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Quantitative Literacy at Michigan State University, 3: Designing General Education Mathematics Courses

Samuel L. Tunstall
Michigan State University, stunstal@trinity.edu
Vincent Melfi
Michigan State University
Jeffrey Craig
Michigan State University
Richard Edwards
Michigan State University
Andrew Krause
Michigan State University

See next page for additional authors

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Abstract

In this paper, we describe the process at Michigan State University whereby we have created two courses, Math 101 and 102, designed to foster numeracy and alleviate mathematics anxiety. The courses--which are not sequential--provide a means of satisfying the University's general education requirement without taking college algebra or calculus, among other options. They are context-driven and broken into modules such as "The World and Its People" and "Health and Risk." They have been highly successful thus far, with students providing positive feedback on their interest in the material and the utility they see of it in their daily lives. We include background on the courses' history, their current status, and present and future challenges, ending with suggestions for others as they attempt to implement quantitative literacy courses at their own institution.

Keywords

quantitative literacy, numeracy, general education, post-secondary education, curriculum

Cover Page Footnote

Samuel Luke Tunstall is a graduate student in mathematics education and University Distinguished Fellow at Michigan State University. His interests include the sociology of mathematics education and the ways in which mathematics courses can promote numeracy. He began working on MSU's QL curriculum development and assessment measures this year.

Vincent Melfi is an associate professor of Statistics and director of the Program in Mathematics Education at Michigan State University. His research interests include the quantitative literacy of college students and adaptive allocation in clinical trials. He conducted preliminary assessments of QL on MSU's campus and has led the team of curriculum developers throughout its work.

Jeffrey Craig is a PhD Candidate in mathematics education at Michigan State University. His research interests include affective dimensions in epistemology and in transformative learning with quantitative literacy as a vehicle for that transformation. He worked on the design team for the courses, as well as teaching the pilot courses last summer, fall, and this spring.

Abe Edwards is an academic specialist in the mathematics department at Lyman Briggs College within Michigan State University. His research interests include quantitative literacy as well as improving interdisciplinary collaboration between mathematics and science educators at the undergraduate level. His work on the QL project included designing the curriculum and piloting lessons, particularly with respect to health and risk.

Andrew Krause is a graduate student in mathematics education at Michigan State University and academic specialist in the University's Mathematics Department. His research interests include quantitative literacy and the nature of students' experiences in undergraduate mathematics classrooms. He worked on the design team for the courses, as well as teaching the pilot courses last summer, fall, and this spring.

Bronlyn Wassink is a teaching specialist in the Mathematics Department at Michigan State University. Her research interests are Mathematics Education, Geometric Group Theory, and Applied Statistics. Her work on this project stemmed from being the course coordinator and lead instructor for MSU's Quantitative Literacy courses.

Victor Piercey is an associate professor of mathematics at Ferris State University. He is interested in the impact of curriculum and instruction reform on math anxiety and other affective measures. He served on the committee that established the quantitative literacy project during his time as a graduate student at Michigan State University.

Authors

Samuel L. Tunstall, Vincent Melfi, Jeffrey Craig, Richard Edwards, Andrew Krause, Bronlyn Wassink, and Victor Piercey

Introduction

The value of quantitative literacy (QL) for college graduates is well documented. Numbers—whether on social media, at the doctor's office, or in one's finances—inundate students' lives, and the decisions they make in interacting with them have a cumulative impact on their risk comprehension (Fagerlin et al. 2007; Lipkus and Peters 2009), income level (Eide and Grogger 1995; Levy et al. 1995; Rivera-Batiz 1992), and decision-making ability (Jasper et al. 2013), among other things. In tandem with a 2005 University Task Force's recommendations, these effects comprise the rationale for creating a set of quantitative literacy courses, Math 101 and 102, at Michigan State University (MSU). These courses are quite distinct from traditional ones that students in college might encounter; they are not vehicles for teaching "watered-down" mathematics, but rather contain context-driven, engaging, and pragmatic content, and the courses' structure was chosen to counter mathematics anxiety. In this paper, we detail the creation process of the courses and the positive impact on attitude we have observed thus far. We also discuss MSU's QL program in relation to programs at other universities, and some of the challenges in implementing quantitative literacy courses especially at large institutions. We conclude by suggesting how the lessons we have learned might guide others as they create or modify QL programs in their own institutions.

