IMPLEMENTING A QUANTITATIVE LITERACY
CORE COMPETENCY REQUIREMENT IN THE COLLEGE OF ARTS AND SCIENCE
AT MIAMI UNIVERSITY

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Issues involved in a process of revising university learning requirements with the goal of enhancing students' Quantitative literacy (QL) are reviewed. QL is often characterized as a habit of mind that is demonstrated by breadth of application in different disciplinary contexts. QL includes statistical literacy along with number sense and an appreciation of models of functional relationships. The implementation of a QL core competency requirement is described, and the use of a faculty learning community to develop and promote QL is discussed as is the importance of securing central administrative support. Developing a constituency of early QL promoters and a review structure with broad background is critical. Ultimately, a well-articulated collection of QL learning outcomes with examples of each is needed to help win over the skeptical and reluctant.

CONTEXT AND INTRODUCTION

A group of faculty at Miami University from a variety of disciplines became interested in enhancing the quantitative literacy (QL) skills in our students. Miami University is a moderate sized public university with 16000 students who pursue degrees in 5 colleges or schools. While general education requirements and college-specific requirements existed, there were no explicit requirements for QL. As a result of these efforts, the largest division at the university, the College of Arts and Science (CAS) has embraced a QL competency requirement. In the sections below, the history of how QL discussions evolved at Miami is reviewed, the current situation is reported, and a few lessons learned are summarized.

WHAT DO WE MEAN BY QUANTITATIVE LITERACY (QL)?

The National Numeracy Network defines numeracy or quantitative literacy (QL) as "an aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work" (http://www.woodrow.org/nced/national_numeracy_network.html). Vacher and Wallace (2008) advocated the promotion of these skills across all disciplines and levels, and Madison and Steen (2008) provide a nice historical review of QL issues. From these ideas, we characterized QL as being comprised of understanding relationships, number sense, and/or evidence-based decision making/stat literacy.

Steen (2001) described the promotion of QL as a call for "more meaningful pedagogy across the entire curriculum" that differed from advocating simply more mathematics. This sentiment resonated with a number of colleagues at Miami, and this led to action.

A LITTLE ABOUT WHAT MIAMI UNIVERSITY REQUIRED

Miami University has a number of academic divisions all of which host majors. While these divisions may have specific requirements, all share general liberal education requirements contained in the Miami Plan for Liberal Education or Miami Plan. The plan emphasizes thinking critically, understanding context, engaging with other learners, reflecting and acting. Included in this plan is a set of foundation courses, a thematic sequence of courses and a senior capstone. The foundation course requirements are usually satisfied in the first two years of study and includes foundation courses in: English composition; fine arts, humanities, social science; cultures; natural science; and mathematics, formal reasoning, technology. The mathematics, formal reasoning, technology foundation requirement could be satisfied by courses that included: linguistics, introduction to computer concepts and programming, mathematics for teachers, finite mathematical models, calculus, formal logic and, last but not least, statistics.

It is clear that some of these courses will have a strong QL flavor; however, it is not true that all will. It is clear that this category is too broad. In addition, many students were satisfying

this requirement using Advanced Placement (AP) credit. It was clear to a number of faculty members believed this requirement did not address the goal of promoting "an aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work" (National Numeracy Network) nor did it capture the sense of QL as a "meaningful pedagogy across the curriculum" (Steen 2001).

HISTORY OF QL EFFORTS AT MIAMI.

The formal start of efforts to expand QL efforts occurred at a Dec. 2006 meeting of academic administrators where the provost reported the teaching and use of statistics across campus. A center for writing excellence was beginning at Miami, and the timing seemed right to propose an analogous center for quantitative literacy. With the support of the Dean of Arts & Science, a semester-long process meeting started to discuss the best mechanism for promoting QL. This effort involved staff from across campus (8 departments represented from 5 divisions, libraries and regional campuses). This group produced a proposal for a internally funded center for QL. While this was not funded, the QL discussion had momentum to continue. A meeting with the provost and director of liberal education emphasized the need to articulate what features of QL should be appreciated by a student by the time they graduate. In addition, a proof-of-concept course was suggested, and a plan to develop this further was requested.

