QS Requirement Review Committee Report

April 27, 2011

The Ad-hoc Subcommittee of the Curriculum Committee to review the Quantitative Studies (QS) Requirement for students in Trinity College of Arts & Sciences (see Appendix A for a list of members) met regularly during the spring and fall semesters 2011. Our initial discussions focused on the review of the charge (see Appendix B), a history of Duke's QS requirement, an examination of how students currently satisfy the QS requirement, the quantitative curriculum requirements at some of our peer institutions and a discussion of existing definitions of quantitative literacy and their possible relevance to our discussion. Following the suggestion of Matt Serra, we developed a set of objectives (learning outcomes) to describe the competencies we feel all students should have acquired upon completion of the quantitative requirement at Duke. This suggestion was informed by the conclusion of the Standing A&S Assessment committee that, as currently stated, there are no clearly articulated student learning outcomes associated with the QS requirement and that it is necessary to have a clearly defined definition of what our general education requirement for QS means in terms of observable student learning outcomes. The suggestion was also motivated by the desire to clearly formulate what we believe a quantitatively literate Duke student should be able to do.

In *Mathematics and Democracy: the Case for Quantitative Literacy*, Lynn Steen states:

> Quantitatively literate citizens need to know more than formulas and equations. They need a predisposition to look at the world through mathematical eyes, to see the benefits (and risks) of thinking quantitatively about commonplace issues, and to approach complex problems with confidence in the value of careful reasoning. Quantitative literacy empowers people by giving them tools to think for themselves, to ask intelligent questions of experts, and to confront authority confidently. These are skills required to thrive in the modern world.

Our committee believes all students should graduate with the quantitative skills to be empowered citizens in the sense discussed by Steen and, to meet that goal, we recommend the following:

> Students, upon completion of the quantitative studies requirement, should be able to use mathematical modeling and/or problem solving to analyze quantitative problems from a wide array of authentic contexts and everyday life situations. In particular, when presented with a mathematical or quantitative problem, students should be able to:
>
> (1) explain how data analysis, mathematical modeling, or computer programming can be used to solve, or gain deeper insight, into the problem;
>
> (2) demonstrate skill with data analysis, mathematical modeling, or computer programming to solve, or gain deeper insight, into the problem;
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> (3) interpret quantitative evidence and draw appropriate inferences and conclusions from the analysis of the problem;

(4) identify and evaluate the assumptions used in the analysis and the limitations of any conclusions drawn; and,

(5) effectively present the results of their analysis. This includes a clear interpretation of the problem, a reasoned description of the methods used to analyze the problem, justification of any inferences drawn and a discussion of the implications and importance of the problem in its larger social, scientific, political, technical or cultural context.

Upon review of Duke courses that currently carry the QS Area of Knowledge, and of the various ways in which Duke students are currently satisfying the requirement, the committee was increasingly concerned that it was entirely possible for students to meet the current QS requirement without necessarily achieving the desired objectives described above. The committee was also concerned about problems created by offering subject specific statistics courses offered in various departments outside of the Department of Statistics, particularly with regard to overlap and level. In addition, it was also a concern that a significant number students currently meet the QS requirement without taking any courses in a mathematical sciences department (Mathematics, Statistics or Computer Science). We felt strongly that one of the goals of an area of knowledge requirement should be to give the students the experience of being exposed to the disciplinary perspective associated with that area of knowledge.

To ensure that students develop the necessary quantitative skills and dispositions as well as the ability to apply these skills to solve various academic and real world problems, we propose to modify the current two course area of knowledge Quantitative Studies (QS) requirement in the following way:

A course satisfying the Quantitative Studies (QS) area of knowledge requirement would be a course in any discipline whose primary focus is quantitative problem solving or modeling and in which the students, upon successful completion, will have met the five objectives listed above. To complete the new QS requirement, students would need to successfully complete two QS courses, one of which is in the Mathematics, Statistics, or Computer Science department at or above the level of math 25L, Statistics 101 or Computer Science 6.

The two-course requirement ensures that students gain exposure to the quantitative science disciplines by taking at least one QS designated course from the departments of Math, Statistics, or Computer Science. We believe that students will benefit from taking at least one QS course in a department whose primary teaching and research missions are quantitative methodologies. Such courses study quantitative methods for their own sake and independently of specific subject-matter. We believe that learning QS reasoning and skills in this way prepares students to engage in interdisciplinary quantitative reasoning, learning, and research. We recommend courses at the minimum level of Math 25L, Stat 101, or Computer Science 6 because these courses cover the minimum set of topics useful for applying QS methods in genuine problems.