Background on MSU

Michigan State University is a large, public land-grant institution that—as of 2016—serves roughly 39,000 undergraduate students. Before the introduction of the quantitative literacy courses, the general education mathematics requirement required that all undergraduates either complete or place out of college algebra, as well as take a course beyond college algebra such as calculus or statistics. Students must place into the courses they want to take, so if (for instance) they want to take calculus but place into college algebra, they must take both courses. In fall 2015, roughly 2,500 students enrolled in college algebra, 400 in finite mathematics, 2,100 in calculus, and 1,250 in introductory statistics. For many students who take no mathematical sciences courses beyond the two required, these required courses have a lasting influence in impressing upon students the nature of what the mathematical sciences are, and how mathematics might be useful to them in their daily lives. Depending upon how the courses are taught and on their content, this notion is potentially problematic. Indeed, many have criticized courses such as college algebra (e.g., Steen 2004; Small 2006) for their complicity in failing to prepare students for day-to-day encounters with numbers.

In response, changes have been slow but noticeable, with groups like the National Numeracy Network and the Mathematical Association of America's Special Interest Group in QL spearheading reform to make first-year courses—especially those below calculus—both engaging and pragmatic. Given the large number of students MSU serves, this task is especially pertinent when we consider how students' *previous* mathematics experiences are likely to have been significantly different from what we want to foster now. Our goal is to empower students to feel confident in quantitative situations, regardless of their previous experiences in mathematics courses (note we report examining this empowerment later).

At MSU, such reform is being spearheaded by the quantitative literacy courses described in this paper. The reform is based on a variety of factors, including partner-disciplines' increasing emphasis on students' mathematical preparation, a national push toward broader monitoring of general education outcomes, and a goal that all students graduate with a level of quantitative literacy commensurate with societal needs. In 2004, these factors led the Provost to charge an interdisciplinary team of faculty with reviewing the mathematics exit requirements at MSU; specifically, the task force was expected to establish guidelines and QL requirements for all students earning a bachelor's degree, develop an assessment plan that monitored QL outcomes for such students, develop potential models for an interdisciplinary university curriculum that would attend to QL, and recommend an oversight structure of their plan. This commission was a nontrivial task.

The crux of the committee's findings was that the university's exit requirement should be framed in terms of quantitative literacy rather than mathematics. Following the release of the report, the university began a QL assessment inquiry of both its current undergraduates and incoming first-year students (Sikorskii et al. 2011; Gilliland et al. 2011). The explicit development of a QL course began in 2013, when three faculty members developed a special topics seminar. Coming from the departments of statistics, mathematics, and mathematics education, the three co-taught a QL-oriented course, testing out interactive teaching techniques and nontraditional math content. Following the success of this small-scale work, it was decided that Math 101 and 102—a set, rather than sequence, of courses—be formally created. This work was conducted under the auspices of the Program in Mathematics Education, the Department of Mathematics and the College of Natural Science, while being approved formally by the faculty governance system last year. At scale, it is expected that the courses will serve several thousand students per year.

Note that the university mathematics requirement remains that students take or place out of college algebra, as well as take one further course above college algebra; however, Math 101 or 102 may now replace a student's college algebra, allowing the student to take both Math 101 and 102, or one of the quantitative literacy courses, plus calculus or statistics. Math 101 and 102 do not contain the same mathematical rigor that one would find in calculus or statistics, but at the same time they do require critical thinking and writing—a hallmark of quantitative literacy sufficient to meet the university's mathematics requirement. Notwithstanding the fact that students no longer *have* to take college algebra, it is worth noting that students who place out of college algebra may still take a course such as calculus, thus avoiding the quantitative literacy courses; if a student obtains transfer credit for calculus, then the student may waive college mathematics courses altogether. The implication from these scenarios is that—despite the argument that mathematical and quantitative literacy are not equivalent—students at the university are not required to take a course specifically designed with quantitative literacy in mind. No majors require Math 101 or 102 yet either. We hope this practice will change.

