Assessment to Document Student Learning in Frontiers of Science

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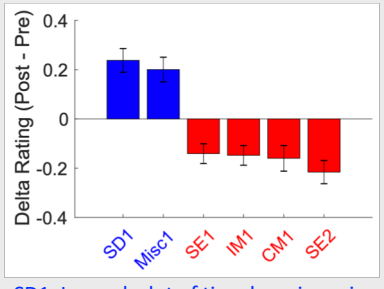
Overview

Pre- and post-course assessment data were obtained during Fall 2018 from ~500 first-year Columbia students enrolled in the Frontiers of Science Core course. Over 95% of participants were CC students; the rest were GS students. The assessment had three components: (1) a science attitudes survey, (2) a scientific concept inventory, and (3) an evaluation of quantitative reasoning skills. For components (2) and (3), students also reported confidence for each response on a scale from one (guessing) to five (certain). The Post test for components (2) and (3) was embedded in the final exam. This report summarizes initial analysis efforts that will guide development and implementation of a revised assessment to take place during the 2019-2020 academic year. Note: In all figures, error bars represent ± 1 standard error of the mean.

Component 1: Science Attitudes Survey

Adapted from a validated instrument by Glynn *et al.,* (2011), the survey consisted of twenty items in several categories: Intrinsic Motivation (IM); Career Motivation (CM); Grade Motivation (GM); Self-Determination (SD); Self-Efficacy (SE); and Miscellaneous (Misc). Students rated the applicability of each statement on a scale from one (never) to five (always). Pre-Post comparisons at the individual student level revealed small but significant shifts for six items as shown in Figure 1.



Reference: Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with science majors and nonscience majors. *Journal of research in science teaching*, *48*(10), 1159-1176.

-SD1: I spend a lot of time learning science.
-Misc1: Being more comfortable with math will help me be more comfortable with science.
-SE1: I am confident I will do well on science tests.
-IM1: I am curious about discoveries in science.
-SE2: I believe I can earn a grade of 'A' in science.
-CM1: I will use science problem-solving skills in my career.

Figure 1. Mean individual delta (Post – Pre) attitudes ratings. Blue bars/text indicate positive shifts (Post > Pre); red bars/text indicate negative shifts (Pre > Post). All shifts shown are significantly different from zero ($p < 0.01$); shifts for other survey items were not significant. Only students who completed both surveys were included in this analysis (N = 368).

Component 2: Concept Inventory

Students answered twelve multiple choice (MC) questions addressing concept learning objectives, with three questions included for each of the course units: Mind & Brain, Astrophysics (AP), Biodiversity (BD), and Earth Science (ES). Each question had four answer choices, (a)-(d). Some items were adapted from concept inventories established by other educators. Changes in the relative frequency of responses for each answer choice and corresponding confidence (Conf.) ratings for select questions are presented in Figure 2.

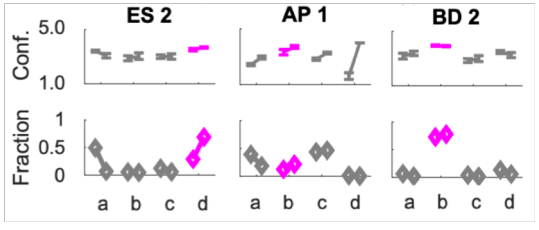


Figure 2. Mean confidence ratings and relative frequency of responses for select MC concept questions. Each connected line segment is a Pre-Post pair. Correct responses for each question are highlighted in pink. N(Pre) = 420; N(Post) = 466. ES2 addressed the mechanism of greenhouse gases (GGs)-dependent global warming; the shift from response (a) to the correct choice, (d), represents correction of the misconception that GGs damage the ozone layer. AP1 addressed the constancy of light speed; the prevalence of response (c) in the Post test represents a lingering misconception. BD2 addressed the meaning of "evolutionary fitness"; the small fraction of students who answered incorrectly on either test represents a ceiling effect.

Component 3: Quantitative Reasoning Skills Evaluation

Students answered seven quantitative reasoning questions on five topics: probability (Prob.), back-of-the-envelope calculations, logarithmic scales, descriptive and inferential statistics (Stat.), and feedbacks. Changes in aggregate response scores (scaled such that 1 represents a perfect score) and corresponding confidence ratings for select questions are presented in Figure 3.

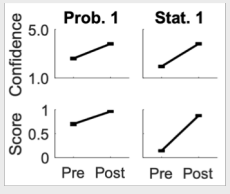


Figure 3. Mean confidence ratings and response scores for select quantitative reasoning questions. Pre-Post comparisons for all seven questions were significant ($p < 0.01$). N's are the same as in Figure 2. Prob. 1 addressed joint probability of independent events; Stat. 1 addressed statistically significant differences; the larger increases in score and confidence for Stat.1 reflect a ceiling effect in Prob 1.

Summary

We detected small but significant shifts for some attitudes survey items. Patterns in MC responses and quantitative reasoning data revealed learning gains, lingering misconceptions, and ceiling effects; confidence generally increased.

Future Directions

We will develop a statistical model to explore relationships between attitudes, concepts, quantitative skills, and exam scores. We will also examine relationships between demographic variables (e.g., science vs. non-science major, gender, etc.) and all of the above measures.

Acknowledgements
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