The requirement purposefully does not force students to take higher level courses that might not fit with their interests or future studies. At the same time, it requires these students to take at least one other course that focuses on using quantitative reasoning, for example to solve problems in a field of particular interest to them.

In Appendix C, several alternatives to the proposal described above are discussed. Each of these was seriously considered by the committee. Although the recommendation proposed above was not the first choice of everyone on the committee, it was acceptable to all of us and was considered by all of us as an improvement on the current requirement. It is simply stated, clear and reflects the learning goals that we all supported.

We discussed in depth how students with varying mathematical background and interests would complete the requirement. For students in the natural sciences and economics, this requirement would be met in the course of completing departmental requirements. For students in the social sciences (other than economics) that require a quantitative methods course, we imagine many would take Stat 101 followed by the research methods course, provided that those courses met the criteria for a QS course. This would have several advantages among which would be to allow the methods teachers to build on the students' knowledge gained in the statistics course so to allow for more depth and focus in the quantitative research methods of the discipline. We imagine that students with weaker math backgrounds would take Stat 10 followed by Stat 101. We are confident that this requirement is achievable by all Duke students, and evidence provided by the Office of Assessment supports this conclusion.

We would hope that departments, in the Mathematical Sciences as well as other Science, Social Science, and Humanities departments would see this modification of the QS requirement as an opportunity to create new classes that would allow students to meet this requirement and that would enrich the curriculum and the learning of students at Duke. We feel that this proposal creates a requirement that more closely reflects our goals for student learning than the present requirement does, is clearly and simply stated, will allow for meaningful assessment and, although demanding for some, will be achievable by all students.

If these changes to the QS requirement are approved by the A&S Council, then all current QS courses would have to be reviewed by the Course Committee to determine whether they meet the new criteria. We realize that initial implementation of the proposal may be a burden on the course committee. We suggest, if the proposal is adopted, that during the first two years of the implementation that a special subcommittee of the course committee be formed to help expedite the approval process for QS courses. In addition, if the new requirement will go into effect for the class entering in fall 2013, then students matriculating before then would be subject to the old requirements and, for four years, there would be some students subject to the old requirement and some to the new one. This would require that the bulletin clearly differentiate "old" QS courses from courses that meet the new criteria. This might necessitate that we rename the new requirement something like QR or that we label the old QS courses in some way.

Appendix A

Ad-hoc Subcommittee of the Curriculum Committee to review the QS Requirement

Bookman, Jack (Chair)	Mathematics
Cooke, Ben	Academic Resource Center
Danesh, Kaveh	Duke Student Government
Darity, Jr., Sandy	Public Policy Studies
de Marchi, Scott	Political Science
Nelson, Diane	Cultural Anthropology
Reiter, Jerry	Statistics
Rodger, Susan	Computer Science
Tufts, Clare	Romance Studies
Serra, Matt	Office of Assessment, *ex officio*
Walther, Ingeborg	Trinity Dean's Office and Office of Curriculum and Course Development , *ex officio*
Williams, Harrison	Staff Assistant

Appendix B

Charge For The Ad Hoc Sub-Committee of the Curriculum Committee to

Review the QS General Education Requirement

The curriculum of Trinity College is innovative and empowering, but it also must remain responsive to the needs of our students and the changing world. In an effort to assure that our learning objects are aligned with the competencies students need to be to successful global citizens in the 21st century, the College is reviewing the Quantitative Studies (QS) curriculum requirement.

To satisfy the requirements of the Trinity College curriculum, Duke students must complete two courses designated as Quantitative Studies. These courses provide opportunities for students to learn quantitative methods "to achieve proficiency in math, statistics, or computer science, or opportunities to engage in the application of explicitly quantitative methods." There are multiple pathways Trinity College students take to complete the Quantitative Studies requirement. Each path may not consistently provide the exposure to quantitative methods that enable students to learn the desired competencies. There are three questions that frame the charge of this review.

In the 21st century, all students should be literate in quantitative methods and analysis, but what constitutes quantitative literacy at Duke?

Should all students be held responsible for learning the same or a very similar set of quantitative competencies?

Like other Areas of Knowledge requirements, should students be offered multiple means and opportunities to satisfy the requirement?

Reviewers should begin by evaluating the current QS requirement, including what value this requirement offers students in the 21st century. Reviewers should also document how we currently assess student learning tethered to this requirement. Based on that initial review, the charge for the committee is as follows: The QS Review Committee will complete four central tasks:

1. Establish a definition of quantitative literacy that could be articulated within our undergraduate curriculum to enable students to achieve specific learning objectives and associated outcomes.

2. Determine if the current QS requirement is enabling the students to achieve the designated student learning objectives.

