Report on Quantitative reasoning Assessment

Fall 2015

The Core Competencies Team (CCT) was formed in order to meet the WASC requirement that we assess the core competencies (Written Communication, Oral Communication, Critical Thinking, Quantitative Reasoning, Information Literacy) of senior students at the institutional-level. The CCT Fall 2015 members are Sharon Hamill, Yvonne Meulemans, Joanne Pedersen, David Barsky, Jessica Mayock, Terri Metzger, and Melissa Simnitt.

The assessments are discipline-neutral and focus on University-level student learning outcomes rather than program or college-level interests. The Quantitative Reasoning Assessment Project was designed to capture students’ levels of quantitative reasoning competency at the culmination of their undergraduate education. Because our campus does not have exit exams or a formal all-campus quantitative reasoning requirement, we relied on volunteer faculty participants to collect data from our sample. It is important to note that assessment efforts, like this one, are not considered research on the process of learning, rather they are intended to measure to what degree a learning outcome is met. Methodologies, sampling approaches and data analysis are determined in the context of campus culture and available resources for the assessment project.

The assessment of quantitative reasoning took place during the Fall 2015 semester. One Mathematics faculty member (David Barsky) scored 86 student diagnostic assessments.

# **Assessment project**

Instrument: The CCT began by reviewing the University Learning Outcomes, which were developed by the University Assessment Council and endorsed by the Academic Senate at its December 2014 meeting. The single statement that refers to quantitative reasoning reads:

Students [graduating with a Bachelor’s degree from CSU San Marcos] will be able to … Analyze complex problems and develop solutions by applying quantitative and qualitative reasoning, integrating knowledge and skills from a variety of disciplines

There was greater specificity in earlier drafts of the ULOs, which, in addition to placing quantitative reasoning in the context of “problem solving,” also referred to it as a method for analyzing and solving real world problems and for appropriately conveying quantitative information to others. The CCT referred to this earlier statement as it planned the assessment because it provided more guidance as to what quantitative reasoning skills should be assessed. The CCT decided that the assessment should not be focused on mastery of abstract *mathematical* formalism, and instead should attempt to measure the ability of students to demonstrate quantitative understanding and reasoning in context.

The CCT reviewed various external (to CSUSM) quantitative reasoning rubrics (VALUE rubric, Quantitative Literacy Assessment [QLAR] rubric, and others) and quantitative reasoning standards (National Council of Teachers of Mathematics [NCTM], Mathematical Association of America [MAA], and Intersegmental Committee of the Academic Senates of the CCC, CSU and UC [ICAS]).

After much consideration, the CCT decided that instead of using an embedded assignment strategy, a short Quantitative Reasoning quiz would be developed and administered in randomly chosen courses. A major factor was the concern that there might not be suitable assignments in many courses. The CCT decided to set the quiz at the Entry Level Mathematics level (i.e., the proficiency level that “native” students are expected to have demonstrated either prior to entry or by the end of the first year, and which transfer students are supposed to meet before taking the Mathematics/Quantitative Reasoning course that is required in order to transfer to CSUSM). David Barsky was assigned the responsibility of developing the quiz. Based on his experience working with incoming first-year students in the Early Start summer program and its predecessor, he drafted eighteen problems that were circulated first to Mathematics faculty and then to other members of the CCT for comments. After a successive refinements and revisions, he recruited several first-year students who had passed the CSU ELM exam at the end of the summer, and timed them as they worked the problems. The quiz was winnowed to nine problems in the following areas:

Numbers and Data:

* Carrying out basic arithmetic calculations (two questions)
* Comparing and ordering decimals (one question)
* Representing and understanding data presented in pie charts (one question)
* Interpreting and calculating the arithmetic mean (one question)

Algebra

* Solving a problem in context that is modeled by a pair of linear equations in two unknowns (one question)
* Finding slopes of lines (one question)

Geometry

* Finding areas of geometric figures (including rectangles and combinations of these figures) (one question)
* Using properties of congruent figures (one question)

The CCT also discussed what other data should be collected with the quizzes. Recognizing that many students might never take a course with significant focus on quantitative reasoning after the lower-division General Education Mathematics/Quantitative Reasoning course, there was some interest in studying whether there was a connection between student performance on the quiz and what courses that student would have taken. As a first step to investigate this, the quizzes asked students: “Did your complete your lower-division General Education Mathematics/Quantitative Reasoning (“B4”) course at CSUSM?” (Students were asked to circle Yes or No.)

As this was the first campus effort to measure the quantitative reasoning skills of seniors and the committee was not certain what to expect, the CCT decided to set the proficiency level at a level comparable to what the University expects of students upon entry.

Faculty Participants: The CCT used a random sampling process to identify courses across the four colleges for the assessment. Additionally, random sampling was used to identify GE courses to include in the assessment. The UAC was provided 10 courses per college from which to draw a random sample of majors; an additional 10 GE courses per GE area (BB, CC, DD) were identified. The UAC moved through the list, contacting faculty for those courses to ask for their participation. Ultimately, three faculty (two in COBA and one in COEHHS) were willing to administer the assessment during 20 minutes of class time. No GE courses were included in the assessment as no faculty were willing to participate.

Process: Three versions of the Quantitative Reasoning Assessment were prepared, with different orderings of the problems to try to minimize effects due to problem placement (e.g., students not having enough time for the last problem) but in two of the three class sections, only version 1 was administered so 70 seniors took version 1 (attached to this report), 12 seniors took version 2, and only 4 seniors took version 3.

After the Quantitative Reasoning Assessments were administered, they were given to David Barsky. The original plan had been for him to recruit and train several graduate students to score the quizzes, but the total number of quizzes taken by seniors was small enough (86 seniors) that it was more efficient for him to score the papers directly.