Math 101 and 102: Quantitative Literacy

Steps in Designing the Course

An important vision—one which drove the design process—is that the courses' structure, content, pedagogy, and assessment should make the course seem quite different from a typical mathematics or statistics course. Our rationale for this design is to help students overcome potential anxiety and past lack of success in those courses, as well as to help set the norm that this course is about more than mathematical techniques. That is, we expect students to communicate quantitative reasoning, to create quantitative displays, and to feel empowered in the work they produce. With this design in mind, curriculum development for two quantitative literacy courses began in summer 2014. Three doctoral students in mathematics education, one in mathematics, and one in biology with interests in quantitative and scientific literacy, met weekly with a professor of statistics and mathematics education to discuss the nature of such a course. Initial conversations centered on casting a vision for QL at MSU. As many researchers have found (e.g., Vacher 2014; Karaali et al. 2016), there is no standard definition for QL. Negotiating a course vision took time, but was considered so foundational that few lessons could be written until a working description was in place. While the course goals and descriptions will change as a result of feedback from pilots and full-scale operations, an early attempt to define the broad goals of the course is as follows:

> These courses provide students with a college-level academic experience that (1) Provides a foundation in quantitative literacy, (2) Supplies the mathematics, statistics, and other quantitative skills needed in a variety of disciplines, and (3) Helps meet the quantitative needs of current students and graduates both inside and outside of academia. A significant portion of the course focuses on using meaningful contexts and applications

> to teach mathematical skills and competencies that show the role of QL in societal decisions, public policy, and problem solving.

Once a vision, albeit subject to change, was in place for the courses, the challenge became one of operationalizing the vision in terms of classroom experiences and learning objectives. Below, we delineate some of the steps, decisions, and issues that we encountered early on.

Vision and Design

To determine a curricular vision that is shared by several different people involves significant dialogue about goals, content, and pedagogy. We benefitted from having several designers engaged specifically in mathematics education and quantitative literacy, coupled with expertise from mathematics, statistics, and science teaching. The decisions that became operational during our summer pilot and fall pilot courses and are becoming operational still during this spring semester involved significant discussion over a period of almost two years.

One of the first decisions to make in the courses' creation was to develop a set of learning objectives. Tentative objectives from the course pilots are:

- Interpret mathematical models in the form of formulas, graphs, tables, and schematics, and draw inferences from them.
- Represent mathematical information in different ways including: visually, numerically, verbally, and symbolically.
- Use arithmetical, algebraic, geometric and statistical methods to understand problems.
- Make predictions about quantitative situations and check predictions against data in order to determine reasonableness, identify alternatives, and make choices.
- Clearly articulate an argument for a social or scientific issue that uses quantitative data in a meaningful way.

These learning objectives are addressed throughout both courses, and they are incorporated into each context-based module.

After developing learning objectives, we next had to decide what exactly should appear in each course. It was decided that the two courses would be distinct in terms of *contexts*, more so than mathematical content. Multiple mathematical components would appear in both courses and spiral back multiple times within a single course, but the contexts in which they appeared would be different. For example, representations appear in all of our modules, with bar-graphs in the media module, payoff matrices in the economics module, and scatterplots throughout each of the modules. With this spiraling, students who took both courses would receive a meaningful QL experience in both semesters, as they applied mathematical and statistical techniques across multiple contexts.

