College’s Center for Teaching and Learning, where she works with faculty to cofacilitate a variety of professional development seminars. She earned her MA in Teaching English to Speakers of Other Languages (TESOL) from Hunter College, and has taught English as a Second Language at LaGuardia and other CUNY colleges.

Bernetta Parson joined LaGuardia in 2008, and was Director of Transfer Services from 2011 to 2014. She holds a Master’s in Urban Affairs from Hunter College and a Bachelor’s in English from Mount Holyoke College, and is currently pursuing a PhD in Higher Education at Syracuse University. She has also served as an adjunct lecturer in the English, Cooperative Education, and Business and Technology Departments.

John Piper has been the researcher in LaGuardia’s Development Office since 2012. He has an M.A. concentrating in historic preservation and museum studies from the University of Maryland and the Smithsonian’s American Studies Program, a B.A. in American history from Lehman College, and an A.A. from John Jay College. He also has a career as an acclaimed photographer and artist.

Michele Piso, Editor of In Transit, The LaGuardia Journal on Teaching and Learning, facilitates CTL professional development seminars in scholarship and publication. She currently co-facilitates New to College, designed to prepare faculty and peer mentors to teach the First Year Seminar, launched in Spring 2014. Until 2013, she regularly taught Critical Thinking, an inquiry and problem-solving based course focused on current social problems. Dr. Piso graduated from the University of Pittsburgh and earned a PhD in Cinema Studies from the University of Oregon, where she also served as a poetry editor for The Northwest Review. She dedicates her work on In Transit to the memory of H. M. (https://www.facebook.com/haigmanoukian).
Preethi Radhakrishnan is an Associate Professor in the Natural Sciences Department at LaGuardia Community College. In her fourth year at LaGuardia, she teaches courses such as Fundamentals of Biology I and Human Anatomy and Physiology I. Dr. Radhakrishnan has a PhD in Biology and Animal Behavior from Macquarie University, Sydney, Australia and conducted her postdoctoral research at the University of Central Florida. Her research interests include the molecular basis of behavioral pathways related to reproductive behavior, alcohol addiction, and circadian rhythms.

Md Zahidur Rahman received a ME and PhD in Electrical Engineering from the CUNY Graduate Center. He is an Associate Professor in the Mathematics, Engineering, and Computer Science Department at LaGuardia and a registered professional engineer in New York and Michigan. His research interests are in environmental engineering, satellite remote sensing and its application, and alternative renewable energy. He teaches math and engineering courses and is currently co-chair of the Engineering Science and Environmental Engineering programs at LaGuardia Community College.

Michael Rodriguez received his MFA from Brooklyn College and attended the Skowhegan School of Painting and Sculpture. He has exhibited his work internationally and is the recipient of a Pollack Krasner Foundation Grant, New York Foundation for the Arts Grant and a Joan Mitchell Foundation Grant. His work is in numerous collections including the Museum of Modern Art, NY. Professor Rodriguez teaches studio art courses at LaGuardia Community College, and has been the Chair of the Humanities Department since 2009.

Justin Rogers-Cooper is an Assistant Professor at LaGuardia Community College, where he teaches pedagogical theory, urban studies, and writing and literature courses. He received his PhD in English with a certificate in American Studies from the CUNY Graduate Center in 2011. He has also taught at Kingsborough Community College, Queens College, and Skidmore College. His research focuses on nineteenth-century ethnic studies and transnational labor practices, as well as social media in the classroom.
Bill Rosenthal joined LaGuardia’s Mathematics, Engineering, and Computer Science Department in 2010. In the 30 years since he completed his mathematics PhD, he has taught mathematics, computer science, education, and women’s studies at private liberal-arts colleges, Hunter College, Michigan State University, and an elementary school in Tampa, Florida. His scholarship includes work in pure mathematics, calculus curriculum and teaching, school-university collaboration, culturally relevant teaching, and environmental education. In 1990, he received Ursinus College’s Sears-Roebuck Award for Teaching Excellence and Campus Leadership.

Judit Török is the Co-Director of the Making Connections National Resource Center at LaGuardia. She has led professional development seminars at the Center for Teaching and Learning since 2007. She received her PhD in Philosophy at the New School University. Her current research explores moral identity development, themes in global learning, and integrative online pedagogies. She is also a certified yoga teacher who promotes a breath-centered practice that cultivates mindfulness and self-discovery.

Frank Wang received his PhD from Columbia University and joined LaGuardia Community College in 2004. His research interests include relativistic mechanics and nonlinear dynamical systems. He has written a textbook, *Physics with Maple: The Computer Algebra Resource for Mathematical Methods in Physics*, contributed several book chapters, and published numerous papers in mathematics and physics journals. For his contributions toward improving basic skills instruction and STEM education, Dr. Wang received the CUNY Chancellor’s Award for Excellence in Undergraduate Mathematics Instruction in 2009.

