Assessment of Quantitative Reasoning in Applied Psychology

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Abstract. This study reports efforts by the Department of Psychology at Portland State University to assess student knowledge and skills in quantitative areas of Psychology. Preliminary research showed that faculty unanimously agree that *research design* (e.g., distinguishing experimental and correlational research designs), *psychological measurement* (e.g., test reliability and validity), and *statistics* (e.g., calculating central tendency indices, interpreting correlation coefficients) are important competencies for undergraduates majoring in psychology. Each of these competency areas is either directly related to or dependent upon students' quantitative literacy. Moreover, at Portland State, math faculty cover several of these concepts in two social-science statistics courses required for psychology majors. This report describes assessment practices and outcomes for quantitative literacy in these areas. The research included psychology students (majors and non-majors) at all levels of the undergraduate program. We found relatively low levels of competence in areas of quantitative research methodology, with psychology majors outperforming non-majors. Senior-level students who completed our intended methodology course sequence reached acceptable mastery levels. However, there appeared to be little advantage for students who had completed the required statistics sequence as compared with those who had not. These results are interpreted within a "continuous improvement" model where, based on these data, adjustments are made to program planning and individual courses that are intentionally designed to impact our learning goals and objectives.

Background

Psychology has a long history of interest in individual assessment across a wide variety of contexts. Consequently, psychologists have played a leading role in much of the scholarly research on learning and behavioral change. However, only within the last decade have psychologists begun to pay serious attention to assessment of learning in undergraduate psychology programs. Perhaps the most tangible demonstration of this interest is the recent release of *Undergraduate Psychology Major Learning Goals and Outcomes: A Report*, a task force study endorsed by the American Psychological Association (Murray, 2002). The study identified learning outcomes for ten educational goals in psychology.[1] Quantitative literacy plays a prominent role in several goals described in the report. For example, the "Research Methods in Psychology" goal explicitly focuses on data analysis and interpretation. Similarly, the "Values in Psychology" goal emphasizes the utility of the scientific method and the value of using empirical evidence to make decisions.

Many psychology programs heavily rely on mathematics departments to provide their statistical training. This reliance most commonly occurs at the undergraduate level, but some graduate level psychology programs also encourage (or require) students to take quantitative methods courses taught by math faculty. In either case, quantitative literacy is a critical component of the psychology major, since advanced courses assume students have a grasp of basic statistical concepts and understand how to apply those concepts to psychology. Thus, math departments often play critical roles in psychology training. Consequently, strong quantitative literacy assessment efforts provide both psychology and math programs with useful data about whether their courses accomplish each program's educational objectives.

In 1998, the Portland State University psychology program responded to a request by the Dean of the College of Arts and Sciences that all departments identify learning goals/objectives their majors should have achieved at graduation. One motivation for this request was the knowledge that the next round of higher education accreditation review would require a focus on authentic indicators of student learning, not just the traditional set of input data (e.g., the number and kinds of classes taught, student enrollments). The university president also designated assessment of student learning as one of three Portland State University presidential initiatives to emphasize the central role of assessment at the university. In response to these challenges, the

[1] www.apa.org/ed/monitor/julaug02/psychmajors.html

Psychology Department crafted an assessment vision involving tracking student learning from our initial introductory courses, through our research methods and experimental psychology courses, to our advanced seminars in industrial/organizational, applied developmental, and applied social psychology. This design enables us to determine whether our programs actually affect student learning by tracking changes in students' performance across our curriculum, and using the empirical data generated by our research to guide decisions about curriculum development.

Assessment in Psychology

Our initiative began with a series of workshops in which psychology faculty generated approximately 50 valued learning outcomes. These outcomes were organized into nine broad learning goals that closely resembled the goals suggested by the APA task force report described above. Faculty also indicated which learning outcomes and goals pertained to each of their courses. We used summary ratings (by faculty) of these outcomes and goals to establish assessment priorities. We then organized the learning goals into three categories: Theories and Issues, Application of Psychology, and Psychological Research Methods. Consistent with our description above, the faculty ratings suggested that Research Methods was a high priority topic because mastery of student learning in this area is closely tied to learning about other aspects of psychology.

The broad area of Research Methodology and Statistics consists of four topics:

- Research Design and the Scientific Method,(e.g., use of experimental, observational, questionnaire strategies);
- Psychological Measurement (e.g., reliability and validity in psychological assessment);
- Statistics, and
- Research Ethics.

Quantitative literacy is an essential component of several of these topics. For example, the statistics area presently focuses on three quantitative literacy concepts: central tendency, variation, and association. Upon graduation, we expect students to be able to conduct and present the findings of basic statistical tests in each of these areas as well as to interpret and critique presentations of these tests in published empirical literature. Similarly, we expect students to master basic concepts in research design and psychological measurement. Although research design and psychological measurement are somewhat different than what might traditionally be regarded as quantitative literacy, students use quantitative skills as they learn about these domains. For example, students must understand the concept of correlation to be able to grasp differences between forms of reliability and validity.