A key decision was whether to teach the course *content*-first (followed by some applications) or *context*-first (and develop the QL machinery necessary to solve real problems). Our goal was to teach QL through real-life contexts, rather than to teach mathematics and statistics in the abstract, followed by interesting applications. In many ways, much of the content co-emerges with context—there is no clear demarcation of order. Furthermore, we chose to divide the course into modules that focus on themes such as Health and Risk, Natural Science, Politics and Voting, Numbers in the Media, Personal Finance, Economics, and The World and its People. These choices are subject to change from semester to semester. We felt that this decision better reflected insights into pedagogy (e.g., Lampert 1990), philosophies of education (e.g., Dewey 1916/2004; Freire, 1974), and theories of motivation (e.g., Bandura 1977). From well-chosen contexts, the mathematics arises naturally. As examples, the mathematics content for Health and Risk included basic probability, Bayes' Rule, and the distinction between absolute and relative risk; that for The World and its People included logarithmic scales, estimation, and orders of magnitude. Woven throughout the modules are basic principles like percent increase, the creation and interpretation of graphs, and other topics. Thus far, we have piloted the following modules each semester.

Math 101

Module 1: The World and Its People
To potentially include: order of magnitude; use of Gapminder data; logarithmic scales; relative and absolute variables; conditional probabilities (given someone's demographics).

Module 2: Media Messages
To potentially include: logical fallacies; graphs in the media; creating and critiquing infographics; develop quantitative arguments; foreign aid; language bias.

Module 3: Health and Risk
To potentially include: Bayes' rule; correlation and causation; carcinogens; sensitivity and specificity; reading nutrition labels; evaluating nutritional claims (e.g., GMOs); risk and micromorts.

Module 4: Knowledge in Natural Science
To potentially include: evolution; climate science; funding NASA; spotting bad science; carbon dating; the magnitude of quantities in relation to the universe.

Math 102

Module 1: Finance
To potentially include: credit card and loan payments; savings accounts; APR and APY; fixed and adjustable rate mortgages; credit scores; stock market; tax systems; insurance.

Module 2: Economics
To potentially include: supply and demand; specialization and trade; opportunity cost; production possibilities frontier; scarcity; and the national budget.

Module 3: Voting Systems
To potentially include: voting systems, such as Borda count, pairwise comparison, plurality, and plurality with elimination; fairness criteria, Arrow's Theorem, weighted voting systems, apportionment of the U.S. House of Representatives, and gerrymandering.

Module 4: Justice
To potentially include: racial profiling; the welfare system and economic justice; the War on Drugs; environmental justice; school funding.

From these modules, one can see clear connections between our courses and those served by the Bennett and Briggs (2015) text, as well as that of COMAP's *For All Practical Purposes* (2016); however, there are clear additions, such as the unit on natural science, and that on justice. Deciding which modules made sense to teach together in the same semester was not an easy decision, as choices were related to how the two courses would interact with each other. In the end, it was decided that students could take the courses independent of one another, and in either order. This independence potentially increases the pool of students who can enroll in the courses. Moreover, it was decided that Math 101 would contain specific mathematical content to prepare students for general education laboratory work as part of MSU's Integrative Studies in General Science.

With respect to pedagogy, the design team was in full agreement that both courses would employ an active-learning approach. We wanted the course to be distinct from those that students might have taken in the past, and different too from courses that they might otherwise encounter in the University's Mathematics Department. As a result, it was decided that—to as great an extent as possible—class time would find students actively engaged in developing QL through engaging with real-life problems. Of course, we realized that avoiding lectures altogether was unreasonable and unnecessary, but we wanted to be purposeful about when to employ a lecture, and when to employ more active learning approaches. To this end, we scoured existing curricula for engaging activities, designed our own activities, tapped into the National Numeracy Network, and talked with other QL instructors across the country to build a compendium of lessons that we hoped students would find engaging and important. A sample of three assignments is included in the Appendix. Later in the paper, we discuss how the active-learning component is evolving as the course size becomes larger.

