Abstract

Data collected from Malcolm X College students in the spring semester of 2017 were analyzed through the lens of the institutional student learning outcome of Quantitative reasoning. Students were enrolled in courses at both the entry and exit levels of the institution. Quantitative data have been previously analyzed, detecting no differences in reasoning ability between students at entry and upper divisions of coursework. Qualitative data from an open-ended item on the assessment instrument are analyzed here. The item asked students to evaluate a claim based on data presented in a graph. Using a thematic coding approach, responses are aligned with four categories: (1) non-reasoning, (2) reasoning without data, (3) misinterpretation of the graph, and (4) reasoning with data. The largest group of students was able to successfully reason with the data to respond to the item, however, approximately half of the students were able to demonstrate reasoning without using the data presented or based on a misinterpretation of the data presented. This nuanced result demonstrates a growth edge for students both inside and out of the classroom; students will encounter similar data representations in educational pursuits as well as in the media. Recommendations to improve students' ability to interpret data contained in graphs will be developed through a consultation with subject matter experts in quantitative reasoning.

Prepared by Dr. Rebecca Gibbons, Director of Assessment and Evaluation
11/11/2019

Introduction

Institutional assessment efforts at Malcolm X College (MXC) include the measurement and analysis of the six Institutional Student Learning Outcomes (ISLOs): Critical thinking, Quantitative reasoning, Oral & written communication, Cultural understanding & sensitivity, Scientific competency & literacy, and Information & technological literacy. These ISLOs are measured and analyzed on a rotating basis; Quantitative reasoning was measured in the spring semester of 2017 and is being analyzed in the fall semester of 2019. The analysis stage comprises of processing and interpreting data collected via a previous application of an assessment instrument. In the case of Quantitative reasoning, the instrument was generated in-house, and is available through MXC SharePoint. Per the 2017 MXC Assessment Committee Handbook, the definition of the outcome was:

By the time students graduate from MXC, they should be able to think logically and critically to solve contextual problems vis-a-vis the process of accurately interpreting and evaluating evidence, critiquing the thinking of self and others, and clearly explaining/articulating conclusions and solutions.

The competencies included in this student learning outcome were:

1. Accurately read, interpret, and comprehend quantitative information in models, graphs, tables, and charts.
2. Effectively communicate quantitative information symbolically, numerically, verbally, and visually/graphically.
3. Apply rules of logic and mathematical principles, and drawing appropriate inferences to perform numeric computations with accuracy, estimate answers, and check one's work for reasonableness.
4. Use and synthesize computational, graphical, mathematical, and logical skills to develop solutions or solve problems.
5. Recognize the limitations of mathematical/statistical models and the significance of context in solutions and problem solving.

A quantitative reasoning assessment designed to address this ISLO was administered to students enrolled in a variety of courses at both the entry and exit level. This assessment included three multiple-choice items and one open-ended item. Data from the multiple-choice questions were analyzed in past semesters with the intention of exploring differences between students in upper- and lower- division courses; this analysis is available on the MXC SharePoint site. There were no statistically significant differences found between students in upper-level and lower-level courses, and the majority of students responded to the items correctly.

Data from the open-ended item were not analyzed immediately after instrument application. The data were stored and are analyzed here. The multiple-choice items provided information about student achievement of the Quantitative reasoning competencies 3 and 4 (above), specifically, the ability to accurately perform computations to solve problems. However, the methods by which students solve problems are not evident in these responses; the open-ended item allows for a nuanced analysis of student reasoning. This report contains an analysis of the qualitative data collected with an interest in identifying growth edges to best assist students.

