

2010

# Creating a Masters in Numeracy Program

Eric Gaze  
*Bowdoin College*, [egaze@bowdoin.edu](mailto:egaze@bowdoin.edu)

Follow this and additional works at: <http://scholarcommons.usf.edu/numeracy>



Part of the [Mathematics Commons](#), and the [Science and Mathematics Education Commons](#)

---

## Recommended Citation

Gaze, Eric (2010) "Creating a Masters in Numeracy Program," *Numeracy*: Vol. 3 : Iss. 2 , Article 8.  
DOI: <http://dx.doi.org/10.5038/1936-4660.3.2.8>  
Available at: <http://scholarcommons.usf.edu/numeracy/vol3/iss2/art8>

---

# Creating a Masters in Numeracy Program

## **Abstract**

The Master of Science in Numeracy program at Alfred University received full approval from the New York State Education Department (NYSED) in May of 2007. This first-of-its-kind program seeks to provide teachers at all levels, from across the curriculum, the skills, and more importantly the confidence, to introduce relevant quantitative concepts in their own disciplines. Created to be a complement of the MS Ed. in Literacy, the 30-hour MS in Numeracy program consists of four required core courses (Teaching Numeracy, Teaching with Data, Assessment and Learning Theories in Numeracy, and Doing Science and Numeracy), five electives from a list of numeracy and literacy courses, and a Masters project. The program graduated its first student in May 2008 and three more since then. Major challenges for the program have included the uncertain (i.e., by-application) connection between an MS and licensure (in contrast to the automatic professional certification for MS Ed. degrees) and the small number of faculty involved in teaching the numeracy courses. The current status of the program is questionable as the person (the author) who taught the first three core courses has left the University and has not yet been replaced. Even so, I believe this MS in Numeracy program offers a potentially useful example of a strategy to enhance the spread of QL through teacher preparation.

## **Keywords**

numeracy, teacher preparation, professional development, graduate programs

## **Creative Commons License**



This work is licensed under a [Creative Commons Attribution-Noncommercial 4.0 License](https://creativecommons.org/licenses/by-nc/4.0/)

## **Cover Page Footnote**

Eric Gaze is Director of the Quantitative Reasoning Program at Bowdoin College, where he also teaches Quantitative Reasoning. He is the chair-elect of the QL-SIGMAA of the Mathematics Association of America and serves on the board of directors of the National Numeracy Network.

## INTRODUCTION

The recently released draft of the Common Core Standards<sup>1</sup> for K-12 curriculum is currently under review. In an e-mail from the President of the National Council of Teachers of Mathematics (NCTM) to all NCTM members there is a call for the following three areas to receive more attention in the standards (Kepner 2010):

- **“Problem solving** needs to be a consistent presence throughout the standards along with emphasis on reasoning and sense making expressed daily in students’ mathematics learning. It is important that the standards include both specific problem-solving skills to be taught through the grades as well as the expectation that students engage in and solve problems as part of learning and assessment.
- **“Mathematical connections** need to be more prominent throughout the standards. Explicit direction in the standards linking mathematics to real-world applications and other mathematics can greatly enhance the richness of the mathematics that is taught and assessed.
- **“Technology** needs to play a larger role and be interwoven throughout the standards. It is imperative that students of the 21<sup>st</sup> century learn how to use and apply powerful, emerging tools appropriately. The standards should provide for the application of mathematics understanding to problem solving with technology.”

These three areas underlie the vision of Alfred University’s Master of Science in Numeracy, which received full approval from New York State Education Department (NYSED) in May of 2007.

The timeliness of this program for education students is illustrated by *Calculation vs. Context: Quantitative Literacy and its Implications for Teacher Education* (Madison and Steen 2008), a product of a workshop (June 22–24, 2007) at the Wingspread Conference Center, Racine WI, that addressed the “potential of teacher preparation as a tool for enhancing numeracy” (Steen 2008, p. 11). Frank Murray’s article in particular articulates the myriad difficulties in preparing teachers at any level and in any discipline (including mathematics) to teach quantitative literacy (QL): it requires “a confidence to tackle uncharted quantitative matter, serviceable knowledge of mathematical procedure and knowledge, logical thought and problem solving, an extension of the quantitative into the political and social...” (Murray 2008, p. 166). Add to this repertoire of critical thinking the vagaries in state teacher licensure programs, and the conclusion of the workshop participants to focus QL efforts at the college level

---

<sup>1</sup> <http://www.corestandards.org/> (accessed March 2010).

seems well founded: “Even though some might wish that students’ QL needs would be met by their secondary education, it seems clear from the analyses at Wingspread that the *most creative and effective forces for QL will be those in postsecondary education*” (emphasis added) (Steen 2008, p. 22).