Of course, we also had to establish how we would assess students' learning within the course, keeping in mind that assessing QL is unlike assessing mathematical competence (Wiggins 2003), because QL is inherently tied to real-life contexts. It is impractical, however, for us to observe students in natural habitats (e.g., on the job, at the grocery store, discussing politics, reading a newspaper, buying a car) and assess their QL performance. Nevertheless, we wanted assessment to be as authentic as possible, while bearing in mind that high-stakes exams are likely to cultivate mathematics anxiety rather than alleviate it. This decision meant using a variety of assessment measures, including single and group projects, discussion board posts, class presentations, written reports, and more traditional quizzes and exams. We employed the Desire2Learn platform for most assignments, including discussion boards. We also employed MyMathLab for online homework. Below is the actual grading structure used in the spring 2016 course pilot.

- Reading assignments: 5%
- Lecture group-work activities: 5%
- Recitation group work activities: 25%
- Recitation participation: 5%
- Online homework: 20%
- Quizzes: 10%
- Projects: 15%
- Final Exam: 15%
- Lecture poll participation (bonus 3%)

As with most college courses, we considered textbooks as part of the design process. An influx of QL-oriented texts has emerged in recent years. Our team considered a number of these books, including Bennett and Briggs (2014), COMAP (2016), Gaze (2015), and Crauder et al. (2014). A consideration in choosing a text was that we wanted the mathematical content to have strong connections with real-world problems. We also wanted a text that would give students rich experiences with basic numeracy, algebra, mathematical modeling, statistical thinking, geometric/spatial reasoning, and logical argumentation. However, we did not want the textbook to define the course curriculum, but be a resource for module development. During the initial pilot, we used the Bennett and Briggs (2014) text to help get the courses off the ground, but we are still investigating appropriate materials. One option would be to create our own "course pack" of assignments, lesson plans, and assessments.

Organization and Logistics

From a logistical standpoint, specific members of the design team took the lead on designing specific modules. Although we realized that multiple people would work on each module, it was important that one person have a sense of ownership over each particular one. Not only did this decision help distribute the workload; it also allowed individuals from diverse backgrounds to contribute centrally to the course.

Initial Results

The summer 2015 pilot of both courses (wherein all students received credit for both courses) involved twelve students and had two instructors, both of whom were members of the design team. The fall 2015 section of Math 101 included 105 students; for the spring 2016 semester pilot of Math 102, there are approximately 220 students enrolled. It is not surprising to the instructors or development team that students have responded positively to the course thus far. Following is a sampling of representative comments from the fall 2015 term:

> As a student who is a Communication Major and will not be using algebra in day to day job tasks, MTH 101 was a good alternative. It allows me to have a background in the types of real world math that I will be using. MTH 101 is very applicable to lots of different disciplines. Very recommended.
>
> I finally feel as if I can understand math. I no longer feel like an incompetent person. I actually enjoy this class. I didn't stress out as usual, and start forgetting everything on a test. I was able to have my questions answered, and was not afraid to ask them as well. I am excited to take the next course.
>
> MTH 101 really changed my outlook on math classes. Before this course, I had taken MTH 103 [college algebra] twice, and failed it both times. As a student who isn't geared towards math, this class was great. For once in my life, I didn't feel stupid in a math class while taking this course. I think it should 100% be permanent for other students who also are not geared towards math.
>
> This class makes math interesting and relevant to our lives. And it does not seem like a waste in terms of real life.

Overall, students have found that the mathematics is useful and that the assignments are engaging. Moreover, the course appears to be a pragmatic and realistic alternative for students alienated by college algebra. Indeed, another question we asked at the end of the course was: Have you taken college algebra at MSU before, and if so, which of the two courses do you prefer? Only three of the 42 who had taken both said that they preferred college algebra.

We also administered five Likert-scale questions adapted from Gaze et al.'s (2014) quantitative literacy and reasoning assessment (QRLA) instrument to monitor shifts in students' attitudes over the course of the fall semester. We asked students the same questions during the first and final weeks of class. Students answered each question with a one for "strongly disagree" and five for "strongly agree." The statements are below. The results are in Figure 1. They show strong, positive gains in students' attitudes towards numbers in daily life.

