

Williams-Wellesley-Amherst Workshop on Quantitative Skills October 4, 2003

Panelists: Ollie Beaver, Williams Math Department; David Cox, Amherst Math Department; Stewart Johnson, Williams Math Department; Jennifer Innes, Amherst Q Center; Corri Taylor, Wellesley QR Program; Moderators: Greg Call and Rick Griffiths

Consensus Points:

- Teaching students quantitative reasoning requires a full semester, at a minimum.
- A QR course should be a credit-bearing course, taught by regular faculty.
- Creating an effective course will require experimentation, but we should begin by designing a course aimed explicitly at improving under-prepared students' quantitative reasoning skills (rather than a First-Year Seminar, surreptitiously assigned to students in need of assistance).
- The QR diagnostic should be administered to all students during Orientation.

Areas requiring further discussion:

- What is the purpose of the program? Is promoting quantitative literacy an important goal of the institution? Should a QR program focus exclusively on those who are interested in quantitative courses? Should the purpose of the program be to allow all students, despite their preparation, to succeed in introductory level courses? Is there support for the more ambitious goal of opening all majors to all students?
- What department, if any, should have responsibility for teaching a QR course?
- Would the various needs of the College be better served by developing a single QR course (Wellesley's model) or by developing multiple QR streams for students with different needs and interests (Williams' model)?
- Would Amherst be better served by a centrally administered QR model or by allowing each department to invent its own diagnostic and course?
- Should we be concerned that such a program might promote "stereotype threat" (e.g., that it might cause students of color to under-perform, in response to a fear that their performance might inadvertently confirm a negative stereotype about their race)?

The Challenge, as described by David Cox:

1. Identifying the problem is complicated because students' skill deficits occur at different levels in different areas. Although students need stronger calculation skills, their greatest area of deficiency seems to be knowing how to approach a problem and reasoning how to convert the problem to a numerical solution.

2. Diagnosis is complicated by the need to differentiate between students who have skill deficits and those who have reasoning problems, and the diagnosis may be further complicated by visual and spatial reasoning deficits, as well as reading problems.
3. Informing students of the need for assistance while preserving their sense of self-esteem and self-respect requires special skill and sensitivity.
4. Changing the curriculum to reflect societal changes should be considered in addressing the problem.

Programs at Other Colleges

Wellesley Program

Wellesley assesses all students' quantitative skills during Orientation. The College sends students a booklet to help them prepare for the diagnostic exam during the summer. The exam itself is a blunt instrument, designed for identifying students with serious problems. It requires students to solve 18 problems requiring a variety of skills. Under some circumstances, a student may take the exam more than once. The QR director, an associate, and eight students grade each exam by hand.

Students who answer half or more than half of the questions incorrectly (approximately 6-10% each year) must enroll during their first year in the Quantitative Reasoning course, which meets three times weekly in the classroom and once a week in a lab setting. Wellesley offers the course in 4 sections, 3 in the fall and 1 in the spring, with a maximum of 15 students in each class. The two instructors, the QR Director (a former economics professor) and a Visiting Professor (math) use the course to teach students how to employ basic math, (including algebra, geometry, probability and statistics, orders of magnitude, linear and exponential growth, graph theory, estimation, and scientific notation) to solve problems in a variety of contexts (analyzing demographic, financial, educational, and scientific data). They place a priority on teaching students how to analyze problems. The purpose of the QR requirement is to prepare students during their first year for the many courses which require basic quantitative skills, and, in particular, to prepare students for the second quantitative requirement, the "Quantitative Reasoning Overlay Course." Overlay courses emphasize statistical analysis and interpretation of data within a specific discipline, generally in the context of a laboratory science class or statistics class. Wellesley currently offers these courses in the following disciplines: astronomy, biology, chemistry, geology, mathematics, philosophy, physics, psychology, statistics, and sociology. In addition, Wellesley students must take three courses in math or science, including one lab, to satisfy their distribution requirement.

Wellesley believes course enrollments have changed and confidence-levels have risen as a result of their QR program. The science and economics faculty think their students are better prepared, although they still experience a large attrition from their programs.