The MS in Numeracy program at Alfred University is an attempt to address how QL can be infused into K-12 education. It was started with an idea from Kathryn and Jim Curl of the University’s Department of Education. The idea was to strengthen the mathematics preparation of pre-service teachers by incorporating numeracy into EDUC 405, Literacy in the Content Areas. I was asked to team teach this course with Kathryn in the 2004/05 school year. This collaboration led to the creation of the MS in Numeracy program, which was envisioned to complement the MS Ed. in Literacy. I became the “mathematics coordinator” for this new venture, assumed a joint appointment in Mathematics and Education, and offered the first course, EDUC 571, Teaching Numeracy, to two students in the fall of 2005. The Curls and I crafted the proposal for the MS in Numeracy program, submitted it to NYSED in spring 2005, and it was approved two years later. The first student graduated in May 2008, and three more in May 2009.

Currently, the future of the program is in doubt. Kathryn and Jim Curl have retired from Alfred. I left the University for my new position at Bowdoin College in Fall 2009, and I had been the only faculty member teaching numeracy courses in the MS in Numeracy program except for the Doing Science course.

It is important for readers to understand the basics of teacher licensing procedures in New York in order to appreciate the challenges facing the program. Students graduating from an approved undergraduate Education program receive an *initial certification* to teach. They must meet the requirements for their *professional certification* within five years by teaching for three years and completing a Masters degree. There is a crucial distinction between an MS and an MS Ed. The MS Ed. degree is *pre-approved* by NYSED as counting toward professional certification, while an MS degree requires the teacher to apply to NYSED independently for review of their degree. Our intention in creating the Numeracy program was that it would essentially be on equal footing with an MS Ed. in Literacy. Teachers from all disciplines and different levels may use an MS Ed. in Literacy as counting toward their professional certification, as it is considered to be a “functionally relevant discipline” to all teachers. Trying to get our Numeracy program recognized as an MS Ed. was a major challenge.

Despite the tenuous status of the program at present, I believe it may be useful for the QL community to know of this first-of-its-kind masters program to address numeracy and teacher education. This example is especially relevant as the NCTM has just released a joint position statement calling for the creation of

elementary math specialists,<sup>2</sup> with a need for advanced certification opportunities and professional preparation programs for such specialists. The MS in Numeracy program would satisfy these needs. The intention of the Alfred program is to provide teachers at all levels, from across the curriculum, the skills, and more importantly the confidence, to introduce relevant quantitative concepts in their own disciplines. The concept is that students in the program would see the transfer and applicability of mathematical content in the context of other disciplines, as well as its relevance to their daily, personal, and civic life. I will start with an elaboration of the rationale for the program, then describe its curriculum, and finally discuss some lessons learned.

## RATIONALE

*Rethinking Mathematics: Teaching Social Justice by the Numbers* (Gutstein 2006), begins with a quote from a 9<sup>th</sup> grade student in the Chicago Public School System:

I thought math was just a subject they implanted on us just because they felt like it, but now I realize that you could use math to defend your rights and realize the injustices around you...Now I think math is truly necessary and, I have to admit it, kinda cool. It's sort of like a pass you could use to make the world a better place. (Gutsein 2006, p. 1)

A major goal of the MS in Numeracy program is to have this transformative effect not just on students but on the teachers themselves! The MS in Numeracy program seeks to give teachers a sustained in-depth experience in the utility and applicability of mathematics. Thus the MS in Numeracy graduate program is not simply remediation of computational and algebraic skills. Articulating exactly what is meant by a “quantitatively literate person,” however, is a major challenge in the development of a graduate program in numeracy, as this is a new area of higher education (Bookman et al. 2008, p. 911).

In particular there are going to be those who question graduate credit being given for the study of “elementary mathematics.” This is the same problem faced by those who seek to raise awareness of the sophisticated nature of the mathematical knowledge required to teach in elementary school (Wu 2009, p. 4). There is, however, growing pressure on states to address the inadequate mathematics preparation of teachers at all levels. The National Mathematics Advisory Panel (NMAP) was convened by Presidential order in 2006 to assess the state of mathematics education in the United States. This panel of experts conducted an exhaustive review of over 16,000 research publications and policy reports in math education and came to the conclusion that our current system of

---

<sup>2</sup> <http://www.nctm.org/about/content.aspx?id=26069> (accessed June 12, 2010)

mathematics education is “broken.” They acknowledge that teachers’ content knowledge is important but are unable to identify exactly what it is teachers should know (NMAP 2008, p. xxi). In particular, the *Final Report* issued by this panel calls for more research to be undertaken to determine how different approaches to the mathematics preparation of teachers impacts student achievement (NMAP 2008, p. 38).