- Q1: Numerical information is very useful in everyday life.

- Q2: Numbers are necessary for most situations.
- Q3: Quantitative information is vital for accurate decisions.
- Q4: Understanding numbers is as important in daily life as reading and writing.
- Q5: Learning information containing a lot of numbers is not a waste of time.

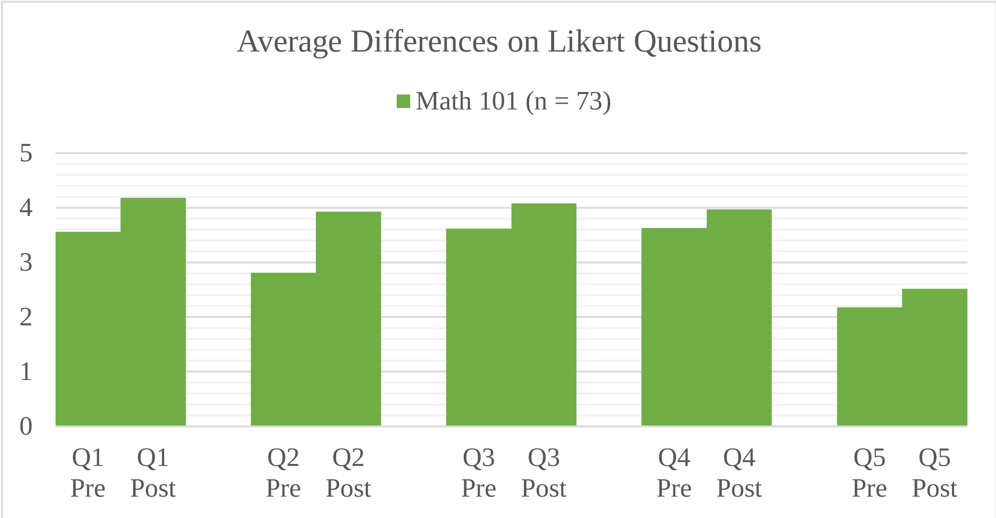

Figure 1. QLRA Likert-scale question results

It is important to note that one should not assume that by simply taking a math course, students will answer positively to these questions (Tunstall 2015). Accordingly, these gains are practically meaningful. Notwithstanding the initial results, the developers and instructors recognize that the courses are an evolving endeavor. The team understands that the initial results are not measuring changes over a long period of time, and thus provide limited insight into meaningful dispositional changes. Additionally, we were not able to administer the content questions of the QLRA; however, we plan to do so in future semesters.

Challenges

A demanding step in creating Math 101 and 102—as discussed before—was to develop a vision for what quantitative literacy is, and how it would manifest in two courses at a particular educational institution. Central to this vision is the context-driven and project-based nature of the two courses. As the courses develop and as the enrollments increase substantially over the next few years, there will be several challenges related to this vision. First, assessment of student attitudes and outcomes will be crucial in determining whether this vision is serving students well, and in possibly amending the vision. Second, professional development for both faculty members and students (both graduate and undergraduate) who will be part of the instructional team is needed. Content and pedagogy for the courses are different from most courses in mathematics and statistics, and it is unreasonable to expect instructors to be successful without training and support. Third, administrators who hire faculty and student instructors and who provide funding for the courses will need to understand the importance of the course content and pedagogy, especially since the courses require more resources than typical courses in mathematics (although substantially less than typical courses in other natural science disciplines).

Currently the QL team is collaborating with the Hub for Innovation in Learning and Technology at MSU[1] to design and administer a wide variety of assessments, including longitudinal assessments of students as they progress through their undergraduate careers, to inform future development of the courses and to measure the impact the courses are having on students' quantitative development. Faculty professional development and support is being coordinated with the Center for Instructional Mentoring at MSU, which fortunately is co-directed by a member of the QL design team. The third "administrative" challenge is less amenable to direct action, but results of assessments of student learning and attitudes will (hopefully) be a powerful reminder of the courses' success.