A course on news and number was developed and delivered by a journalism professor and a statistician to address the first component, and a Faculty Learning Community (FLC) was formed to address the second. The FLC was populated by faculty from all divisions but included a set of individuals intrinsically interested in QL issues. The *formation of a cohort* of colleagues who are interested in promoting QL skills is a critical first step for promoting QL and for developing and implementing a QL requirement. The *support of deans and provosts*, both through budget to support the FLC meetings and through encouragement, was a second key step to promote and develop QL. While this was a faculty initiative, the success at an institutional level required central support.

The first year of this FLC (2008-2009) was an investigation into how QL was defined and how other institutions promoted QL. In addition, all participants explored enhancing QL in at least one course through a teaching project. This FLC was supported for a second year (2009-2010) in which the group was explicitly charged with developing a QL core competency requirement. The formal proposal to include a QL Core Competency requirement was approved in Fall 2010. The CAS Quantitative Literacy (QL) requirement was one course that *builds upon the Miami Plan V* requirement (Mathematics, Formal Reasoning, and Technology). Arguably, a QL course might be desired during every year of study; however, there were realities that needed to be incorporated. We thought that it was important to have a course beyond the foundation requirement, and this was affirmed.

One important aspect of implementing a broad requirement such as this is *helping faculty and instructors* see this effort promotes a critical skill, and they already may be in a position to address many QL learning outcomes in their class. A workshop was held in the summer of 2012 where the QL core requirement was presented, and then individuals or teams worked on developing a formal CAS QL proposal.

WHAT ARE WE DOING NOW?

The College of Arts & Science now has the QL as a divisional requirement. It is possible to propose a new course to satisfy this requirement or to revise an existing course. The key is that the course must have at least 3 student learning outcomes involve QL and that at least 1/3 of the student learning outcomes for the course are QL-related. The criteria that must be satisfied to be considered a QL class are (from CAS QL proposal form):

1. Include <u>at least 3</u> QL student learning outcomes (SLOs) from the following list of 6. These QL SLOs are based on Bloom's Taxonomy and each link to one or more of the Lumina Foundation's outcomes.

Group A (Knowledge & Comprehension)
- SLO 1: Identify the quantitative aspects of a problem or situation
- SLO 2: Interpret numerical displays and information

Group B (Application & Analysis)
- SLO 3: Apply quantitative methods to a different situation
- SLO 4: Analyze, compare and/or contrast components of numerical information

Group C (Synthesis & Evaluation)
- SLO 5: Communicate or create an idea with numeric information using multiple forms of representation (words, graphs, tables and other displays)
- SLO 6: Evaluate, assess, or critique different forms of numerical evidence

2. Include graded QL assignments and activities at multiple points, distributed over the course of the semester.

3. Include graded assignments requiring students to translate a QL skill to a practical application or to solve a problem.

The QL SLOs above are broad categories that can be tuned to fit the goals and content of a variety of courses in different subject and evaluated using a variety of assignments. As part of the proposal, an assessment plan is needed. This plan must address three tiers: 1) Faculty Perceptions; 2) Student Perceptions; and 3) SLO Assessment. Courses will be modified based on these assessments, and the assessment will be included in department program review.

Courses spanning the natural sciences, social sciences, humanities, mathematics and statistics are now approved as CAS-QL courses. *Former members of the QL faculty Learning Community members were leaders in generating proposals for this new requirement*. A list of the early entries in this group are given below:

ATH 496/596	Observing Primate Behavior
BMZ 116	Biological Concepts
CHM 111	Chemistry in Modern Society
CHM 375	Analytical Chemistry for Majors
ENG 222	The Rhetoric of Information and Data Visualization
GEO 205	Population and Migration
GEO 242	Mapping a Changing World
GLG 111	The Dynamic Earth
GLG 121	Environmental Geology
GLG 141	Geology of U.S. National Parks
HST 202	History and Numbers
IMS/JRN/STA 404/504	Mind and Medium
JRN 312	Public Affairs Reporting
MTH 435	Mathematical Modeling
MTH 453/553	Numerical Analysis
POL 306	Applied Research Methods
PSY 293	Research Design and Analysis I
PSY 294	Research Design and Analysis II
PSY 324	Advanced Social Psychology
SOC 262	Research Methods
STA/ISA 333	Nonparametric Statistics
STA 363	Regression & /Design of Experiments
STA 475	Data Practicum
ZOO 161	Human Physiology
POL 101	Politics and National Issues

LESSONS LEARNED? … CONCLUSION

In the description above, I tried to provide a sense of the effort and key ingredients needed for success when considering a the inclusion of a QL requirement. I describe case study of an institution where a QL requirement was developed and adopted. A broad coalition of faculty was the spark that started and maintained this process.