Professional development in the form of an MS in Numeracy program is one such approach that deserves serious consideration and study. The underlying rationale for the MS in Numeracy program is the basic premise that *teachers must know and understand before they can teach effectively*. Teachers need a well-developed idea of what math is good for, beyond some vague idea that scientists and engineers need it somehow, and that the mystical calculus is required for entry into these fields. They need to see the interconnections between their own math content and subsequent curriculum all the way to statistics and calculus. They need to know how the math they teach relates to QL and the way in which we communicate with numbers. In short, they need to see the point of the whole math curriculum so that they are not forced to present mathematics as an isolated series of procedures to be memorized.

The MS in Numeracy program provides a firm grounding in the fundamental quantitative skill set that underlies the ways and means in which we communicate with numbers. Although there is no officially agreed upon definition of such a skill set, there do exist indications of what such a set should include. Lynn Steen, a major advocate of QL over the last several decades, notes that:

current schooling is strikingly deficient in achieving a primary goal of middle school mathematics, namely to convey the interrelated meanings of fractions, percents, proportions, decimals, and rates. ...Kepner noted that one reason for the decline in comprehension of these topics by high school graduates in the last half century is that teachers taught them according to different algorithms required for calculation rather than as different perspectives on a common topic. (Steen 2008, p. 21)

The core curriculum for the graduate numeracy program is based on presenting the QL skill set as different perspectives on the common topic of ratio. This simple idea of comparing the relative size of two quantities surprisingly underlies much of the ways in which we communicate with numbers. The NMAP report echoes the critical importance of fractions, percents, proportions, decimals, and rates for public literacy and workforce readiness (NMAP 2008, p. 3). The National Assessment of Adult Literacy (NAAL 2005) found that 87% of adults in this country lack basic facility with ratios such as comparing and contrasting cost per ounce in a grocery store.

Corrine Taylor, the current President of the National Numeracy Network (NNN) and Director of the Quantitative Reasoning Program at Wellesley College,

undertook a study of what QL skills are most important in the business world. First she looked at the Graduate Management Admission Test (GMAT), which is used by over 1,500 business schools worldwide to help screen applicants for their MBA programs, and she found these same topics of fractions, percents and ratios showing up again and again (Taylor 2008, p. 111). Continuing, she summarized what QL skills are needed in business and reiterated the three areas of problem solving in real-world contexts using technology (Taylor 2008, p. 118).

Providing teachers with this “reasoning and sense-making” knowledge, via numeracy graduate coursework, will make them better teachers of mathematics, meaning they will become confident experts, empowered to teach mathematics across the curriculum. They and their students will become more engaged with mathematics, leading to qualitative and quantitative gains in mathematics appreciation and achievement. Teachers must first *know* before they can *teach*. The National Math Advisory Panel conducted a survey of randomly chosen Algebra I teachers from across the country. The 743 respondents indicated the need for a greater focus in elementary school on basic skills and concepts (fractions and decimals) as the biggest change they would like to see in the curriculum; with the majority citing “unmotivated students” as being the single biggest challenge they face in teaching Algebra I successfully (NMAP, 2008, p. 9). In order to motivate and engage students, and have the transformative effect mentioned at the beginning of this section from the 9<sup>th</sup> grader, students must see the utility and relevance of the mathematics. This requires that teachers themselves first deepen their appreciation and understanding of the subject.

## CURRICULUM

Four courses make up the core of the Masters in Numeracy program:

- EDUC 571: Teaching Numeracy
- EDUC 572: Teaching with Data
- EDUC 573: Assessment and Learning Theories in Numeracy
- EDUC 574: Doing Science and Numeracy

These 3-credit required courses plus five 3-credit electives and a required Masters Project constitute the 30-credit program. The core sequence develops and reinforces the quantitative skill set in the context of real-world applications. Spreadsheet technology (Excel) is a major tool for problem solving and exploring rich content that helps with the development of mathematical connections. The electives can be chosen from the MS Ed. in Literacy program or Independent Studies from the following list of topics:

- Teaching Methods and Numeracy in the Classroom
- Calculus Concepts
- Visual Displays of Quantitative Information
- Modeling for Insight
- Multivariate Data Analysis
- Probability and Statistics
- Mathematical Modeling

These Independent Studies courses continue the application of the mathematics to varied contexts. Statistical literacy and modeling become a focus, with SPSS being introduced along with Excel to aid in studying advanced material. Throughout the courses, practical utility and application of mathematics is paramount.

