Millikin University
Student Learning in Quantitative Reasoning

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Executive Summary: Quantitative Reasoning (QR) is a non-sequential requirement in the MPSL. All Millikin students are required to fulfill this by taking a designated QR course. A goal of this program is that through quality advising, students take a QR course that fits the needs of the student's academic area. Here we report a full year (**fall of 2017 and spring 2018**) of data collection and analysis for purposes of assessment. We can make decision on the success for QR courses this year due to a lack of data.

To enhance the reliability of the data and to reduce the number of faculty needing to report, the QR committee had determined that starting spring 2016, that the only mathematics classes that will be required to collect QR data will be MA109 and MA 110. All other former mathematics QR courses have one of these two as a prerequisite. The reporting responsibilities for all other QR course (i.e. courses outside of mathematics that satisfy QR) will remain the same.

Goals

A student who successfully completes a Millikin QR course will demonstrate the ability to:

(1) use deductive reasoning in a formal, symbolic, axiomatic system, and
(2) apply the theorems of the system to solve appropriate problems.

The learning goals of the quantitative reasoning requirement are part of broader aims of this requirement. Through this requirement Millikin hopes to:

(a) To offer the basic quantitative reasoning skills necessary for success in every profession. All work involves understanding the basics of numerical, statistical, or logical analysis. This type of thinking is fundamental to understanding the world and no career is exempt from this way of knowing.
(b) To prepare students to be competent citizens by developing the quantitative skills necessary to understand fundamental reasoning that involves numbers, statistics, or logical reasoning. Citizens must be able to understand e.g., graphs, detect faulty statistical analysis, or spot basic flaws in reasoning. These courses serve democracy by developing such skills.

Clearly these two goals support the first two university-wide goals:

> University Goal 1: Millikin students will prepare for professional success.
> University Goal 2: Millikin students will actively engage in the responsibilities of citizenship in their communities.

Each career has specific requirements in regard to deductive reasoning. A psychologist may work on a daily basis with statistical analysis on her experimental data, while a lawyer might need to spot an *ad hominem* fallacy in an oral argument. A manager will need to understand what the accountant means, while an artist might need to prepare a usable table to demonstrate the efficiency of their program in a grant request. All of these are examples of quantitative reasoning. The broad range of careers benefits from the range of courses offered that teach quantitative skills. Many humanities, arts, and pre-law students take logic. Business and nursing require math courses. Social scientists need statistics. Careful advising that includes career goals helps students select the quantitative course that best supports their individual aim, while all of these courses prepare students for success in their profession.

In addition to helping students flourish in their job, quantitative reasoning is basic to good citizenship. To be a fully functioning citizen in this country, you must be able to understanding the news and ask appropriate questions. Those tasks require quantitative reasoning. One cannot pick up a newspaper without finding statistics about the amount of oil produced in Iraq, the population growth, the rate of immigration, and so on. Unless you can understand the basics of these figures, charts, graphs, and the reasoning they are based on, you cannot sort out the bogus from the noteworthy. At its most basic, this requirement aims to produce students who can become these kind of citizens.

The learning goals are simple: learn to use deducting reasoning and be able to apply it appropriately. The larger goals are less concrete: to give students the quantitative skills they need to succeed as a citizen and on the job.

Snapshot

<u>Faculty</u>

The faculty who taught the QR courses for Fall 2017 and Spring 2018 are listed in Tables 1 and 2.

<u>Facilities</u>

None of the courses require facilities beyond classrooms. Most require technology rooms with computers and projectors.

Types and number of students served

All students are required to complete a QR course.

Number and types of courses taught

Select courses in Mathematics, Philosophy, Music Theory, Theater and Behavioral Sciences meet the QR requirement. The number and types of courses taught are detailed in Table 1. All of these courses were chosen because they fulfill the requirement of manipulation of symbols according to rigorous inference rules or algorithms.