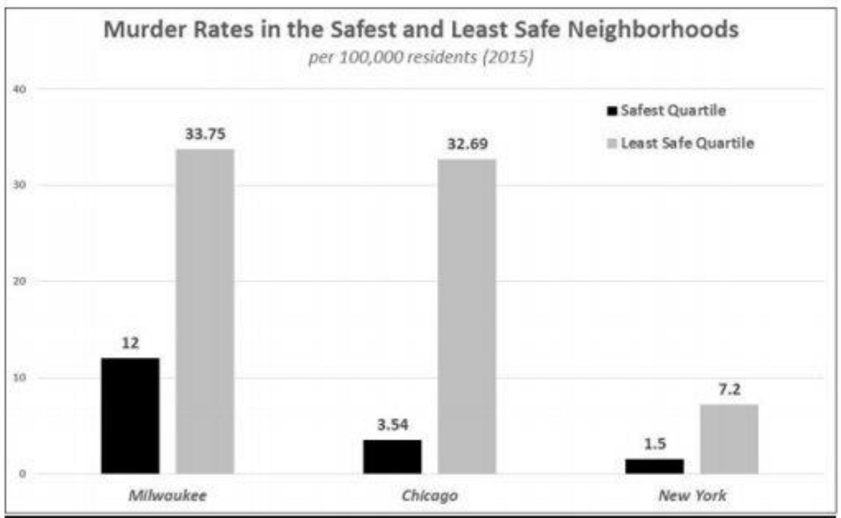
Analysis

The item can be found below:

4. Use the graph below to determine whether or not the following statement is true or false:

The smaller the city, the higher its murder rate.

Explain your answer using evidence from the graph as needed.



Source: https://www.thetrace.org/2016/07/crime-rates-american-cities-murder-inequality/

(Cities are ordered by their size, from least to most populated from left to right.)

The item can be identified within Quantitative reasoning competency 1 (above) as well as critiquing the thinking of the self and others, as listed in the definition. The 308 responses to the open-ended item discussed here came from a distribution of students enrolled in: college success (106), microbiology (57), biology (17), theater (8), political science (10), psychology (83), and sociology (27).

The open-ended response format allowed students to demonstrate their reasoning skills; because this was the first administration of the instrument in our population, there was no pre-determined rubric or set of expectations for student responses. As such, the data were analyzed via open coding in a thematic analysis framework; responses were used to generate the codes and identify the sophistication of reasoning. Responses varied in length and accuracy, and four categories of responses were identified. These are (1) non-reasoning, (2) reasoning without data, (3) misinterpretation of data, and (4) reasoning with data. Importantly, despite the range of responses, each was able to be identified within a category. The distribution of responses to categories is represented in Figure 1. Each category is described by the sophistication of reasoning and supported by sample responses.

