Quantitative Writing: Communicating Data

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Abstract

Quantitative writing helps students analyze and interpret quantitative data. It is a skill that requires students to identify a problem, discuss it, support the discussion with numerical data, and communicate that data effectively to a general, real-world audience. The University of Texas at San Antonio (UTSA) has developed the Quantitative Literacy Program (QLP) to enhance students' quantitative reasoning in disciplines across the curriculum. As a requirement for graduation, students complete at least one course that has been enhanced with quantitative literacy (a Q-course). Students explore, visualize, and analyze the results of data they collect and effectively express the results of their analyses in a written document. The scope of the quantitative writing ranges from a brief description or summary of the main observations associated with the data to creating an argument and defending the overall conclusions supported by the data and illustrated with tables and figures. This paper discusses the importance of quantitative writing across the curriculum and provides specific examples of how quantitative writing has enhanced courses throughout the curriculum at UTSA.

Keywords: Quantitative Literacy, Quantitative Writing, Communicating Data

1. Introduction to UTSA's Quantitative Literacy Program

In order to satisfy the University's Quality Enhancement Plan (QEP), the University of Texas at San Antonio (UTSA) adopted the Quantitative Literacy Program (QLP) to enhance student learning and to integrate quantitative literacy into existing courses. Begun in 2011, the QLP is currently in its fifth year of implementation. During its first three years, the QLP targeted courses that fell under students' general education/core requirement and then, in the fourth year, expanded to include major-specific upper division courses.

To date, the general education/core courses which have been redesigned to incorporate quantitative literacy are:

Basic Statistics
Biosciences I
Contemporary Biology I
Economic Principles and Issues
Freshman Composition I and II (Writing)
Introduction to American Politics
Introduction to Archaeology
Introduction to Environmental Systems I
Introductory Macroeconomics
Introduction to Mathematics
Introductory Microeconomics
Introduction to Physical Anthropology
Introduction to Sociology
Introduction to World Civilizations to the 15th century
Introduction to World Civilizations since the 15th century
Technical Writing
Texas Politics and Society

As noted earlier, during the fourth year of the program, upper division courses became the primary target of the QLP as a means to capture transfer students needing to satisfy the graduation requirement of a Q-course. The upper-division Q-courses added during the fourth phase of the plan (AY2014) are:

Architectural Structures
Biomechanics (Kinesiology)
Conduct of Communication Inquiry
Environmental Systems (Architecture)
Introduction to Social Research
Introduction to Special Education
Multidisciplinary Studies: Senior Seminar
Research Design and Analysis in Criminal Justice

To assess the effectiveness of the program, a team of UTSA statisticians designed the Quantitative Literacy Assessment Test (QLAT), an instrument to measure baseline Quantitative Reasoning skills. This test, administered to all incoming freshman and transfer students, assesses reading and interpreting graphs, calculating basic probabilities, sampling, and analyzing data.

Additionally, participating courses administer a pre-test, enhanced Q-assignments, and a post-test all designed by the Q course coordinator (a faculty member designated to oversee all sections of the Q-course) with assistance from the QLP team. The QLP Team consists of members from departments at UTSA; the Department of Management Science and Statistics, the Teaching and Learning Center, and the Writing Program.

The QLP team also developed a standardized method to assess eight student learning outcomes associated with the pre/post test and Q-assignments (to be discussed below).

2. Importance of Quantitative Writing

"Quantitative Writing (QW) is the written explanation of a quantitative analysis…." (1) Writing about data allows students to identify a research problem, discuss a research question, support the discussion with numerical data, and to communicate and interpret data effectively.

"Quantitative Writing is a powerful tool for enhancing student learning….[It] teaches students the flexible, adaptive, analytical higher-order strategies necessary for the increasingly complex, data-rich environments of the 21st century." (1)

Students in naturally quantitative courses, such as mathematics and statistics, are often asked to perform a calculation and find the result. However, merely calculating a numerical value is meaningless without the ability to analyze and discuss, orally or in writing, what the number means.

Students in naturally writing intensive courses, such as Freshman Composition and English are asked to write reports, present arguments, and support their arguments citing sources. However, this discussion has not typically included using data to support their argument.