Finally, we note that our decision to focus on quantitative literacy issues also mirrors one of the key ability areas identified by Portland State University's faculty senate for our graduating seniors:

> *Quantitative Reasoning and Representation* — ability to deepen understanding of the value and need for this type of reasoning, the ability to understand the graphical presentation of data, and to transform information into quantitative and graphical representations.

Our Assessment Research

The main purpose of this case study is to describe our preliminary research efforts to assess quantitative literacy and related concepts. This research provides baseline data for future assessment efforts and empirical support for changes to the curriculum. In particular, our data illustrate some of the ways assessment data can be used to document the impact of a program and to pinpoint areas of particular need in curriculum development. We view assessment as fundamentally aimed at demonstrating the effect of the program on student behavior change, typically defined as increased student mastery over learning goals previously identified by the department. Thus, effective programs should demonstrate high levels of overall performance as well as desired patterns of changes in learning over the course of the program.

Our first programmatic assessment efforts involved the development of a 20-item multiple-choice exam covering topics related to research methodology. The test consisted of questions on research design (e.g., distinguishing experimental and correlational research designs), psychological measurement (reliability and validity), and statistics. The statistics section is the most directly related to quantitative literacy and concerns the portion of the curriculum taught in the math department. The statistics questions focused on very basic statistical concepts, such as calculating central tendency (mean, median) and variability (range) measures and interpreting correlation coefficients. Many other relevant concepts were not included (e.g., hypothesis testing). We also asked four quantitatively oriented psychology faculty to rate the difficulty level of the questions, the difficulty of the distracters (i.e., the three incorrect response options for each question) and the level of cognitive difficulty associated with each question. Using these ratings, we sorted the questions into high challenge and low challenge scales. We also sorted the items into three substantive scales corresponding to statistics, research design, and psychological measurement. In each case, the scores were defined as mean proportions of questions successfully answered.

The test was administered during two academic terms to over 800 students taking a wide array of undergraduate psychology classes (from freshman to senior level). We strategically sampled classes so the participants would represent a broad cross section of our students. This strategy enabled us to capture changes in students' mastery of quantitative literacy topics from the time they entered the major (i.e., at the beginning of the courses in our introductory sequence), to their advanced level courses. Moreover, the non-majors taking these courses serve as sort of a quasi control group for examining psychology majors. That is, we would expect to see greater change in majors as compared with non-majors.

Analyses and Findings

We made three types of comparisons. First, we compared the test scores of psychology majors (who are required to complete a sequence of methodology and statistics courses) to non-majors. Second, we examined majors' changes in test performance as they progress through the curriculum. Finally, we investigated differences by class level in quantitative literacy for all students taking psychology courses, including majors, minors, and non-majors, by class level.

Table 1 in the appendix to our report on the SAUM website presents differences between psychology majors and non-majors on each of the test scores.[2] The total scores of 57% for majors and 46% for non-majors represent low levels of quantitative literacy. However, psychology majors out-performed non-majors on all subtest scores by 9-13%, depending on the subtest considered. Interestingly, the highest scores were for the statistics dimension for majors. The statistics score was the only subtest to meet or exceed 70%, which is commonly viewed as "C" level performance in graded classes. The psychology department requires psychology majors to complete two statistics courses, and statistical topics are either explicitly or implicitly covered in several other courses—perhaps to a greater extent than other research methods topics. Thus, our findings most likely reflect the different levels of focus on these topics.

The generally low levels of performance suggest ample need for improvements in our efforts to address quantitative literacy issues. This preliminary finding is consistent with our experience, as well as those of colleagues at other institutions. Undergraduate students often express a great deal of distaste for, or ambivalence toward, topics related to research methods and statistics. For example, psychological measurement was ranked 45th out of 46 on a recent survey of our students' interests in topics related to psychology. It is important to note that students may not be to blame for these attitudes. Faculty may need to redouble their efforts to teach these concepts in engaging ways. Finally, one piece of good news for psychology majors is that they showed consistently higher levels of performance than non-majors. These differences provide some evidence of beneficial effects of our program for our students as compared with students in other programs.

All psychology majors must complete a core set of curriculum requirements. Many of these requirements concern quantitative literacy issues, including: (a) relatively basic coverage in our two-course required introductory psychology sequence, (b) specific coverage of quantitative literacy issues in statistics courses taught in the math department (but required for psychology majors), and (c) an intense focus on research methodology issues in our upper-division research methods course. This curriculum is founded on the assumption that each of these courses contributes to students' capacity to conduct research, evaluate published studies, and interpret the results of data analyses in applied contexts.

We examine this assumption in Table 2 of the appendix to our report on the SAUM website.[3] This table examines overall test performance for psychology majors broken down by the number of these required courses they have completed. As a whole, the majors scored 57% on the test. These scores were slightly higher for students who had completed the entire sequence (61%) and lower for students who had not completed any of the sequence (52%). Interestingly, there was no difference in overall test performance for students who had the introductory course(s) only and those who had completed the introductory course and a statistics course (both groups obtained an overall score of 56%). This suggests that future attention needs to be given to the extent to which research-focused courses are having their intended effects in our curriculum.

