Assessment of Quantitative Reasoning at the University of Arizona

Fall 2023

Overview

The assessment of Quantitative Reasoning (QR) at the University of Arizona (UArizona) is the second of four ABOR-requested assessments of our general education program. The objective of this rubric-based assessment was twofold: 1. to measure student achievement of QR, and 2. to identify areas for improvement in student learning to strengthen our general education program in the area of quantitative reasoning.

The UArizona faculty defined Quantitative Reasoning in the following way:

> *QR is the ability to draw logical conclusions from available quantitative information about a problem under study. It entails competence in critiquing, reflecting upon, and applying quantitative information (e.g. using numerical, graphical, tabular or symbolic representations) in the contexts of personal, professional and public life.*

Achievement of this outcome is best measured through institutional coursework that prioritizes quantitative reasoning without fixating solely on computation (e.g., revised General Education courses with the QR attribute). The UArizona sample included 519 artifacts from 7 different general education courses with the QR attribute.

Who Participated in Scoring Student Work?

- Over 30 faculty, staff, and doctoral students participated at different stages of the assessment.
- 18 of these participants were trained as evaluators to score students' work. They represented many of the colleges and disciplinary areas across campus.

What Student Samples Were Assessed?

- Student work was collected from 7 different lower-division, general education courses with the QR attribute whose signature assignment met our rubric criteria for QR. These courses ranged from Economics to Latin American Studies to Fashion Industry Science and Technology.
- From a collection of over 1000 artifacts, 519 were selected for evaluation to be sure that we had a representative sample across classes.

How Was the Rubric Created?

A collective of our faculty worked to create a modified VALUE rubric for Quantitative Reasoning (see introduction to tri-university report). The UArizona version of the rubric (Appendix A) is tailored for the students that attend our institution, and it aligns with the tri-university QR rubric themes and ABOR policy 2-210 (Appendix B).

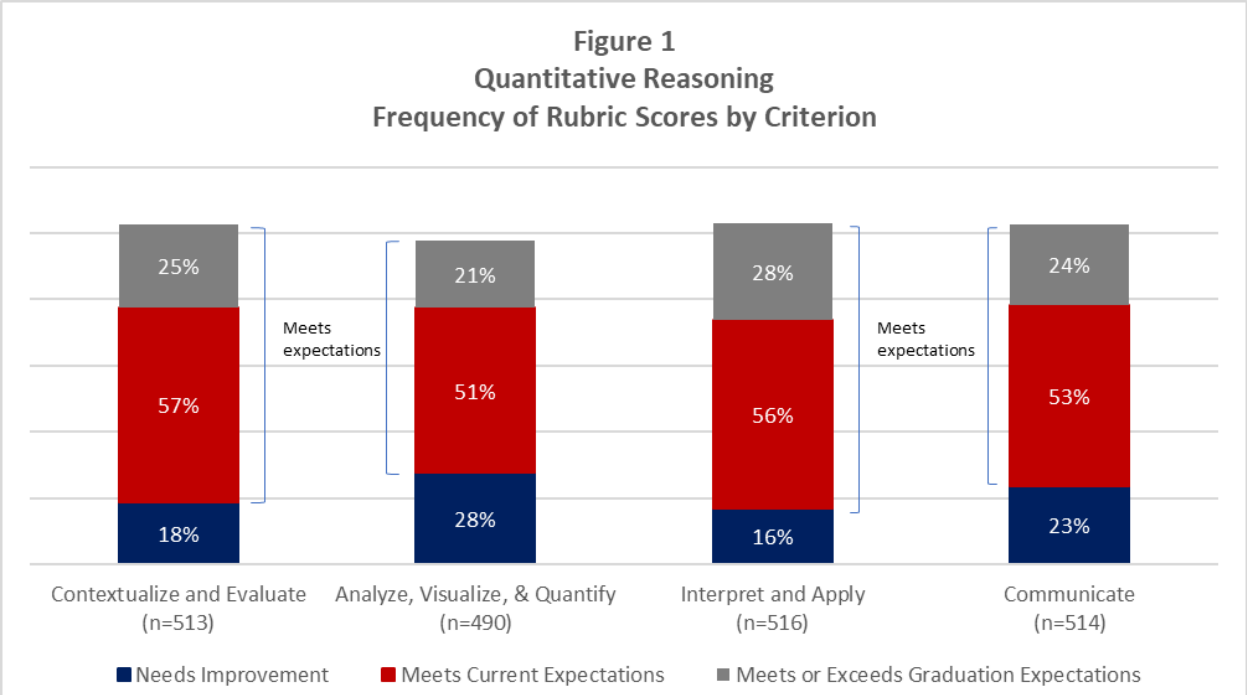
How was Student Work Assessed?