Courses in the core four-course sequence were taught multiple times and in a variety of formats including traditional 15-week, three-hours-a-week courses; summer classes that ran anywhere from one to three weeks; and off-site one-week professional development programs. The first course, EDUC 571, was taught more than the others as the MS Ed. in Literacy program added it as a requirement in 2009. Only the first three Independent Studies were actually taught; most electives taken by students in the MS in Numeracy program were from the Literacy course selections. This was mainly due to the lack of available instructors for Independent Studies. Table 1 lists the texts used or recommended for the courses. Brief descriptions of each course follow.

**EDUC 571: Teaching Numeracy** introduces the concept of QL or numeracy. The main text, *Numeracy: A Quantitative Literacy, Communicating with Numbers* (Gaze in prep), focuses on building the quantitative skill set (ratios, proportions, units, conversions, scales, and percents) around the fundamental concept of ratio. Spreadsheet technology using Excel is emphasized throughout as the primary means to engage in problem solving and critical thinking with real-world context. The quantitative skill set is applied to real-world problems involving linear and exponential modeling, data analysis, probability and random simulations, and logic functions. Students are expected to read an article each week from newspapers or periodicals, and create a worksheet/quiz with three to five questions on the article. Readings from Best (2001) supplement this part of the course, as students relate ideas from the text on the social construction of statistics to the quantitative material in their articles. There are two projects based on the

Spreadsheets Across the Curriculum (SSAC) Library.<sup>3</sup> The first project is simply to complete one of the modules from the General Collection.<sup>4</sup> The second project has the students create a module of their own for use in their own classroom. Readings from Miller (2004) supplement the creation of these modules as teachers think about how to present quantitative information for their students.

**Table 1****Texts Recommended for the Courses**

Course	Text	Reference
Teaching Numeracy	<i>Numeracy: Communicating with Numbers</i>	Gaze in prep
	<i>Damned Lies and Statistics</i>	Best 2001
	<i>The Chicago Guide to Writing About Numbers</i>	Miller 2004
Teaching with Data	<i>Statistics for the Terrified</i>	Kranzler 2007
	<i>Statistics in the Real World</i>	Larsen and Stroup 1976
	<i>How to Lie with Statistics</i>	Huff 1993
	<i>Freakonomics</i>	Levitt and Dubner 2004
Assessment and Learning Theories	<i>Outliers</i>	Gladwell 2008
	<i>Calculation vs. Context</i>	Madison and Steen 2008
	<i>Overcoming Math Anxiety</i>	Tobias 1993
Teaching Methods and Numeracy	<i>Rethinking Mathematics</i>	Gutstein and Peterson 2006
	<i>Teach Like a Champion</i>	Lemov 2010
Calculus Concepts	<i>Calculus Concepts</i>	Latorre et.al. 2005
Visual Displays	<i>Visual Displays of Quantitative Information</i>	Tufte 2001
	<i>Visual Explanations</i>	Tufte 2003
	<i>Exploratory Data Analysis</i>	Tukey 1977
Modeling for Insight	<i>Turning Numbers into Knowledge: Mastering the Art of problem Solving</i>	Koomey 2008
	<i>Modeling for Insight</i>	Powell and Batt 2008
Multivariate Data Analysis	<i>Using Multivariate Statistics</i>	Tabachnik 2006
	<i>Reading and Understanding Multivariate Statistics</i>	Grimm and Yarnold 2008
	<i>Using SPSS for Windows and Macintosh: using and Understanding Data</i>	Green and Salkind 2008
	<i>Super Crunchers</i>	Ayres 2007
Probability and Statistics	<i>Probability and statistics for Engineers and Scientists</i>	Devore 2007
Mathematical Modeling	<i>A Course in Mathematical Modeling</i>	Mooney and Swift 1999

<sup>3</sup> [http://serc.carleton.edu/sp/ssac\\_home/](http://serc.carleton.edu/sp/ssac_home/) (accessed June 5, 2010)

<sup>4</sup> [http://serc.carleton.edu/sp/ssac\\_home/general/examples.html](http://serc.carleton.edu/sp/ssac_home/general/examples.html) (accessed June 5, 2010)

**EDUC 572: Teaching with Data** focuses upon handling data. Our society is inundated with data found in tables and charts in newspapers, magazines and television, while the Internet has brought access to unimaginable data resources. This course focuses on handling data in the classroom. Functions are studied as models for analyzing data, and statistical techniques, descriptive and inferential, are explored. Examples from across the curriculum make the course relevant for teachers of all disciplines and levels, and Excel is utilized as the main technological tool. There are weekly homework assignments involving ideas from Kranzler (2007) and examples from the workbook by Larsen and Stroup (1976). Students are expected to analyze a dataset each week using the concepts under discussion. These data sets provide a resource for teachers to use in their own classrooms.