Assessment efforts involve documenting change across an entire educational experience. Moreover, many of the courses that are not explicitly part of our methodology sequence either implicitly or explicitly address methodology issues. Therefore, a second way to explore the effects of the program on quantitative literacy concerns showing performance changes across class levels. Table 3 of the appendix to our report on the SAUM website shows the test scores both for the entire research sample and only for psychology majors. It is important to note that the entire sample data include the majors as well as the non-majors, so these data

[2] www.maa.org/saum/cases/PSU-Psych-A.html

[3] www.maa.org/saum/cases/PSU-Psych-B.html

underestimate the differences between non-majors and majors across program levels.

As this table shows, students in both groups gain in test mastery at each level of the curriculum. The gains are modest, ranging from 5% gains from freshman to senior level for the majors on psychological measurement to 15% gains from freshman to senior level for the entire sample on high challenge items. There are a couple of clear trends worth noting. First, both for majors and the entire sample, there are small improvements in test scores across the curriculum. These findings suggest students are improving their quantitative literacy skills as they progress through the psychology curriculum. Second, psychology majors show higher performance at each class level. Thus, psychology majors have greater mastery of these skills both at entry and upon completion of the program. These findings may be attributable to non-psychology majors being less facile with and/or less interested in methodological issues in psychology. Finally, we note that the test scores were uniformly higher for the statistics subtest than the research design or psychological measurement subtests, particularly for the psychology majors who, by the time they reached senior level classes, reached a marginally acceptable mean of 76% correct on the statistics test. Although there are multiple interpretations of these data, they appear to show that students who have completed more of the psychology curriculum reach higher levels of mastery on quantitative literacy skills.

Insights

Our preliminary analyses indicate a couple of distinct conclusions about quantitative literacy among psychology majors. First, we noted consistent patterns of improvement across levels of the major, suggesting that our current curriculum benefits students. However, the overall levels of performance on these exams are lower than we desire. Thus, it is important to note several reasons why the test scores might be lower than expected in a typical academic examination context. First, students were not informed in advance that the tests would be administered and were not encouraged to specifically prepare for these test questions. Second, student test performance was not linked to their grades in the courses. Students received extra credit for completing the tests regardless of their performance on the exam. Thus, their motivation to perform well was lower than in the typical context of testing for a grade. This means that their scores should not be interpreted in relation to what faculty might expect of students in a normal testing context. On the other hand, most of the questions were of relatively low difficulty levels and did not address sophisticated topics such as hypothesis testing or statistical significance.

Although there are legitimate reasons to expect students' performance to be lower than might be expected on a graded test, we see ample room for improvement in students' performance on future assessments. Therefore, we have engaged in a series of initiatives designed to improve our quantitative literacy training. These initiatives include:

- Developing introductory-level course assignments that actively engage students in quantitative literacy in psychology before they enter statistics courses taught in the math department. In the past, students received relatively little instruction in quantitative literacy in their introductory courses and were expected to learn many statistics topics in math-taught statistics courses in which examples were less clearly tied to psychology. To help address this problem, we have introduced introductory-level assignments that systematically explore research design, psychological measurement, and statistics in hands-on student work. Examples include requiring students to gather their own research data, conduct basic statistical analyses, and present findings in written form. The goal of these assignments is, in part, to help students contextualize the knowledge they receive in their statistics courses and to help them transfer their knowledge from the statistics courses back into the psychology curriculum.
- Expanding our web-based learning resources related to quantitative literacy. These efforts include posting links to existing resources at various web sites and the development of an on-line lab in which introductory psychology students conduct and report the results of a complete research project. The World Wide Web has many examples of useful statistics resources, particularly for psychology courses. We are capitalizing on those resources by locating, gathering, and organizing web material for our students.
- Improving our strategic planning with faculty who teach research methods to develop standard learning goals for research methods courses and other courses focused on quantitative reasoning. This partnership involves efforts to encourage faculty teaching methodology and statistics courses to more actively participate in assessment research design and to draw from the departmental assessment planning as they construct and revise their own courses.
- Experimenting with performance-based grading systems in which students must demonstrate minimum quantitative literacy proficiency levels to receive a B– grade and with "perform to mastery" systems in which students are given multiple opportunities to demonstrate proficiency on the same set of quantitative literacy topics.

Conclusion

Each year, we make small but tangible improvements to the depth and breath of our assessment initiative. Along the way, we have had many opportunities to learn from our mistakes, and even a few opportunities to benefit from our successes. Perhaps the most important thing we have come to appreciate is the importance of, and the challenges with, aligning course content and course assignments with assessment goals. For example, our decision to consciously focus on quantitative literacy required us to add additional course time to that topic and to cut the amount of time devoted to other topics. These decisions can be complex, emotionally arousing, and even adversarial if not handled properly. However, all of the initiatives described above have been implemented to some degree and, in subsequent research we hope to demonstrate improvements in our students' mastery of quantitative literacy.

Reference

Murray, B. (2002). What psych majors need to know. *Monitor on Psychology*, July/August 2002.