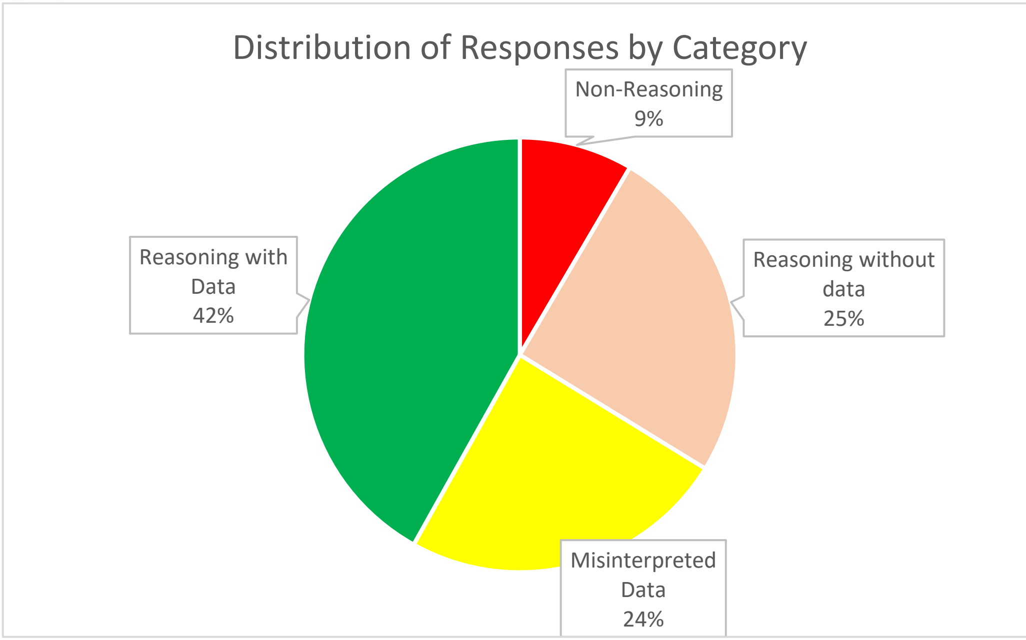


Figure 1. Demonstration of responses by category

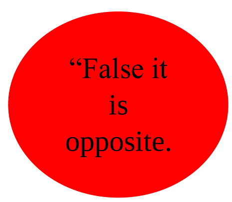


Figure 2. Sample response in the Non-reasoning category.

Category (1) Non-reasoning. The responses in the non-reasoning category, for reasons unknown, did not engage with the data or any other structure in the description of the answer. The majority of these responses consisted of only the word "true" or "false," without an explanation. However, some responses had text that did not demonstrate reasoning in the responses to the item: "The following statement is undetermined due to the fact that the x and y axis are not properly labeled and there is no way to determine the sizes of the cities," "It doesn't matter the size of the city, murder happens anywhere." These responses might indicate that the student did not read the portion of the question asking for a response, or that they did not engage with the task as desired. The responses that fit into this category consisted of 26 of the 308 responses, for a total of 8.44% of the responses. Of these, 13 were from college success (12.26% of college success), 9 from microbiology (15.79% of microbiology), 2 from psychology (2.41% of psychology), and 2 from theater (25.00% of theater).

"True – because you are able to keep track of a smaller city than you are with a bigger city."

Figure 3. Sample response from the Reasoning without data category.

Category (2) Reasoning without data. The responses in this category span from recounting personal experience to citing other data collection. The unifying theme in these responses is that the responses do not use the data and chart provided, but attempt to reason through the statement with other sources of evidence, such as anecdotes or media reports. The majority of responses in this category makes statements like, "No it's the bigger the city the higher the murder rate." Other examples include: "True and false because all cities that are small doesn't have a high murder rate;" False it is just saying cities and not elaborating on neighborhoods;" "I believe its true because if they all were to have the same number of murders the smallest population would have the highest rate;" "I don't agree with this statement because smaller cities usually have lesser crime rate because everybody usually knows everybody and they all usually stick together as a community." Uniting these responses is their ability to reason, but not use the data presented; this is either due to a lack of ability to read the graph or distrust in the data. This category comprised 78 (25.32%) of the responses. Of these, 27 were from college success (25.47% of college success), 2 were from biology (11.76% of biology), 11 from microbiology (19.30% of microbiology), 6 from political science (60.00% of political science), 20 from psychology (24.10% of psychology), 10 from sociology (37.04% of sociology), and 2 from theater (25.00% of theater).

"False, Milwaukee is a pretty big place and the murder rate is the same if not higher than Chicago."

Figure 4. Sample response from the Misinterpretation of data category.

Category (3) Misinterpretation of data. This category includes responses that use quantitative reasoning to identify their response to the item, but demonstrate a misinterpretation of the information contained in the graph. The most common response in this category is a simple misplacement of the size variable: "This is false Chicago is bigger than New York and the murder rate is higher." However, other misinterpretations, such as the definition of "quartile" and "rate," range across this data. Examples include: "Would say that this isn't true, for Chicago nearly has the same amount of "least safe quartile" as Milwaukee. But New York has the least amount of unsafe but also the smaller population. So the smaller the city has nothing to do with murder rates;" "False the graph is based on 100000 residents each city was equally large yet had the three different murder rates;" "Shown from the graph Milwaukee seems to have a higher murder rate because Chicago and New York are larger cities. Milwaukee has a 33.75 percent high murder rate and Chicago has 32.69 and New York 7.2 percent." This category comprised 75 (24.35%) of the responses. Of these, 22 were from college success (7.14% of college success), 7 were from biology (41.18% of biology), 12 were from microbiology (21.05% of microbiology), 1 from political science (10% of political science), 24 from psychology (28.92% of psychology), 7 from sociology (25.93% of sociology), and 2 from theater (25.00% of theater).