- To ensure reliability, all reviewers were calibrated on the rubric prior to the scoring process. Each artifact was evaluated twice, with a third reading taking place if the first two scores showed a difference greater than 1.
- When reviewing the artifacts, if evidence of a particular criterion was not present, the scorer could mark n/a. In these cases, the artifact was not included in the average score for that criterion, explaining why the *n* for each criterion is different.

What Did We Learn?

The UArizona rubric differs slightly from ASU and NAU. We all have three levels of accomplishment, but we combined "meets" and "exceeds" expectations into the highest level of achievement during our scoring. We also identified a tier of students who, while meeting the expectations for QR at this time, might provide areas of opportunity for improvement in teaching and learning. We did this in the hope that it would better reflect the levels of student learning to enable faculty to understand what can be improved with respect to teaching QR.

Figure 1 shows the frequency of student scores for each of the rubric criteria. The Analyze, Visualize & Quantify criterion was the area with the highest n/a scores suggesting that this may be a future area to emphasize with faculty when they are creating signature assignments. It is clearly evident by these data that the majority of the students are meeting current or graduation expectations. These findings are aligned with other similar, rubric-based QR assessments done by other institutions. (Texas A&M, 2022; University of North Dakota, 2015; University Kentucky, 2012)



When we disaggregated the data by student demographics, there were no unexpected differences in scores when sorted by gender, however some ethnicities trended lower than others. First generation students also scored slightly lower in 3 of the 4 criteria.

Because our general education curriculum is fairly new and these samples were collected during the first year of implementation, we consider these findings to be a baseline for future assessments. Some initiatives that we should consider moving forward include:

- Offering workshops on writing effective signature assignments in quantitative reasoning, especially emphasizing analyzing, visualizing, and quantifying data.
- Developing Faculty Learning Communities based on best practices in teaching quantitative reasoning.
- Launching a “quantitative reasoning across the curriculum” initiative with faculty leadership, similar to the successful writing across the curriculum (WAC) initiative.

Appendix A: UArizona's Quantitative Rubric and Description

Quantitative Reasoning Attribute Description

Students will demonstrate competency in working with quantitative information by critically analyzing quantitative information, generating ideas that are supported by quantitative evidence, assessing the relevance of data and its associated implications in a variety of contexts, and communicating those ideas and/or associated interpretations using various formats (graphs, data tables, equations, oral presentations, or written reflections).

Four distinct steps alluded to in the description, each associating with one rubric competency:

- assessing the relevance of data and its associated implications in a variety of contexts
  - → **Contextualize and Evaluate**
- Working with quantitative information of various formats (e.g. graphs, data tables, equations)
  - → **Analyze, Visualize, and Quantify**
- critically analyzing quantitative information and generating ideas that are supported by quantitative evidence
  - → **Interpret and Apply**
- communicating those ideas and/or associated interpretations using various formats (oral presentations and/or written reflections)
  - → **Communicate**

Rubric Design and Format Guidelines

- The rubric should be designed with readers/scorers from various backgrounds in mind.
  - The rubric should be designed to minimize scorer bias and maximize equitable scoring of student work.
- The rubric should apply findings of relevant scholarship related to the learning and assessment of quantitative reasoning.
  - The rubric should reflect that quantitative reasoning learning and assessment is informed by research and practice across the curriculum.
- The rubric should be able to be used (with/without) seeing the assignment sheet.
  - Scorers should prioritize what the author is communicating as opposed to their ability to follow specific assignment requirements.
- The rubric should be able to be used for varied assessment types utilizing varied means of communication (e.g. multimodal, multimedia, etc.).
- Proficiency categories:
  - Category names should reflect learning as an ongoing process.
  - Descriptors should be offered for each proficiency level.
- Quantitative Reasoning Competency categories:
  - Category names should communicate that competencies when taken together represent an inquiry process.
  - Categories held to four to better reflect milestones in an inquiry process and improve reliability in scoring and training of scorers/readers.