3. QLP Student Learning Outcomes

As previously mentioned, to assess outcomes across various disciplines, the QLP team identified eight student learning outcomes as a way to standardize the assessment process. These learning outcomes form the acronym EVALUATE. (2)

The QLP quantitative student learning outcomes for UTSA are:

EXPLORE

- Define a problem and identify measurements
- Collect and organize data/information to support a theory
- Develop an appropriate plan to provide a solution

VISUALIZE

- Identify specific characteristics from charts/tables/graphs
- Create, graph, or construct different representations of data
- Investigate patterns/trends using various graphical techniques

ASSIMILIATE
- Compare two representations of the same dataset
- Distinguish between two methods of data collection
- Integrate information from different sources to draw conclusions

LOGIC
- Compute probabilities of events
- Assess the likelihood of occurrences
- Present a cohesive argument through measurement of risk

UNDERSTAND
- Perform simple conversions
- Recognize and identify scales of measurement
- Defend the limitations of an analysis and discuss bias and reliability

ANALYZE
- Compute basic numerical summaries
- Perform appropriate quantitative methods to examine a theory
- Use appropriate quantitative models to predict outcomes

Two of the eight student learning outcomes focus on assessing quantitative writing:

TRANSLATE
- **Define quantitative terms in a written statement**
- **Summarize the main observations represented by the data**
- **Transform a verbal statement into a numerical (quantitative) statement**

EXPRESS
- **Describe methods and variables related to data in written statements**
- **Report results of quantitative analyses**
- **Defend analyses and draw overall conclusions from the data**

4. UTSA Q-course Assessments

In Fall 2012, all Q-courses designed and began to administer a pre/post test across all sections of the discipline's Q-course. Each course was required to incorporate at least four QLP student learning outcomes (including the quantitative writing component, Translate). At the beginning and end of the semester, instructors administered pre/post tests consisting of 8 – 10 multiple choice questions. Analyses were conducted for all outcomes, except Express.

Realizing the importance of being able to assess the Express SLO as part of the pre/post test, the QLP team added the Express criterion to all Q-courses. Therefore, as of Fall 2015, all Q-courses redesigned their pre/post test to incorporate the quantitative writing component, Express. That is, each student was asked to write a short essay on a course-specific, instructor designed prompt that is able to be graded by utilizing a well designed rubric created by the Q course coordinator and QLP Team.

In addition to administering the pre/post test, all Q-courses give at least one mid-semester assignment addressing at least two QLP Quantitative SLO's (EVALUA) and both QLP Communication SLO's, Translate and Express. The QLP team has collected data for all Q-questions and has run analyses to track student performance from the beginning to the end of each course (to be discussed in section 7).

5. Example: Basic Statistics Course

Basic Statistics is a naturally quantitative intensive course. In this introductory statistics course, writing typically was not introduced until the tenth week of class when students were asked to write conclusions from hypothesis tests. The following is an example of a typical assignment given in a Basic Statistics course prior to its being designated a Q-course.

Consider the table below (Table 1) on presenting the number of individuals promoted by gender and then answer the following questions:

- What proportion of all employees were promoted?
- Out of the female employees, what proportion were promoted?
- Out of the male employees, what proportion were promoted?

Table 1

	Promoted	Not Promoted	Total
Males	20	10	30
Females	15	5	20
Total	35	15	50

Questions were simple probability calculations and students were required to submit answers in percentage form – just a numerical value.

Now that Basic Statistics is a Q-course, writing is introduced as early as the first week of class to describe charts and graphs. While the same data presented in Table 1 were utilized once Basic Statistics became a Q-course, the assignment was adapted to incorporate a writing component.

The prompt for the enhanced course, therefore, asked students:

> Based on the data presented in the table (Table 1), are males or females more likely to be promoted? Explain your answer in 1 – 2 sentences using numerical values to support your answer. An expected response would be: According to the data presented in the table, there is a larger probability (75%) of females as compared to males (67%) who were promoted. Therefore, females are more likely to be promoted than males.

Students were not only expected to identify and calculate which probabilities they needed to answer the question, they were also required to defend their answer in written form using their calculated percentages.