"Yes it is true because Chicago is a bigger city than Milwaukee but it has less murder however, New York is bigger than both and it has less murder rate than both cities."

Figure 5. Sample response from the Reasoning with data category.

Category (4) Reasoning with data. The responses in this category demonstrated the ability to respond to the prompt with some degree of accuracy, basing their claims on the data presented. The majority of responses were aligned with this one: "The above statement is true. New York is the largest city of the three listed below. And it definitely does have the lowest murder rate. Chicago is larger than Milwaukee and its murder rate is the second lowest. Milwaukee is the smallest city and appears to have the higher murder rate in both quartiles." While all responses in this category reasoned with the data, not all were perfectly accurate. For example: "False. New York is a big city with a small murder rate and Milwaukee is a small city with a high murder rate;" "False. As the graph shows, Chicago is bigger than Milwaukee but there is barely a difference in murder rates between the two." Some responses involved other mathematical operations: "It is false, because if you make a ratio of least safe rate over most safe rate, Chicago doesn't follow the trend. Milwaukee the smallest city had 2.8 least safe/safest, New York has 4.8, and Chicago has 9.2." This category comprised the largest number of responses, at 129 (41.88%). Of these, 44 were from college success (41.51% of college success), 8 were from biology (47.06% of biology), 25 were from microbiology (43.86% of microbiology), 3 from political science (30% of political science), 37 from psychology (44.58% of psychology), 10 from sociology (37.04% of sociology), and 2 from theater (25.00% of theater).

Implications and Future Work

Qualitative data such as those collected by the open-ended item in the spring 2017 Quantitative reasoning assessment allow us to explore the reasoning ability of our students with increased nuance. While on the surface, it would appear that students are unable to accurately respond to the item, the reason behind that ability allows us to design and implement targeted interventions. The students at Malcolm X College (MXC) are able to conduct effective reasoning in the face of evaluating a claim for its veracity. However, less than half of those assessed were able to engage in effective data and graph interpretation, as described in the Quantitative reasoning competencies.

Interpreting data contained in various visualizations is a vital skill for students to learn in today's knowledge economy. As increasing amounts of information are provided to our students through media reports and in other settings, they need the ability to discern the quality of information and the relevance that it holds in their decision-making. Indeed, interpretation is the first step toward meaningful analysis with which students can make informed decisions as citizens, which is the goal of the Quantitative reasoning student learning outcome. Achievement of this institutional student learning outcome will also ease the achievement of other student learning outcomes across the institution; the test for admission to the nursing program measures objectives such as M.2.1: "Interpret relevant information from tables, charts, and graphs;" and M.2.2: "Evaluate the information in tables, charts, and graphs using statistics."

The mission of MXC is to promote personal and professional achievement in the student body. Therefore, the implication of this work is that direct instruction in strategies for interpreting data contained in graphs should be incorporated in to the student experience broadly. The techniques for doing so will be generated in consultation with subject matter experts in quantitative reasoning, including faculty and staff in the general education, health sciences, student services, and adult education divisions.

Despite any results of the measurement and analysis of spring 2017 data, the quantitative reasoning institutional student learning outcome has been revised to "Upon completion of a degree at Malcolm X College, students should be able to interpret, communicate, and use computational, graphical, mathematical, and logical information. The measurables are:

1. Interpret: Accurately translate quantitative information from computational, graphical, mathematical, and logical sources.
2. Communicate: Effectively communicate quantitative information symbolically, numerically, verbally, and visually/graphically.
3. Use: Deploy computational, graphical, mathematical, and logical information to develop solutions and solve problems.

These new measurables align with the competency measured in this analysis, particularly the Interpret measurable. The instrument administered in the spring semester of 2017 can continue to be used to allow for determination of any increase in success from the previous to the next measurement stage for Quantitative reasoning.

Prepared by Dr. Rebecca Gibbons, Director of Assessment and Evaluation
11/11/2019