**EDUC 573: Assessment and Learning Theories in Numeracy** aims to introduce students to the research base concerning assessment and learning theories in numeracy by exploring the following questions:

- How do we know if a person can be declared “quantitatively literate”?
- What skills and knowledge—and what applications of those traits—are required for a basic level of QL?
- What do we mean by a basic (or intermediate or advanced) level of QL?

Students read papers (Anderson et al. 2000; Steen 2001; Bookman et al. 2008; NMAP 2008) and texts that directly address these questions, with a special focus on exactly what content knowledge is required to empower teachers to effectively teach and assess QL across the curriculum. Students use an existing QL assessment instrument assessing both college and high school students. Results are analyzed using statistical techniques, and the instrument itself is evaluated using ideas from the articles.

**EDUC 574: Doing Science and Numeracy** is a lab-based science course where students get to see how numeracy concepts are applied in a scientific setting. The scientific method is emphasized, with the idea that science literacy is important for all teachers. Labs include some that focus on the role of science in recent technological developments, giving teachers relevant examples for their classrooms.

### ***Independent Studies***

**Teaching Methods and Numeracy in the Classroom** uses Gutstein (2006) to explore how teachers can create meaningful activities that will engage their students in mathematics. Students work through the sample projects from the

text, and are expected to create a project of their own each week. Lemov (2010) provides a useful taxonomy of the teaching techniques of the most effective teachers in the country. Students in this course are expected to practice these techniques each week while presenting their numeracy activities to the class.

**Calculus Concepts** introduces teachers to the study of calculus. The text by Latorre et al. (2005) emphasizes graphing calculator technology to explore the fundamental concepts of calculus. Data sets are used with the calculator-generated models from various function types (linear, polynomial, exponential, logistic). Students then explore rates of change using the models in real-world context. Integration is briefly introduced with applications related to probability distributions, the idea being to prepare students for further applications of calculus in the Probability and Statistics course. It is crucial that all teachers have some concept of what calculus is and why it is important because our entire high school math curriculum is dedicated to creating a calculus pipeline. Algebra receives so much emphasis because it is thought to be vital for success in calculus, and fractions then get lots of attention because it is believed fractions provide a foundation for algebra (e.g., NMAP 2008). Teachers need to understand why calculus receives so much attention, and also appreciate how the fundamental numeracy skill set of ratios and rates underlies much of what calculus teaches.

**Visual Displays of Quantitative Information** explores how we represent data visually. The texts are all classics. The two books by Tufte (2001, 2003) provide stunning visuals, while Tukey (1977) presents an “old-school” approach to plotting data by hand. I find the two authors complement each other and that teachers benefit from drawing their own visuals by hand as opposed to always using technology. Students are expected to work through exercises from Tukey (1977) and create their own visuals of current data with inspiration from Tufte (2001, 2003).

**Modeling for Insight** is a study in problem solving (Kooimey 2008) that uses the art and craft of modeling with spreadsheets (Powell 2008). The course is a natural extension of the work done in the core sequence using Excel and probably should be a requirement for the Masters program. Although the text by Powell (2008) is ostensibly for MBA programs, it does an excellent job of providing guidance in working with ill-formed problems, and it actually builds on much of the financial applications from the EDUC 571 course.

**Multivariate Data Analysis** introduces students to the important statistical software package SPSS as applied to multivariate analysis, a critical tool for social scientists. In addition to the texts by Tabachnik (2006), Grim and Yarnold (2008), and Green and Salkind (2008), I recommend the popular book by Ayers (2007) for an enlightening overview of how data crunching is challenging our notions of intuition and expertise.

**Probability and Statistics** builds on the previous coursework in data analysis and calculus, for the advanced student. In particular, this is an excellent topic for applications of integration techniques from calculus to probability distributions.

**Mathematical Modeling** provides a follow-up to the Probability and Statistics course. This course is definitely for more advanced students, similar to a bio-mathematics class that touches on linear algebra and discrete versions of systems of differential equations. The examples tend to be from biology and thus differ significantly from the financial applications of the Modeling for Insight course.

The required Masters project counts as a 3-credit course and builds on the data analysis and modeling techniques studied in the coursework.