3. If reviewers find that students are not achieving a level of quantitative literacy designated in the newly established definition, then propose an alternative to the current QS requirement.

4. Develop a potential method or methods for standardizing the assessment of learning outcomes derived from the Quantitative Studies requirement.

Although this is a review for the extant curriculum, reviewers should be mindful that their work will lay the foundation for the quantitative requirement that will inevitably be part of a more comprehensive review of the entire curriculum in the future. Reviewers should be thorough and deliberate. A preliminary report should be submitted by the end of spring semester 2010, with a full report due at the end of fall semester 2010.

Appendix C

Alternatives to the Current Proposal

1. The following proposal was seriously considered but rejected:

To complete the QR requirement, a student must complete <u>one</u> of the following two paths:

Successfully complete one course in any discipline that satisfies the QS criteria with the stipulation that this course has a prerequisite of calculus at or above the level of Math 26L, statistics at or above the level of Statistics 101, or programming at or above the level of Computer Science 6.

OR

Successfully complete two QS-designated courses without prerequisites, one of which is in the Mathematics, Statistics, or Computer Science department at or above the level of math 25L, Statistics 101 or Computer Science 6.

This has the advantage of providing an expedited path (analogous to the path for advanced students in foreign language) for students with advanced placement in mathematics but was opposed by the majority of the committee because it added an unnecessary level of complexity to the requirement, option 1 was not an option many students would take, and option 1 was not consistent with the larger learning goals of the requirement. We also considered a variation of this requirement where the second path would require students to take three QS courses, but this was rule out because other areas of knowledge had only a two course requirement.

2. We had a lot of discussion comparing the current foreign language requirement and a possible new QS requirement. One suggestion we considered was requiring that students take a three course sequence of courses in one of the mathematical sciences where the second had the first as a prerequisite and the third had a second as a prerequisite. This was attractive because it seemed analogous to the FL requirement and would more likely produce students with demonstrable quantitative skills and competency than a weaker requirement. However, this requirement would likely create massive academic support problems and might not be achievable by all Duke students.

3. Late in our deliberations the following proposal came to our committee from Dalene Stangl, the DUS in Statistics.

“Statistics is a science that develops methodology useful in quantitative research for all disciplines. As such the Guidelines for Assessment and Instruction in Statistics Education (GAISE) guidelines emphasize that introductory statistics is best taught in a way that students can understand basic concepts and generalize and use methods across disciplines. To promote

this thinking, we propose to revamp the structure of undergraduate statistics at Duke.Currently six sections of statistics are taught from within the department each semester, and there are courses taught by psychology, sociology, evolutionary anthropology, and political science. Across these many courses, mathematical prerequisites and conceptual rigor differs dramatically. Student course selection falls primarily by major and mathematical rigor. This current organization of statistics courses causes difficulty for many reasons that have been discussed in depth in the DASS Task Force report and the current QS review.

“As an alternative, we propose that all students be required to take one of four statistics courses during their first year at Duke. The course would follow the GAISE guidelines for undergraduate statistics education. Placement would use the courses from student transcripts upon which admission to Duke was based. Courses would have two hours of lecture and two hours of lab covering interdisciplinary applied data analysis. Any department may contribute data and labs relevant to their discipline, but courses would NOT be taught specific to a major. Students would be expected to understand statistics conceptually and be able to apply these concepts to data from any discipline. Students would be expected to complete at least one data analysis assignment using data from each of the areas of knowledge and from each of the “school fields” listed in the table below. Students would complete a more complete set of analyses in any three areas of their own choosing.

“We propose 4 tracks based solely on the rigor of a student’s mathematical background. Track A would meet the needs of students who are not mathematically inclined, having avoided AP calculus and/or AP statistics. These students would likely score below 80% on our current placement exam which covers math through basic and intermediate algebra. Track B is for students who may not excel at math, but have a basic understanding of algebra and have taken one semester of high school calculus. It would also catch students who took AP statistics rather than calculus. Track C would be for students who have credit for two semesters of calculus, but who are not ready for a rigorous mathematical statistics course. Track D would be for students who have AP credit for Math 31 and 32, are mathematically savvy, and are likely to go on for graduate or professional degrees in disciplines that rely heavily on quantitative research.”

This proposal was attractive to several members of the committee because it would provide a (somewhat) common experience for all Duke students and would meet our quantitative literacy goals. However there were two main objections: (1) that it preferenced statistics over mathematics and computer science and (2) that there would be large implementation costs. There was some discussion of including a significant computer programming aspect to each of these course, but the consensus was that this idea would take some time to develop and should revisited at some future date.