Williams Program

The Williams program began as a “beaker reader test” in 1984, designed to prevent entry into biology, chemistry, physics and math courses until students had mastered the quantitative skills necessary to succeed at quantitative course work. Economics associated itself with the program somewhat later. During the early years of the program, the QR exam was administered to all in-coming students. All students who didn't pass the diagnostic, and who expected to enroll in particular quantitative courses, were required to take the QR course. The course was initially taught by a Quantitative Methods FTE, who was not associated with any particular academic department.

In the program's current configuration, Williams has incorporated the diagnostic exam into its college requirements for all students. Students must take three graded courses in math and science to satisfy their divisional requirement, and they must first pass either the diagnostic (and interview) or the QR course before they are permitted to enroll in the science, math, or economics classes. During First Days, all entering students take an 18-20 question multiple-choice quantitative diagnostic exam which is scored that same day using a standard pc scanner. Before the day is over, the College notifies approximately 100 students, based on test results and/or SAT testing, that they will need to participate in a 5-15 minute screening interview with a faculty member in the program. Faculty interview about 25 students per day, asking them about their high school preparation and their academic interests. They then advise about half the students to take one of three courses: Those with the most serious preparation gaps are guided into very small classes (8 students/class) which focus on numerical skills (Math 100) and the remainder are placed in either a small (~10 students) pre-calculus course (Math 101) or a statistics course (Statistics 100 or 101), depending on the student's academic interests. The remaining students (often including some football players looking for an easy course) receive counseling on the science and math divisional requirements and information about available quantitative resources on campus. They are permitted to enroll immediately in quantitative courses.

Williams has not yet evaluated their program, but the feedback from science faculty suggests general satisfaction with the results.

Smith Program

Smith has no quantitative program. They employ a Quantitative Skills Counselor who teaches the two-semester QS 101 and 102 which is designed to teach the pre-calculus skills that under-prepared and returning students (especially Ada Comstock Scholars) may need. The course must be taken for both semesters for a student to receive credit. Because Smith has no distribution or divisional requirements, students may arrive on campus with extremely poor quantitative skills and never address the deficit.

Options for Amherst

A Quantitative Reasoning Program

Agreeing on the fundamental goal behind a QR program is essential to the discussion, but no agreement was reached during the workshop. Although some focused on the requirements of creating an educated citizenry (perhaps best achieved by changing the focus from trigonometry and calculus to analysis and statistics), more participants were inclined towards developing a QR program that would create access to Amherst classes. Even there, different goals emerged. For most of the workshop participants, the goal of a QR diagnostic and QR course should be, at the very least, to give students the preparation that would allow them to succeed in introductory level classes; others hoped it would give students choices, and others still, a context for those choices. Some would favor a program that could allow students to achieve their goals (e.g., the pre-requisites for medical school) and others would simply favor reducing the bimodality that complicates teaching. Some questioned whether a QR course would be sufficient to prepare students for upper-level courses. Most participants thought a QR class might offer sufficient preparation for the introductory level in a number of fields, but not for the more advanced topics that a student might encounter within the major. Whether the College should require any students to take a QR course after failing the diagnostic was not addressed.

A Diagnostic Test

Participants expressed support for developing a quantitative diagnostic exam which would be administered to all first-year Amherst students for placement purposes during Orientation, particularly an exam along the lines of Wellesley's exam, which focuses on reasoning skills that are generally applicable, rather than discipline-specific questions. The Wellesley experience suggests that SAT scores might provide an accurate indicator above a certain level (SAT M > 710, in their case), but below that level SAT scores seem to be less predictive. They found that the equity message derived from testing everyone, regardless of SAT scores, justified administering the exam to all students. Another advantage to that approach is that it prevents individual students who haven't taken the exam from trying to negotiate entry into classes in later years. A concern that students might avoid courses so as to avoid the exam would also be eliminated by a universally-administered exam.

The question was raised whether Amherst's option of allowing students to begin with a more challenging course and then drop to a lower level during the add-drop period, or perhaps later resort to the Freshman Drop in the most serious cases, might negate the need for a diagnostic. Several faculty members argued that it did not, and that placing students directly into the QR course, using a diagnostic exam, would be preferable to allowing students to over-extend themselves and then fail. An early placement in the QR course would guarantee that the least well-prepared students would benefit from the entire semester-length course, and would have the further advantage that students would view their placement in the course as one determined by a test rather than by an individual with a particular bias.