Course Number	Title	Faculty
BI240	Analysis of Biological Data	Travis Wilcoxen
MA109	Finite Mathematics	Emily Olson, Paula Stickles
MA110	College Algebra	Joe Stickles
MT111	Music Theory I	Amy Catron, Georgia Hornbacker, Tina Nicholson
MT112	Music Theory II	Laurie Glencross
PS201	Statistical Methods in Behavioral Science	Linda Collinsworth

Table 1. Fall 2017 Courses meeting the QR requirement

Course Number	Title	Faculty
MA109	Finite Mathematics	Emily Olson, Paula Stickles
MA110	College Algebra	Daniel Miller
MT111	Music Theory I	Laurie Glencross
MT112	Music Theory II	Amy Catron, Georgia Hornbacker, Tina Nicholson
PH113	Introduction to Logic	Matthew Olsen
PS201	Statistical Methods in Behavioral Science	Linda Collinsworth

Table 2. Spring 2018 Courses meeting the QR requirement

Programs

The QR courses serve all programs of the university. Some programs have designated courses to meet the requirement. Majors in the Behavioral Sciences (Human Services, Sociology, Psychology) and Nursing meet the requirement with PS201/SO201. Majors in Philosophy meet the requirement with PH113. Tabor School of Business students exceed the requirement with MA130. Many Natural Science and Mathematics majors meet the requirement with either

MA110 or exceed with MA140, while Biology majors may meet the requirement with BI240. Students in the School of Music often meet the requirement with the MT111/112 sequence.

Partnerships

There are no external partnerships involving the Quantitative Reasoning requirement.

The Learning Story

Most of Millikin's programs of study have particular QR needs. The QR course provides the kinds of experiences in symbolic, deductive reasoning required for professional success in these areas. Examples of QR topics in action include statistics in nursing, business and the behavioral sciences, calculus in the natural and physical sciences, and logic in the humanities. In addition, students of the arts gain experiences in symbolic, deductive reasoning that will enhance their ability to grow as educated democratic citizens (e.g., financial mathematics, voting models, and resource analysis).

The particular nature of the experience varies from student to student according to their educational, professional, and personal goals. Not every student needs to learn calculus or statistics or symbolic logic. Nevertheless, every Millikin student will have an experience that challenges him or her to apply rigorous deductive reasoning. The QR requirement provides this experience in the context of the student's major field or in the context of the student's participation in a democratic society.

The QR requirement is seen in action when a biology student successfully applies the integral and differential calculus in modeling the growth of a population of field mice, when a business student successfully argues for the marketability of a new product based upon a sound statistical analysis of a survey, when a pre-law student successfully answers a LSAT question involving syllogisms, or when a musical theatre major successfully obtains a loan for a new car after knowledgably negotiating rates and terms.

Assessment Methods.

The QR goal is a meta-goal encompassing a wide variety of fields and techniques that falls under the broad heading of formal, symbolic axiomatic systems. Hence, the assessment method is equally wide and encompassing. The key to success is the content of the QR courses. Does the course provide the student with experiences in symbolic deductive reasoning?

One Program Review Processes

Syllabi review. Usually, a quick examination of the syllabus is sufficient. In 2017-2018 this was completed by departmental administrative assistants and results were reported directly to the departments and their academic deans.

One Assessment of Student Performance

Samples of final exams will be evaluated, rating how well students demonstrate the ability to use deductive reasoning in a formal, symbolic, axiomatic system, and to apply the theorems of the system to solve appropriate problems.

Assessment Data

The following data were collected by the QR coordinator.

1. Syllabi for all QR courses.
2. Sample problems were taken from final exams from traditional QR courses. Instructors of these courses were asked to identify one problem on their exam that could be used to assess the deductive reasoning learning goal and to identify one problem on their exam that could be used to assess the theorem application goal. The instructors then randomly selected five students' final exams and assessed each student's work according to the assessment rubric the Quantitative Reasoning Task Force developed (see appendix). The assessments are summarized in the tables below.