Paul West is an Associate Professor in the Mathematics, Engineering, and Computer Science Department at LaGuardia and an Adjunct Professor in the Mechanical Engineering Department at City College. He received his PhD in Engineering from the CUNY Graduate Center. His dissertation focused on the specialized area of translational musculoskeletal research investigating pathophysiology in various osteoarthritis and osteoporosis animal models. Professor West teaches math and engineering courses, and mentors students in various college and high school enrichment programs.
Dong Wook Won is an Associate Professor of Mathematics at LaGuardia Community College. He received his PhD from CUNY’s Graduate Center in 2008 and joined LaGuardia in the same year. Together with Drs. A. Miasnikov and A. Ushakov, Dr. Won published “Power Circuits, Exponential Algebra, and Time Complexity” in the *International Journal of Algebra and Computation* and “The Word Problem in the Baumslag Group with a Non-elementary Dehn Function Is Polynomial Time Decidable” in the *Journal of Algebra*.

Burl Yearwood is currently the Chairperson of the Natural Sciences Department. He joined LaGuardia in 2003 and has taught all levels of chemistry. He received his Bachelor’s degree from the University of Alabama and his PhD in Organometallic Chemistry from Wayne State University in Detroit. He has conducted postdoctoral research at the University of Kentucky. Presently, his research deals with the analysis of environmental toxins in Newtown Creek, a Superfund site in Long Island City.

Shenglan Yuan is an Associate Professor of Mathematics at LaGuardia Community College. She received her PhD from the Graduate Center of the City University of New York. In addition to her field of specialty, complex dynamics, she pursues her passion for recreational mathematics and mathematical education. To foster interest in math, she cofounded the LaGuardia Student Math Society with Professors R. Jaafar and Y. Baishanski. In 2012/13, she received the President’s Award for Excellence in Teaching and Outstanding Service.
The LaGuardia Center for Teaching and Learning Professional Development Seminars 2013/14

Art of Advising
Going beyond traditional definitions of “advising as course selection,” this seminar addresses holistic factors critical to effective academic advisement. Participants explore the use of ePortfolio as a pedagogical and advising tool to engage students in discussion of their transition into college and to help students develop meaningful educational plans. Participants also discuss the tools needed to guide students through a reflective and thoughtful transfer process. The seminar is supported by the Title V grant, Making Transfer Connections: ePortfolio and Student Success across CUNY, and builds on the work of the College’s Advising Design Team and the First Year Experience Task Force.

Raj Bhika, Business and Technology, Mercedes del Rosario, CTL, Danielle Insalaco-Egan, Student Affairs, and Bernetta Parson, Office of Transfer Services

Community 2.0: Teaching and Learning Networks
A digital evolution of the traditional learning community model, Community 2.0 supports faculty using Web 2.0 tools as they design and implement connections between students that extend both horizontally across disciplines and classes and vertically across credit levels.

Maria Jerskey, Education and Language Acquisition, Priscilla Stadler, CTL

Connect to Learning
In this 3-year FIPSE-funded project, LaGuardia staff and faculty work with a dynamic national network of 25 campuses – community colleges, private colleges and research universities – to engage collectively in a recursive knowledge-generation process. The project focuses ePortfolio on reflective pedagogy and student learning, correlating improvement on student success measures such as retention with more nuanced assessment of student work using the AAC&U’s nationally normed VALUE rubrics. For more information, see: http://www.laguardia.edu/connections.

Raj Bhika, Business and Technology, J. Elizabeth Clark, English, Bret Eynon, Academic Affairs, Thomas Onorato, Natural Sciences, Kim Ramirez, English, and Judit Török, CTL
Connected Learning: ePortfolio and Integrative Pedagogy
Participants learn about the pedagogical applications of ePortfolio, including the use of ePortfolio to: connect students meaningfully with their faculty, peers, and external audiences; overcome fragmentation in student learning; embed thinking about transfer throughout the curriculum; and integrate students’ diverse learning experiences, both inside and outside of the classroom. The seminar invites faculty to construct their own professional ePortfolios for documenting and reflecting upon their ongoing course revision, modeling a classroom environment in which all participants share with and learn from one another.

Demetrios Kapetanakos, English, Craig Kasprzak, CTL, Ellen Quish, CTL and Adult Learning Center, and Howard Wach, Academic Affairs

Cultivating and Expanding Hybrid/Online Teaching and Learning
Offering two interlocking components, Introduction to Hybrid/Online Teaching and Learning and Developing Advanced Practices and Mentoring Faculty in the Hybrid/Online Classroom, this seminar provides opportunities for faculty to develop course plans and activities, explore new technologies for teaching and learning, and learn from and with each other about the benefits and challenges of teaching in hybrid and online environments.