## IMPLEMENTATION

In the 2005/06 and 2006/07 school years before the MS in Numeracy was approved by NYSED, I offered the Numeracy courses as electives for the MS Ed. Literacy program. After the MS in Numeracy program was approved, four students officially enrolled in it in the 2007/08 school year and four more in the 2008/09 school year. The first graduate in the program was in May 2008 and is now a high school Biology teacher. There were three graduates in May 2009: to a middle school Business teacher, a middle school History teacher and an elementary school teacher. In general, students in the graduate Education programs are a mix of teachers, and students who have just graduated and not started teaching. Numeracy courses were also populated by Literacy students taking electives. Interest was starting to grow amongst graduate assistants for the athletic teams, who could take courses for free but did not necessarily want to teach. In the spring of 2009 the MS Ed. in Literacy program made the first course, EDUC 571, Teaching Numeracy, a requirement for their students.

A major hurdle to marketing and growing the program was the question of professional certification for MS in Numeracy degree holders. During 2007/2008 and 2008/2009 the Department Chair in Education worked with NYSED to try to clarify how an MS in Numeracy degree would translate to professional certification for teachers. During this period the MS Ed. in Literacy program was expanding to a down-state location in New York City and attempts were being made to generate interest in Numeracy there as well. These efforts were hampered by our inability to conclusively guarantee that the MS in Numeracy would count toward professional certification. The fact that I was the only one teaching the Numeracy courses made it difficult to offer enough courses in two different locations.

The comparison with MS Ed. in Literacy programs is helpful in trying to envision the future possibilities of graduate Numeracy programs. Literacy is a

well-established area of higher education with masters and doctorate programs available. Quantitative literacy, however, has never been a part of this graduate coursework. Teachers with an MS Ed. in Literacy receive additional certification as “reading specialists,” and school districts have positions for these specialists. I am making the case that QL deserves the same attention as Literacy, that reading and writing with numbers deserves the same recognition as traditional literacy. There has been discussion in the past of the need for elementary mathematics specialists (EMS), and I am heartened by the renewed call for such specialists by the NCTM noted above (Introduction). In particular, there is now the recognition of a need for advanced certification opportunities and professional preparation programs for EMS, exactly what the MS in Numeracy provides.

## **LESSONS LEARNED**

### ***State Education Regulations and the Proposal***

Having an Education faculty member familiar with the state regulations regarding graduate programs as well as teacher licensure requirements is critical to writing the proposal. Many departments of education have graduate programs that have been in existence for so long that none of the original authors of those programs are still around. State “regs” can be baffling, so having this expertise can save time and effort. Having a liaison in the state department of education who can assist in wading through the bureaucratic red tape is invaluable; just knowing who the right person or department to talk with can save a tremendous amount of time. I strongly recommend not doing anything without first consulting with the state education department in person. Articulating what numeracy is, and how this differs from a typical MS in Mathematics is very important to clear up at the outset. I strongly recommend meeting in person with the state education department to discuss this difference, and emphasize the unique nature of the proposal. A phone conversation may lead to misconceptions, with state education being very surprised when they receive a proposal for something that does not fit into one of their pre-existing pigeon holes.

### ***MS vs. MS Ed.***

There is a big difference between creating a Master of Science (MS) program and creating a Master of Science in Education (MS Ed.) program. MS Ed. programs are much more heavily regulated since this degree usually entails the holder to a professional teaching certificate automatically. MS degree holders may have to apply to the state department of education for professional certification or equivalent. Knowing exactly how the MS in Numeracy program fits into the state teacher licensure requirements is critical for marketing this program to teachers. MS Ed. programs typically have a practicum component where teachers practice

their skills in the schools. This requires oversight and cooperation with partnering school districts. An MS program does not have this component and thus makes this degree more versatile for professionals in other disciplines outside of teaching.

I would recommend having both an MS and MS Ed. option on the books. Creation of a new MS Ed. program, like Numeracy, is going to require the highest state officials in the department of education to essentially create a whole new category of MS Ed. (including guidelines for other schools who may wish to follow suit). This is very different from applying to start an MS Ed. program for an already existing category, with a pigeonhole already in place. MS Ed. programs tend to be very grade specific: early childhood (elementary school), childhood (middle school), and adolescent (high school); and/or discipline specific: Math, English, Biology etc. Articulating why an MS in Numeracy program should be open to teachers from all disciplines and all levels is challenging. This is a novel idea and requires careful attention. MS Ed. in Literacy programs provide a very nice model for creating an MS Ed. in Numeracy. I believe a strong argument can be made to state education that Numeracy deserves the same recognition as Literacy, and thus requires similar graduate work for specialization.