Fall 2017			
Course	**Good**	**Average**	**Poor**
BI240 01	2	2	1
MA109 01	3	1	1
MA109 02	4	1	0
MA109 03	3	1	1
MA110 01	4	1	0
MT111 01	N/A	N/A	N/A
MT111 02	N/A	N/A	N/A
MT111 03	N/A	N/A	N/A
MT111 04	N/A	N/A	N/A
PS201 01	N/A	N/A	N/A
Totals	16	6	3

Table 3. Deductive Reasoning Fall 2017

Spring 2018			
Course	**Good**	**Average**	**Poor**
MA109 01	3	1	1

MA109 02	5	0	0
MA109 03	5	0	0
MA110 01	1	3	1
MT111 01	3	2	0
PH113 01	1	3	1
PS201 01	N/A	N/A	N/A
Totals	18	9	3

Table 4. Deductive Reasoning Spring 2018

Fall 2017			
Course	**Good**	**Average**	**Poor**
BI240 01	3	2	0
MA109 01	4	0	1
MA109 02	4	1	0
MA109 03	4	1	0
MA110 01	3	1	1
MT112 01	N/A	N/A	N/A
PS201 01	N/A	N/A	N/A
Totals	18	5	2

Table 5. Theorem Application Fall 2017

Spring 2018			
Course	**Good**	**Average**	**Poor**
MA109 01	2	2	1
MA109 02	4	1	0
MA109 03	4	1	0
MA110 01	3	0	2
MT112 01	3	2	0
MT112 02	4	1	0
MT112 03	2	1	2
MT112 04	1	3	1
PH113 01	2	2	1
PS201 01	N/A	N/A	N/A
Totals	25	13	7

Table 6. Theorem Application Spring 2018

After piloting the QR rubric in spring 2007, we found that all instructors provided the necessary data without asking a single question about the selection process or about the rubric. This has continued since inception. Therefore, we conclude that the QR assessment instrument is easy to implement and will not make any changes to the procedure for 2018-19. We will continue to evaluate the data collection process as we move forward with the assessments in future years.

Analysis of Assessment Results

1. The review of the syllabi for all QR courses revealed that all of the QR syllabi that were given to the administrative assistants in 2017-18 explicitly stated the QR learning goals except for Music Theory and all of them included topics that directly reflected these goals.

2. The evaluation of random samples of completed final exams concluded the following status of student performance with respect to the QR student learning outcomes.

(1) use deductive reasoning in a formal, symbolic, axiomatic system.

62% of students were evaluated as “Good”, while only 11% were evaluated as “Poor”.

(2) apply the theorems of the system to solve appropriate problems.

61% of students were evaluated as “Good”, while only 13% were evaluated as “Poor”.

Improvement Plans

We are pleased that the data indicate that the QR goals are being met. Nevertheless, we see room for improvement in several areas.

(1) Dr. Emily Olson will take over as QR coordinator. As a result, we should have greater continuity in that role for the next several years.
(2) The QR coordinator will send the QR goals to each QR instructor for inclusion in syllabus each semester not just in the fall.
(3) The QR coordinator will send a “reminder” of reporting responsibilities to each QR instructor prior to finals week each semester.
(4) We will discuss setting benchmarks for percentages of students who are evaluated as “Good” and as “Poor”.

Appendix.

Rubric for Assessing Student Achievement of Quantitative Reasoning Learning Outcome Goals

	Good	Average	Poor
Deductive Reasoning	• Student uses proper symbolic notation in the context of the stated problem • Student manipulates these symbols according to the rules of the axiomatic system • Student achieves desired directive of the problem with no (or a few minor) errors	• Student work achieves exactly two of the following: 1. Student uses proper symbolic notation in the context of the stated problem 2. Student manipulates these symbols according to the rules of the axiomatic system 3. Student achieves desired directive of the problem with no (or a few minor) errors	• Student work achieves no more than one of the following: 1. Student uses proper symbolic notation in the context of the stated problem 2. Student manipulates these symbols according to the rules of the axiomatic system 3. Student achieves desired directive of the problem with no (or a few minor) errors
Theorem Application	• Student correctly selects theorem(s) necessary to solve stated problem • Student performs all necessary calculations needed to apply theorem with no (or a few minor) errors • Student uses selected theorem(s) to form a correct conclusion on the basis of the computations	• Student correctly selects theorem(s) necessary to solve stated problem • Student's work falls into one of the following two categories: 1. Student made major computational errors, but made a correct conclusion based on the computations 2. Student made no (or a few minor) errors in computations, but made an incorrect conclusion made on the computations	• Student work falls into one of the following two categories: 1. Student did not correctly select theorem(s) necessary to solve stated problem 2. Student did correctly select theorem(s) necessary to solve, but made major computational errors and made an incorrect conclusion based on the computations