Each quiz taken by a senior was assigned a coding number (1 through 86). To ensure uniformity in the evaluations, the quizzes were scored one problem at a time (so, the similar triangle problem on every quiz, then the signed arithmetic, etc.) with scores not being recorded until every solution to that problem had been evaluated. A problem-specific rubric (attached), and for each question a record was made that

* The answer exceeded the standard for proficiency;
* The answer met (but did not exceed) the standard for proficiency;
* The answer approached (but did not meet) the standard for proficiency;
* The answer indicated an emerging proficiency;
* The answer contained a student response that did not indicate an emerging proficiency;
* The question was not answered; or
* The student wrote that s/he did not have enough time to attempt an answer.

Generally, students met the standard with a correct answer without any irrelevant or incorrect work. In some problems, students could exceed the standard by showing correct supporting calculations. More detailed information can be found in the attached rubric.

A spreadsheet was created the recorded the code number assigned to each quiz (1-86), the quiz version (1,2 or 3), whether the student identified her/himself as a senior (Y; since this was double-check that only the quizzes taken by seniors were being included), whether the student claimed to have satisfied the lower-division General Education requirement in Mathematics/Quantitative Reasoning at CSU San Marcos (Y or N), and the proficiency level for each question (coded Exceeds, Meets, Approaches, Emerging, Attempted, Not Attempted, or No Time), and a tally of how many questions on the quiz were answered at either the exceeding or meeting level. The determination of whether a quiz indicated overall QR proficiency on the part of the senior was based on the number of exceeding/meeting answers and was not influenced by how the other answers were distributed among the other five possible scores.

The CCT had requested that the proficiency level be pegged to the level of proficiency expected of students taking the Entry-Level Mathematics exam. Based on an analysis of the raw scores needed to pass several versions of the ELM exam, David Barsky estimated that students who performed at the exceeding/meeting level on

* 5 or more of the 9 questions were demonstrating proficiency at this level (for first-year students, this would mean being ready to take a lower-division General Education Mathematics/Quantitative Reasoning course);
* 4 of the 9 questions were approaching proficiency at this level (for first-year students, this would mean needing to take a course at the level of intermediate algebra);
* 3 of the 9 questions were showing emerging proficiency at this level (for first-year students, this would mean needing to take a beginning algebra course); and
* 2 or fewer of the 9 questions were not proficiency at this level (for first-year students, this would mean needing to take a pre-algebra course).

# **The results**

The top line findings are the following:

* 57 of the 86 students (66%) demonstrated ELM-level proficiency in Quantitative Reasoning;
* 14 of the 47 students (16%) were approaching ELM-level proficiency in Quantitative Reasoning;
* 7 of the 47 students (8%) had an emerging proficiency in Quantitative Reasoning; and
* 8 of the 47 students (9%) had minimal proficiency in Quantitative Reasoning

A problem-by-problem analysis was also performed.

* The seniors demonstrated the greatest proficiency in dealing with the five Numbers and Data questions:
  + Over 90% met proficiency in the problem on ordering decimals (the rubric did not allow for exceeding proficiency on this item)
  + Over 80% met proficiency in the problem on signed arithmetic (the rubric did not allow for exceeding proficiency on this item)
  + Over three-quarters met proficiency in the problem on multiplication by powers of 10 (the rubric did not allow for exceeding proficiency on this item)
  + Over 70% met or exceeded proficiency in the problem on interpreting a pie chart.
  + Almost two-thirds met or exceeded proficiency in the problem on finding the missing value to obtain a given mean. [Note: This was the most ‘algebraic’ of the Numbers and Data problems.]
* The seniors demonstrated less proficiency in dealing with the two Geometry questions:
  + Almost half met or exceeded proficiency in the problems on similar triangles and on areas of piecewise rectangular figures.
* The seniors demonstrated the least proficiency in dealing with the two Algebra questions:
  + Almost half met or exceeded proficiency in the problem on solving a linear equation arising in a word problem. [Note: This was the last problem on version 1 and 8 students taking that version did not attempt it, so this finding might be influenced by a placement bias.]
  + Only one-third met or exceeded proficiency in the problem on estimating slopes of lines.

# **Recommendations**

We offer the following recommendations to the University Assessment Council regarding the Report on Assessment of Quantitative Reasoning

Disseminating the results of this assessment begins the process of taking action and moving beyond circulating the reports. We urge the UAC to disseminate the results widely to the following individuals and units across campus:

* Dean of Undergraduate Studies
* The Associate Deans of the Colleges (to share report at meeting with their Deans/and Department Chairs)
* Faculty Center Director
* Faculty Center Teaching and Learning Fellows
* Executive Committee of the Academic Senate for discussion
* Academic Senate as an information item
* Institutional Analysis and Research (this data can be linked to existing data on quantitative reasoning)

Additional recommendations include:

* Faculty (TT and lecturer faculty) and administrators can discuss the assessment results. Possible discussion prompts include:
  + What do you do in your own program to support quantitative reasoning?
  + Where is quantitative reasoning curriculum integrated into the students’ educational experience?
  + Are we OK with only 66% of our graduating students achieving the minimum standard in Quantitative reasoning across all criteria? Do we see this as an area we need to address?
  + Do we see a significant difference between those completing their B4 requirement at CSUSM versus another institution?
* Create a faculty learning community on quantitative reasoning to explore ways to infuse quantitative reasoning (especially geometric and algebraic skills) into varied disciplines.

Attached: Version 1 of Quantitative Reasoning Assessment

Quantitative Reasoning rubric