Josephine Corso, CTL, Janet Michello, Social Science, and Santo Trapani, Business and Technology

ePortfolio and Assessment Mini-Grant Program
This initiative aims to advance the comprehensive integration of ePortfolio into curricula and to advance the College-wide Periodic Program Review (PPR) process by offering departments and academic programs mini-grants in support of faculty development and needed curricula revision processes.

Mercedes del Rosario and Roslyn Orgel, CTL

Faculty Scholars Publication Workshop
This year-long faculty development seminar is designed to assist faculty in their scholarly writing and publication. It seeks to help faculty complete academic writing projects and place them in external, peer-reviewed publications.

Nancy Berke, English, Michele Piso, CTL, and Patricia Sokolski, Humanities
Making Transfer Connections: ePortfolio and Student Success across CUNY
Through this 5-year project, funded by a Title V grant, LaGuardia staff and faculty work with two senior colleges (Queens and Lehman) and two other community colleges (Queensborough and Bronx) in a partnership designed to facilitate transfer and ensure student progress toward the Bachelor’s degree. Under LaGuardia’s leadership, the five CUNY colleges employ ePortfolio practice to strengthen three areas pivotal to transfer success: instruction, advisement, and assessment, which all contribute to building a culture of transfer on the participating campuses. For more information, see: http://www.laguardia.edu/connections.

Raj Bhika, Business and Technology, Bret Eynon, Academic Affairs, Thomas Onorato, Natural Sciences, Kim Ramirez, English, and Judit Török, CTL

New Faculty Colloquium
This year-long orientation to the institution and to teaching and learning at LaGuardia provides the opportunity for new full-time faculty to become acclimated to LaGuardia’s academic environment. Faculty learn from each other and from senior colleagues about LaGuardia’s students and the various pedagogies found to be effective at LaGuardia, and consider some of their options for future growth and development.

Clarence Chan, Health Sciences, Josephine Corso and Priscilla Stadler, CTL

New to College: The First Year Seminars in the Disciplines
For many LaGuardia students, getting into college is easier than staying and succeeding. As colleges nationwide focus on improving completion and graduation, the first semester of college has emerged as a critical juncture for building student success. Responding to cross-campus recommendations, LaGuardia has launched a new First Year Seminar, designed to improve student persistence, achievement and self-efficacy. Taught by faculty in the disciplines and supported by advisement teams, the seminars will utilize peer mentoring and the connective power of ePortfolio to advance student success in the first college year and beyond. Drawing on emerging best practices nationwide, the new course will introduce students to key skills and concepts of the appropriate discipline (e.g. “What does it mean to think like a scientist? A health care professional? What is the value
of studying the liberal arts?”) and facilitate the development of the habits of mind, heart, and hand needed for college success and effective educational and career planning.

The New to College professional development seminar will support faculty planning and implementation of the new FYS course, guide the effective use of digital and online tools and processes, and develop disciplinary topics that help students practice the key first year competencies of inquiry, integration, and problem-solving.

Linda Chandler, English, Bret Eynon, Academic Affairs, Andrea Francis, Business and Technology, Les Gallo-Silver, Health Sciences, Michele Piso, CTL, Ellen Quish, CTL, Preethi Radhakrishnan, Natural Sciences, and Howard Wach, CTL

**Strengthening Core Learning**

Faculty discuss pedagogical approaches and explore low-, middle-, and high-stakes assignments designed to help students build general education competencies in writing, reading, research, critical thinking, and quantitative reasoning. Participants create an ePortfolio containing revised syllabi, assignments, and samples of student work. Upon successful completion of the seminar requirements, participants receive certification needed to teach writing intensive courses.

Evelyn Burg, English, Roslyn Orgel, CTL, Michelle Pacht, English, and Justin Rogers-Cooper, English

**Student Technology Mentors (STMs)**

Working in unique student-faculty partnerships that help faculty to design and use interactive technologies, STMs benefit from intensive training and support that prepare them for success in education and career.

Ali Abdallah and Josephine Corso, CTL

**Writing in the Disciplines for Adjuncts**

Part of a nation-wide interdisciplinary effort, the semester-long Writing in the Disciplines seminar supports part-time faculty as they develop and test writing-intensive assignments for their courses. Seminars are facilitated by interdisciplinary teams of faculty and CUNY Writing Fellows.