### ***Institutional Support***

Institutional support is obviously critical to the program's success. Class sizes will be small to start. Marketing the program has to be a priority for the administration if they wish to see it grow. Having a robust well-established school of education with graduate programs pre-existing in mathematics is optimal in terms of having enough faculty to teach the courses. Competition with other existing graduate programs for faculty as well as students is an important issue that needs resolution earlier rather than later. Marketing the graduate courses in Numeracy as professional development opportunities is a nice way to generate enrollment. The downside is that this usually means weekend or summer classes. I have found that one- or two-week summer classes do not offer enough time for teachers to fully digest the material.

## **CONCLUSION**

There is growing interest in the educational community regarding QL, as well as concern over the inadequate mathematics preparation of K-12 teachers. The Association for Teachers of Mathematics in New England (ATMNE) is holding its fall 2010 conference with the theme of QL. The New Hampshire Department of Education has just released its PreK-16 Numeracy Action Plan for the 21<sup>st</sup>

Century<sup>5</sup>. Massachusetts became the first state in the country in 2009 requiring a mandatory passing score on its mathematics licensure test for elementary teachers. The fact that over three-quarters of the aspiring elementary teachers who took this test in 2009 failed<sup>6</sup> supports the NCTM's call for elementary math specialists.

It is every teacher's responsibility to develop our students' reading and writing abilities, with numbers as well as words. An MS in Numeracy program seems a natural way to address this issue. Such a program can be constructed to infuse reasoning and sense making into the mathematics, so that problem solving connects the mathematics to real-world contexts using technology. This is what is missing in the current mathematics curriculum; this is why students are not engaged in the mathematics classroom; this is why 87% of adult Americans are deemed quantitatively illiterate (NAAL 2005); and this is exactly why we need MS in Numeracy programs as part of the professional development of teachers.

## ACKNOWLEDGMENTS

I would like to thank the referees and editor whose many comments and suggestions significantly improved this paper.

## REFERENCES

- Anderson, J.R., L.M. Reder, and H.A. Simon, H.A. 2000. Applications and misapplications of cognitive psychology to mathematics education. *Texas Educational Review*. <http://act-r.psy.cmu.edu/publications/pubinfo.php?id=146> (accessed June 12, 2010).
- Ayres, Ian. 2007. *Super Crunchers: Why Thinking by Numbers is the New Way to be Smart*. New York: Bantam Books.
- Best, Joel. 2001. *Damned Lies and Statistics*. London, England: University of California Press.
- Bookman, J., S. Ganter, and R. Morgan. 2008. Developing assessment methodologies for quantitative literacy: A formative study. *American Mathematical Monthly*: 115(10): 911–929.
- Devore, Jay. 2007. *Probability and Statistics for Engineering and the Sciences*. 7<sup>th</sup> ed. Pacific Grove, CA: Duxbury Press.
- Gaze, Eric. in prep. *Numeracy: A Quantitative Literacy, Communicating with Numbers*.
- Gladwell, Malcom. 2008. *Outliers*. New York: Little Brown and Co.

---

<sup>5</sup> [http://www.education.nh.gov/innovations/pre\\_k\\_num/index.htm](http://www.education.nh.gov/innovations/pre_k_num/index.htm) (accessed June 5, 2010)

<sup>6</sup> [http://www.wpri.com/dpp/news/local\\_news/local\\_wpri\\_massachusetts\\_aspiring\\_school\\_teachers\\_fail\\_in\\_math20090519](http://www.wpri.com/dpp/news/local_news/local_wpri_massachusetts_aspiring_school_teachers_fail_in_math20090519) (accessed June 5, 2010)