I close with a list of lessons learned and ingredients for success includes:

1. start with demonstration projects to provide "proof of concept" – the QL FLC teaching projects provided important evidence
2. make sure administrative support is secured early (not worth doing it if don't have support) – Provost at MU has underwritten ½ of the FLC and part of the recent workshop
3. identify partners (Writing Centers)
4. QL can't be owned by a department or it will never succeed – this process would have failed if it was perceived as simply another statistics or mathematics course requirement
5. you need to work to sell this – this includes working on curriculum committees, providing workshops, serving as a resources for colleagues, advocating for the effort in your department and beyond
6. need broad engagement across divisions to make big changes – we influenced the CAS requirements but we did not in changing the university requirements [yet!]
7. make sure that this is not yet another "out of your hide" activity. Participation in projects, learning communities need to be valued (e.g. each FLC participant received a $1000 professional expenses account)
8. be patient – It was years in the making but success was achieved.

Next up for QL will be the assessment feedback. The QL requirement is now in place for students who entered in the College in Fall of 2013. We hope this will be the first of many generations of students with stronger QL skills as a result of the college-wide efforts to promote this core competency.

REFERENCES

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Vacher, H. L., & Wallace, D. (2008). The Scope of Numeracy. *Numeracy, 1*(1), Article 1. http://services.bepress.com/numeracy/vol1/iss1/art1

APPENDIX A: FLC COMMITTTEE MEMBERS

QL FLC, the de facto subcommittee for drafting the QL core competency requirement:
    John Bailer (Statistics)
    Annie Blair (Journalism)
    Stacey Bretz (Chemistry and Biochemistry)
    Clyde Brown (Political Science)
    Richard Campbell (Journalism)
    Bia D'Ambrosio (Mathematics)
    Joe Johnson (Psychology)
    Jim Kiper (Computer Science & Software Engineering)
    Glenn Platt (Interactive Media Studies)
    Monica Schneider (Political Science)
    Hank Stevens (Botany)
    Heeyoung Tai (Chemistry and Biochemistry)
    Robin Thomas (Psychology)
    Rose Marie Ward (Kinesiology and Health)
    Jen-chien Yu (Library)

APPENDIX B: Sample Questions Requiring QL Skills to Answer

Examples taken (and slightly modified) from Appendix L of the CAS QL Core Course Requirement Proposal.

1. The stimulus package involves a huge monetary investment by the U.S. government. Can this be understood by an informed citizen? In a related question, how is this information effectively communicated?
2. What is the basis of claims that Social Security will become insolvent in a particular number of years? Does this involve a projection of future population growth? What is the basis of these projections?
3. Different energy producing technologies are available (e.g., coal-burning, nuclear, solar). What climate, economic or health outcomes do each offer? Can the lifecycle cost of producing energy via these technologies be summarized and used to select a particular technology?
4. Two reports are issued summarizing the same political rally. One report says more than one million people participated while the other claimed fewer than 250,000. Which, if either, is correctly capturing the number of participants?
5. Global warming is accepted by the vast majority of environmental scientists. What are the models that underlie this belief? Why do we use models? Could these models be wrong? What is the uncertainty intrinsic in these models?
6. A newspaper article has reported that caffeine is bad for your health. An experiment was reported in which heavy coffee drinkers have higher rates of anxiety. Do you need additional information before you would believe this claim?
7. Millions, billions and trillions are all big numbers but they correspond to very different amounts of debt at a national scale. Parts per million (ppm), billion (ppb), trillion (ppt) are all small concentrations; however if chemical A kills 50% of organisms exposed to it at a concentration of 10 ppm and chemical B kills 50% of organisms exposed to it at a concentration of 15 ppb, then which chemical is more toxic? [Chemical B is relatively more toxic since it has the same effect at a much lower concentration. This requires an understanding that 15 ppb < 10 ppm (10 ppm = 10000 ppb).]
8. Is it worth stretching now to buy a house with a 15-year loan instead of a 30-year loan? Is it worth spending $15K more for an electric car relative to a gasoline car? [You need to be able to calculate the expected cost of operation over the duration over which you own the cars.]
9. Your doctor says you have a 10% risk of heart disease at your current cholesterol level. You can reduce this risk by lowering your cholesterol level through diet change, exercise or by taking a statin drug. Will diet and exercise changes suffice? How would you decide? What did 10% risk mean?