6. Example: Freshman Composition Course

All students are required to take Freshman Composition I and II to satisfy the communication objective of the core curriculum. These courses are naturally writing intensive courses. Before redesigning the course to integrate Quantitative Literacy, a typical Freshman Composition II assignment might have been the following:

Consider possible topics that can be found in the text:

- Carbon trading and its effectiveness
- Examining Biofuel
- Taxing Carbon Emissions
- Citizen responsibility
- Business responsibility
- Government responsibility

Use the following questions to help guide your development of a focused argument:

- Who should take responsibility for the effects of climate change?
- What sources of energy and which environmental practices appear to be the most sustainable?
- How will our individual choices interconnect to make a powerful social response to the threat of climate change?

Focusing on one of the six topics listed above, develop a clearly focused argument that takes a stance, presents all pertinent support, examines the opposition, and proposes a solution. The essay will be at least 4 pages with at least 5 sources, which MUST include the information from the Energy Administration, one or more essays from the text, and additional sources found through the UTSA library databases.

Students were writing, but not using specific data to support and defend their research. Now that Freshman Composition I and II are Q-courses, assignments have been created incorporating six of the QLPs student learning outcomes.

An enhanced Freshman Composition II assignment would now be: Write a classical, causal, or proposal argument that addresses an environmental issue. This argument must be data-driven and include at least one graphic element that illustrates the data. There should be at least 5 sources in this 5-7 page essay. (3)

- Select an argumentative topic with an environmental focus.
- Write your claim.
- Research the topic you selected.
  - Use at least 5 sources
  - One source must be a dataset
    - Find your own data set or use a dataset prepared by the librarian in collaboration with the Writing Program faculty.
    - Collect data to support your claim **(Explore)**.
    - Calculate numerical summaries from the data **(Analyze)**.
- Formulate clear, accurate statements about the data using actual numerical values **(Translate)**.
- Create a graphic representation of the data **(Visualize)**.
  - Include a title, number, labels, and source information.
  - Refer to either text for examples.

- Develop your argument—Example outlines available in the *Writing Arguments* text – remember to utilize the collected data.
- To incorporate the collected data and created graph, you must
    - Summarize the data represented by the graph, briefly **(Translate)**.
    - Offer an alternate interpretation of the data **(Assimilate)**.
    - Argue/defend the conclusions you made about the data, including the specific numerical data for support **(Express)**.

Students still research and compose a persuasive essay as they did prior to the Q integration; however, now they have to defend their conclusions using data to support their answer.

7. Are students learning how to write?

The QLP data specialist, in conjunction with the QLP team, runs Q-course reports each semester to assess student performance. McNemar's analysis is run for each item/question on the pre/post test. The McNemar's analysis gives the percentage of students who scored lower (% Lower Post-test score), about the same (% no change),or higher (% Higher Post-test score) in the post-test compared to the pre-test. Significant improvement from pre- to post-test is indicated by a p-value less than 0.05. In Spring 2015, eight out of thirteen core courses and five out of eight upper-division courses showed significant improvement from pre- to post-test on the written question (Express). The QLP team will continue to work with all courses to further enhance their mid-semester assignment to include more writing.

The importance in assessing students' ability to write lies in the following: Students typically take Freshman Composition I and II within the first two years of their studies at UTSA. Prior to the QLP implementation, students were expected to write intensively in these two required courses; however, they were often not required to write after their core curriculum studies were completed, depending on their major. As a result of the QLP, students are expected to write in all courses mentioned above. Students, therefore, begin to recognize the importance of being able to write across disciplines, and they begin to see the value of incorporating data as a way to support their ideas. Therefore, they are better prepared to transfer skills among their core courses and, later, their major courses. In addition, they are more prepared to make informed real world decisions as they extend their content knowledge and writing skills into their careers after college.

8. Next Steps

In its fifth year, the QLP added no new Q-courses for redesign. The QLP Team chose to focus on the current Q-courses and further enhance their materials based on the results of past semesters' analyses. Q-course reports will continue to be generated each semester based on the pre- and post- test results to analyze the effectiveness of quantitative literacy. The QLP Team will continue to work with Q-course faculty to enhance/revise Q-assignments and pre/post tests.

Currently, core courses are required to assess four or six state identified student learning outcomes. Courses in Mathematics, Life & Physical Sciences, and Social & Behavior Sciences component areas are required to assess Empirical and Quantitative Skills (EQS). As a result of the QLP initiative, beginning in Fall 2016, the University's core curriculum will include EQS as one of its required SLO's for all core courses. Thus, QLP will become part of the University's core curriculum as Quantitative Literacy is incorporated into the fabric of the University.

9. Acknowledgements

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