Rubric Language Guidelines

- Rubric language should apply findings of relevant scholarship related to the learning and assessment of quantitative reasoning.
    - Language should be selected to account for the cross-disciplinarity of related scholarship and the subsequent need to use the most generalizeable terms.
- Rubric language should be measurable.
    - Definitions should be included in the rubric itself or include a glossary.
    - Language should be intentionally selected and not rely on scorers to parse out hyper-specificity in word choice.
- Rubric language should prioritize an asset- or strengths-based approach with descriptors that indicate what is present (not absent) in student work.
- Rubric language should account for diversities in student language and communication style.
    - Rubric language should prioritize the ideas communicated, rather than their means of communication. This acknowledges the existence of particular formalized conventions but allows for the implementation of diverse languages, tones, styles, organization, and representations found in different disciplines and types of student work and among different student populations as well as recognizes students' development in learning and communication skills across contexts to achieve various purposes.

Quantitative Reasoning Rubric*–University of Arizona

Competencies	Meets or Exceeds Graduation Expectations	Meets Current Level Expectations	Needs Improvement
Contextualize and Evaluate	Artifact extensively demonstrates why quantitative information is useful or needed in a given context. Artifact thoroughly demonstrates relevant assumptions, appraises the ethics of a study and/or methodologies used, evaluates the appropriateness of the approaches used, and assesses the potential relevance of the resulting quantitative information.	Artifact demonstrates the need for quantitative information, and evidence of contextual awareness is inconsistent. Artifact defines an assumption broadly and minimally demonstrates specific assumptions of a given context. Artifact describes methodologies used and minimally demonstrates how to evaluate their appropriateness. Artifact outlines the general relevance of a given quantitative approach and minimally links to the given context.	Artifact minimally demonstrates the need for quantitative information or its usefulness in a given context. Artifact minimally defines what an assumption is, is unclear on the methodologies or approaches used, and minimally discusses the potential relevance of resulting quantitative information.
Analyze, Visualize, and Quantify	Artifact extensively manipulates, organizes, classifies, and/or summarizes numerical information, which may or may not include gathering data, making predictions, doing calculations, and/or creating tables. Artifact extensively interprets and creates new numerical/visual representations of quantitative information.	Artifact manipulates, organizes, classifies, and/or summarizes numerical information. Artifact interprets existing numerical/visual representations of quantitative information (e.g. charts and graphs) and minimally creates new visual representations.	Artifact minimally manipulates, organizes, classifies, and/or summarizes numerical information. Artifact minimally interprets and creates the need for quantitative information or its usefulness in a given context.
Interpret and Apply	Artifact extensively demonstrates what the quantitative information suggests, summarizes important points or trends, and relates the quantitative information to the initial context or question and/or relates information to a broader idea, challenge or problem. Artifact revises and/or formulates ideas based on resulting analyses.	Artifact demonstrates what the quantitative information suggests, summarizes important points or trends, and minimally relates the quantitative information to the initial context or question and/or relates information to a broader idea, challenge or problem. Artifact revises previous ideas and minimally formulates new ideas based on resulting analyses.	Artifact minimally demonstrates what the quantitative information suggests, summarizes important points or trends, and minimally relates the quantitative information to the initial context or question and/or relates information to a broader idea, challenge or problem. Artifact minimally revises previous ideas and minimally formulates new ideas based on resulting analyses.
Communicate	Artifact includes extensive construction of explanations and/or arguments that are clearly supported by quantitative information and related interpretations. Artifact discusses the meaning and/or importance of resulting interpretations. Artifact compares and contrasts ideas that are backed by quantitative information and those that are not. Artifact produces and demonstrates various representations of quantitative information and references these aids in discussions.	Artifact includes construction of explanations and/or arguments that are clearly supported by quantitative information and related interpretations. Artifact discusses the meaning and/or importance of resulting interpretations, with a few inconsistencies. Artifact compares and contrasts ideas that are backed by quantitative information and those that are not, with a few inconsistencies. Artifact produces and demonstrates various representations of quantitative information and minimally references these aids in discussions.	Artifact minimally includes construction of explanations and/or arguments that are clearly supported by quantitative information and related interpretations. Artifact minimally discusses the meaning and/or importance of resulting interpretations, with a few inconsistencies. Artifact minimally compares and contrasts ideas that are backed by quantitative information and those that are not, with a few inconsistencies. Artifact minimally produces and demonstrates various representations of quantitative information and minimally references these aids in discussions.

*This rubric was developed iteratively with the Quantitative Reasoning Assessment ABOR subgroup using materials graciously provided by Helen Baxendale, Northern Arizona University, and the Written Communication ABOR subgroup, all of which were informed by the AAC&U VALUE rubrics for Quantitative Reasoning and Written Communication.