A Quantitative Reasoning Course

Workshop participants supported the idea of developing a flexible program like the one at Williams (i.e., offering multiple options, rather than just one class in quantitative reasoning), to address the diverse levels of preparation, skills, and interests of Amherst students. This model could include a basic course in quantitative reasoning (several strongly recommended that a context-rich algebra program be an integral part of this QR course). A sub-set of students with an inclination towards quantitative subjects and somewhat stronger reasoning skills might be placed directly in Math 5/6, and a different sub-set of students, interested in social science areas, might be counseled to begin with a statistics course. Some students might even benefit from taking both the QR course and a second course (either Math 5/6 or a statistics class). Some thought this would be preferable to changing Math 5/6 to meet the needs of particular students (such as those inclined towards a pre-med program).

Most participants agreed that, to be effective, the QR course would need to be a full-term, credit-bearing course. At Amherst, students tend not to take seriously courses that do not offer credit. Wellesley's experience also supported this conclusion. They offered the course as a half-credit course at one time (1997), but now offer it as a full credit course. In the spirit of experimentation, several questioned whether it might be possible to offer an intensive version of the course during Interterm. However, the staff at both Wellesley and Williams reported that their experiences with short courses were unsuccessful. Both the staff and the students found the experience too intense and quickly burned out. In their experience, students who have difficulty reasoning quantitatively do not progress through this kind of material in a linear fashion, and some must develop an arsenal of different study skills, which requires time. For those students, in particular, delaying the first chemistry class until second semester would allow them to make some critical adjustments, acclimating to college life and academic expectations before tackling more challenging material.

Many attendees supported the idea of a curricular solution, taught by regular faculty. Several alternative approaches, currently in use within existing courses, received support, but no one deemed them sufficient. For example, several professors have engaged in creative solutions on their own (e.g., Pat O'Hara's Phoenix Program and Beth Yarborough's 5-hour/week economics sub-group); while worthy, several pointed out that these solutions depend on the voluntary actions of individual professors and do not constitute a sufficient institutional response to a much greater challenge. Although a centralized solution could theoretically involve the Q-Center, several argued that placing a QR course in the Q-Center could risk changing the way the center functions. The Q-Center could supplement the curriculum with special modules on limited topics. However, most participants preferred introducing a new curricular model that would teach students how to think logically about quantitative problems.

Experimenting with a QR course as a First-Year Seminar also appealed to a few participants. Others, however, argued against this approach on several grounds: it would be difficult to ensure that the appropriate students were in the class; in quantitative areas, it was important to separate struggling students from better-prepared students who might

intimidate them; it would not address the problems soon enough; and the FYS should be reserved for teaching writing, another area that may not be a strength for many of these same students. Panelists from both Wellesley and Williams agreed with the need to separate students. They noted that the students who typically land in their QR courses tend to be extremely fragile. These students usually require a highly cooperative environment, with positive reinforcement for their accomplishments, a class where they can support each other while being brutally honest about their aversion to math.

The question of who should teach a quantitative reasoning course was not resolved. Both the Wellesley and Williams programs began by hiring special faculty to teach the QR courses; after some turnover and difficulties with searches, faculty holding Ph.D.'s in math and economics (and no special training in quantitative reasoning) now teach the courses at both schools, although, at Wellesley, the positions are contract-based (rather than tenure-based) and housed in the QR office.

Additional Special Summer Programs

Williams runs a 5-week pre-frosh summer science enrichment program for 16-24 students. In the past they have invited students who come from backgrounds that are under-represented in the sciences. Beginning next year (as a response to the Michigan affirmative action case), they will also invite students from first-generation college families to the program. Since the goal of the program is to sustain and promote success in the fields of calculus, chemistry and biology for under-represented student groups, most of those invited possess a strong academic background and include very few of the students who will be placed in either M100 or M101.

Wellesley's Davis Scholars (older returning students who often arrive with very weak skills) must take an algebra course before entering if their math skills are deemed seriously deficient. Wellesley offers the Pathways Program (a 3-4 week summer program before Orientation for first generation students) to prepare students for the critical thinking skills they will need at college.