A further task we face now is scaling the course up to allow more students to enroll. It is expected that most students majoring in non-STEM fields will take one or both of the new courses, which would result in enrollments of over 1,000 students per semester. The courses will have one "large" meeting of approximately 200 students per week, and these students will then be broken into seven "small" recitations of about 30 students. Both meetings will be 80 minutes in length. As the course scales up, the number of graduate and undergraduate students who will need to become proficient in a context-driven curriculum with active learning pedagogy will be rather large, and mentoring capabilities will need to scale also. To boot, with more students naturally comes the need for support in the University's Mathematics Learning Center. Helping students in such a course is a non-trivial task for the tutors who work in the center, given that most of the tutors likely did not take a class of this nature in their coursework. Training tutors to effectively work with Math 101 and 102 students is something the team intends to begin in the fall 2016 semester.

A related challenge is making the large-class meetings—as well as assessments—interactive and engaging. One means of making class engaging is using applications that permit polling; for the spring 2016 semester, we are

[1] The Hub is a new campus center with the goal of improving undergraduate teaching and learning. See www.hub.msu.edu for more information.

piloting a free software called Socrative.[2] The students appear to enjoy using it, and it is useful for the instructor in obtaining formative feedback on students' understanding of the material during class. In pursuit of making the class more interactive, we have also experimented with having students complete group work during the larger class. With a small number of teaching assistants, however, the reality of doing so has been difficult. In future semesters, we expect to hire undergraduate assistants in order to allow for more group work and personnel. An additional component of scaling the course up is assessment. As discussed earlier, our vision was not a course driven by computation or multiple-choice questions. Open-ended questions—the majority of the items students complete—take time to grade, and hence for each assignment the course coordinator must decide how points will be allotted. The written assignments and projects also take a significant amount of time to grade. This issue is another reason that the course is relatively resource intensive.

We are also cognizant of *future* challenges as we move forward. We have yet to enact a long-term assessment measure to monitor learning and affective outcomes—one that among the checks will include an indicator of how students are performing in later general education science courses. Additionally, maintaining our original, collective vision will continue to be difficult, as the graduate teaching assistants—who provide their unique perspective during recitation—come and go. This group is especially important, given that the course will be offered on a large-scale lecture-recitation model; training the graduate assistants, as well as finding means of reducing the perceived size of the course, are challenges we grapple with currently. Moreover, the original buy-in from faculty administrators across campus was instrumental in laying the groundwork for the course, so it will continue to be important that faculty and administrators across the university (as well as students, of course) recognize the value of the courses.

QL at other Institutions

QL programs are not new. Since the early 2000s, many colleges and universities have introduced quantitative literacy or reasoning requirements within their broader general education programs. These QL stipulations now permeate the collegiate landscape to the extent that it is rare for an institution not to have one. For instance, in 2013, the Western Association of Schools and Colleges—which includes universities such as UC Davis and San Jose State University—began requiring institutions to demonstrate direct measures of quantitative literacy assessment for accreditation. Moreover, as quantitative requirements have come

[2] See www.socrative.com for more information about this polling software.

under fire (especially at the community-college level) for impeding student progress toward graduation, there has been increased work not only to raise success rates and decrease time to degree, but also to design courses that foster quantitative literacy. For instance, community colleges in the North Carolina two-year system have rolled out a state-wide quantitative literacy course (Math 143) that students may use to satisfy their general education mathematics requirement and even transfer to four-year colleges (Todd and Wagaman 2015). Related, the Carnegie Foundation and the DANA Center of UT Austin have introduced Quantway/Statway and Mathways, respectively, for use at an increasing number of community colleges and four-year universities (Howington et al. 2015). The modular approach of these pathways is actually quite similar to that of Math 101 and 102 at MSU; however, within each of those frameworks, there is only one course students can take to earn college-level mathematics credit.