Phyllis van Slyck, English
Carnegie Seminar on Teaching and Learning
(on hiatus)

The scholarship of teaching and learning (SoTL) is generally defined as the rigorous and systematic study of student learning, publicly shared, open to peer review and critique, and committed to collective knowledge-building. The Carnegie Seminar commits itself to these principles and to LaGuardia’s vision of an integrated culture of evidence-based teaching and learning. As the nation reflects on problems facing our schools, the values and missions of community colleges are more visible and pivotal than ever in the educational and intellectual life of our country. LaGuardia’s Carnegie Seminar provides faculty the opportunity to cultivate habits of pedagogical research that result in transformed and shared understanding of student experiences in our classrooms and beyond.

Ongoing Seminar Goals and Focus
The Carnegie Seminar offers participants the dedicated time, space, and critical feedback necessary to frame a researchable line of pedagogical inquiry, implement classroom research, and document findings. Faculty distinguish among good teaching, scholarly teaching and learning, and the scholarship of teaching and learning, explore SoTL principles, theories, methods, and practice, and gain familiarity with foundational SoTL texts. Finally, with the guidance and constructive critique offered by seminar mentors, facilitators, and peers, faculty frame a researchable question, design and implement a pedagogical research method, collect and analyze data, and prepare a publishable research paper on their findings for internal and external publications.

Committed to LaGuardia’s culture of intentional teaching, the Carnegie Seminar is rooted in the Center for Teaching and Learning’s participation in the Integrative Learning Project directed by the Carnegie Foundation for the Advancement of Teaching and the Association of American Colleges & Universities (AAC&U). The Foundation has guided faculty across the country in scholarly inquiry into teaching and learning, in documenting their discoveries, and in contributing to new knowledge and more purposeful classroom practice. (http://www.carnegiefoundation.org/programs/)

Inquiries: Michele Piso, CTL (mpiso@lagcc.cuny.edu, 718-482-5483)
Call for Papers, *In Transit*, V7, 2015–16

The Call for Papers for *In Transit*, V7, 2015–16 will be formally posted in June 2014. Information will include process, proposal and manuscript format, length, and deadlines. At this time, we invite you to consider submitting a SoTL proposal that addresses themes on reading or the first year experience listed below:

**Theme One: Ways of Reading across Disciplines**

*How do we interpret, evaluate, and remember texts?*

We invite writers to identify distinct and effective strategies that strengthen students’ abilities to distinguish the values, reasons, and conventions appropriate to reading diverse forms of text: philosophy, poetry, history, science, accounting, etc. Topics may include, but are not limited to, the following:

*Reading Purposefully*

- Distinguishing arguments, identifying diverse forms of evidence, asking appropriate and provocative questions of the text; developing reciprocity between writer and reader

*Reading on the Run*

- Where, what, when, and how do our busy and exhausted students read? In what formats? Does reading short Internet pieces make us stupid?

*Reading Required: Coverage vs Uncoverage*

- Which texts must students read, how much, and why? Across the disciplines, is reading consistently assigned? Are assigned readings effectively utilized in class?

*Strategies for Skilled and Marginal Readers*

- Differences in prior exposure and experiences in decoding, summarizing, reflecting

*Reading, Faculty Frustration, and the Assumed Benefits of Reading*

- Did anyone even read the assignment? Are our assumptions and expectations out of synch with students’ – and the culture’s – reading experiences and behaviors?

*Reading Metaphor*

- Locating and living with ambiguity and multiple meanings

*Reading the Arts*

- Music, film, painting....
Theme Two: Ways of Engaging and Retaining First Semester Students

*In Transit,* V7 will solicit explorations of the academic, personal, and social experiences of students making the transition into their first semester in college. Proposals will emphasize comprehensive and intentional approaches to teaching and learning in the first year; proposals may include, but are not limited to, the following themes:

A Whole College Approach to First Year Success

- Aligning Student Affairs and Academic Affairs
- Defining the roles of faculty, peers, and staff in student success: institutional programs and resources that enhance the first-year experience

Designing the FYS pedagogy and curricular/co-curricular learning strategies for students in Business, Natural Sciences, Health Sciences, and Liberal Arts First Year Seminars

- Faculty reflections on personal transformation: exploring differences between disciplinary teaching and teaching the First Year Seminar. What have faculty learned?

Defining Success in the First Year

- Dispositions and expectations that promote retention and whole-student development

Pedagogy and the First Year Competencies

- Inquiry/problem solving, integration, and global consciousness in the classroom

Partnering with First Year Peer Mentors

- Can positive peer mentor/student relationships support motivation and self-sufficiency?

Mindful Pedagogy for Specific Populations (i.e., first generation, adult learners and transfer students, the under- and misrepresented, etc.)

- Understanding students’ needs, assumptions, cultural values

Advisement and Educational Planning

- Exploring academic, professional, and personal goals and decision-making

Assessing First Year Programs and Strategies

- Measuring the effect of the FYS on students, faculty, and staff

Inquiries: Michele Piso, CTL (mpiso@lagcc.cuny.edu, 718-482-5483)