- Green, Samuel. Salkind, Neil. 2008. *Using SPSS for Windows and Macintosh: Using and Understanding Data*. New Jersey: Prentice Hall.
- Grimm, Lawrence. Yarnold, Paul. 2008. *Reading and Understanding Multivariate Statistics*. Washington, DC: American Psychological Association.
- Gutstein, Eric and Bob Peterson, Bob. 2006. *Rethinking Mathematics: Teaching Social Justice by the Numbers*. Milwaukee, WI: Rethinking Schools Publication.
- Huff, Darrell. 1993. *How to Lie with Statistics*. New York: W. W. Norton and Company.
- Kepner, Hank. 2010. March 19, 2010 Personal correspondence.
- Koomey, Jonathan. 2008. *Turning Numbers into Knowledge: Mastering the Art of Problem Solving*. Oakland, CA: Analytics Press.
- Kranzler, John. 2007. *Statistics for the Terrified*. New Jersey: 4<sup>th</sup> Ed. Pearson Education Inc.
- Larsen, Richard, and Donna Stroup. 1976. *Statistics in the Real World: A Book of Examples*. New York: MacMillan Publishing. (out of print)
- Latorre, Donald, John W. Kennelly, Iris Fetta Reed, and Laurel L. Carpenter. 2005. *Calculus Concepts: An Informal Approach to the Mathematics of Change*. Boston: Houghton Mifflin Company.
- Lemov, Doug. 2010. *Teach Like a Champion: The 49 Techniques That Put Students on the Path to College*. New York: Jossey-Bass.
- Levitt, Steven, and Stephen Dubner. 2005. *Freakonomics*. New York: Harper Collins.
- Madison, Bernard L, and Lynn Arthur Steen. 2008. *Calculation vs. Context: Quantitative Literacy and its Implications for Teacher Education*. Washington DC: Mathematics Association of America.  
<http://www.maa.org/QI/calcvcontext.html> (accessed June 12, 2010).
- Miller, Jane. 2004. *The Chicago Guide to Writing about Numbers*. Chicago: The University of Chicago Press.
- Mooney, Douglas, and Randall Swift. 1999. *A Course in Mathematical Modeling*. Washington DC: The Mathematical Association of America.
- Morin, Bruce. 2009. Aspiring school teachers fail in math. WPRI.com, Eyewitness News.  
[http://www.wpri.com/dpp/news/local\\_news/local\\_wpri\\_machusetts\\_aspiring\\_school\\_teachers\\_fail\\_in\\_math20090519](http://www.wpri.com/dpp/news/local_news/local_wpri_machusetts_aspiring_school_teachers_fail_in_math20090519) (accessed June 12, 2010).
- Murray, Frank. 2008. The licensure of teachers for quantitative literacy. In *Calculation vs. Context: Quantitative Literacy and its Implications for Teacher Education*, ed. Bernard Madison and Lynn Arthur Steen, 163–185. Washington DC: Mathematics Association of America.  
<http://www.maa.org/QI/cvc/cvc-163-185.pdf> (accessed June 12, 2010).

- NAAL. 2005. A First Look at the Literacy of America's Adults in the 21<sup>st</sup> Century. National Center for Educational Statistics. Available at: <http://nces.ed.gov/Pubsearch/pubsinfo.asp?pubid=2006470>
- NMAP. 2008. Executive summary. In *The Final Report of the National Mathematics Advisory Panel*, xi–xxvii. U.S. Department of Education. [www.ed.gov/about/bdscomm/list/mathpanel/index.html](http://www.ed.gov/about/bdscomm/list/mathpanel/index.html) (accessed June 12, 2010).
- Powell, Stephen, and Robert Batt. 2008. *Modeling for Insight: A Master Class for Business Analysts*. New Jersey: Wiley.
- Steen, Lynn Arthur (ed). 2001. *Mathematics and Democracy: The Case for Quantitative Literacy*. The Woodrow Wilson National Fellowship Foundation, National Council on Education and the Disciplines. <http://www.maa.org/ql/mathanddemocracy.html> (accessed June 12, 2010).
- . 2008. Reflections on Wingspread Workshop. In *Calculation vs. Context: Quantitative Literacy and its Implications for Teacher Education*, ed. Bernard Madison and Lynn Arthur Steen, 11–23. Washington D.C. Mathematics Association of America. <http://www.maa.org/ql/cvc/cvc-011-023.pdf> (accessed June 12, 2010).
- Tabachnik, Barbara. 2006. *Using Multivariate Statistics*. Boston: Allyn and Bacon.
- Taylor, Corrine. 2008. Preparing Students for the Business of the Real (and highly Quantitative) Workplace. In *Calculation vs. Context: Quantitative Literacy and its Implications for Teacher Education*, ed. Bernard Madison and Lynn Arthur Steen, 109–124. Washington D.C. Mathematics Association of America. <http://www.maa.org/ql/cvc/cvc-109-124.pdf> (accessed June 12, 2010).
- Tobias, Sheila. 1993. *Overcoming Math Anxiety*. New York: W.W. Norton and Company
- Tufte, Edward. 2001. *The Visual Display of Quantitative Information*. Cheshire, CT: Graphics Press
- . 2003. *Visual Explanations: Images and Quantities, Evidence and Narrative*. Cheshire, CT: Graphics Press
- Tukey, John. 1977. *Exploratory Data Analysis*. Reading, MA: Addison-Wesley Publishing
- Wu, Hung-Hsi. 2009. What's Sophisticated About Elementary Mathematics? *American Educator*, 33(3):4–14.