Table 1.
A Sampling of QL Programs across the United States

	Approximate Undergraduate Population Size	General Education Mathematics Requirement
Michigan State University	39,000	Four credit hours, such as calculus or college algebra
James Madison University	20,000	One course, such as its QL-specific class, college algebra, or statistics
Colby Sawyer College	1,200	Any mathematics course above its base-level quantitative literacy course
Boston University*	18,000	Two mathematics and or computer science courses
Central Washington University	11,000	A mathematics course and a reasoning course, both of which may be fulfilled by quantitative-literacy focused courses
Ohio State University	52,000	For BA students: two courses, one in mathematics or logic, and the other containing a data analysis component. For BS students: calculus 1.
UC Irvine*	28,000	Three quantitative intensive courses that may include those which only include mathematics as a tertiary skill (e.g. physics, chemistry)
UC Boulder	26,000	One course from an approved list that includes mathematics courses above college algebra, as well as courses in statistics, physics, and economics.
Iowa State University	30,000	One course that is quantitative in nature, which could include computer science or logic in philosophy
Duke University*	6,500	Two quantitative intensive courses, at least one of which hails from computer science, mathematics, or statistics
UNC Chapel-Hill*	18,300	One traditional mathematics course (e.g. precalculus, statistics) and one quantitative intensive course, such as advanced microeconomics

Note: A college is considered selective (*) if its undergraduate acceptance rate is at or above 50%.

From scouring our resources and connections, it appears that very few four-year institutions have a set of quantitative reasoning courses akin to the ones described here. The closest in nature appears to be Central Washington University. It is important to note here that a quantitative literacy course is not the same as what is commonly referred to as math for the liberal arts—a course that can masquerade as one which fosters numeracy without necessarily doing so (Ganter 2012). Courses like Math 101 and 102 appear to be more common at smaller institutions such as Colby-Sawyer College, as seen in Table 1; the largest one with a QL-specific course appears to be James Madison University. Note we chose the universities in Table 1 to encompass a wide variety of university sizes and QL programs.

From Table 1, the pattern among selective and larger institutions is to require one or more mathematics-related courses at or above the pre-calculus level. In creating the general education programs at such institutions, the faculty may have had the mistaken assumption that mathematical and quantitative literacy are the same (Steen 2001); indeed, calculus does not necessarily foster numeracy, so we believe more institutions should be aware of this fact. Another possible explanation is that institutional barriers—similar to those described earlier—are preventing interested parties from taking up the cause of QL. In either case, we believe that there is significant room for larger (and more selective) universities to improve their offerings of QL courses.

Conclusion

In this paper, we have presented the development of a large-scale QL course at MSU, from its beginnings in a multidisciplinary task force report to its current manifestation in the classroom. For parties reading that are keen on beginning a QL course program at their own institution, we have a number of suggestions. To begin, it is helpful if one can delineate the types of work that your QL team members do; the faculty at MSU who spearheaded the reform worked to defend the course and deal with policy changes, while the graduate team developed the content and reported back. Not having to juggle these tasks was key in freeing up time for the team to focus on course development. Additionally, one cannot overstate the importance of institutional support for large-scale innovation of this nature. The cost of this project was not insignificant. The design team had to be paid; pilot materials—and instructional time—had to be purchased. Beyond such things, the active engagement and support of administrative units such as the Department of Mathematics, the College of Natural Science, and the Office of the Provost were essential. Additionally, it was important to reach out to undergraduate academic advisors to help them learn more about the course so they could recommend it, when appropriate, to their students.

We are fortunate to have a group of faculty and students who are passionate about quantitative literacy, as well as the support of important administrative units. Without these ingredients it would be difficult to bring about such a major change in students' quantitative experiences, especially at a large institution. Our hope is that other institutions—especially large state schools—begin to take the same journey we have.

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