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The Benefits of Peer Instruction and Collaborative Study in Acquisition of Data Analysis Skills

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Extended Abstratct

The development of sound quantitative reasoning skills is a very important learning goal for the undergraduate Biology labs at UCSD. Achievement of this goal is part of two other learning goals: developing strong critical thinking skills and proficiency in scientific writing. However, analysis of numerical data is not nearly as intuitive for students as managing descriptive data and mastery of complex data sets and can be a daunting task. To make this goal achievable, I have incorporated a very structured and interactive learning module to promote practice and retention of quantitative skills in the context of ongoing lab experiments. In this approach, students work with three incrementally challenging datasets to gauge, improve, and test their competence in quantitative reasoning. The first data set is the simplest and allows them to determine their baseline skill levels while the final data set is related to authentic research conducted in our lab and is the most complex of the series.

The centerpiece of this strategy is an intensive and highly interactive data analysis workshop in which students work in pairs to organize, analyze, and summarize a moderately complex data set using a spreadsheet program, such as Excel™, with subsequent independent work. The format of the workshop promotes healthy dialogue between students and between students and instructor while the students are in the learning process. This provides the opportunities to answer questions in real time, gauge student understanding before misconceptions set in, and monitor and guide work as it proceeds to avoid frustration and fatigue. This approach has the advantage that it can be readily adapted to any desired level of quantitative complexity.

Description of the Datasets

The first and simplest dataset tracks the effectiveness of toilet paper as a barrier to bacterial transfer and the efficacy of washing as a way to remove contamination. The second tracks fecal contamination of water bodies using the Colilert-18 or the Colilert-18 Quanti-tray method. Students are required to categorize the water samples, sort the data, determine the control conditions, calculate the averages and standard deviations, analyze the trend of the results, and present their findings in the form of tables and figures. Although this is a more complex dataset and requires more analysis, part of the work is completed in the workshop in collaboration with their partners and with feedback during the analysis. The latter part of the analysis is done independently. The third dataset is generated by the entire class from a 3-week enrichment study in which students enrich target organisms (thermophiles, acidophiles, etc.) from an environmental sample such as soil. Students are responsible for all aspects of the data generation, organization, and analysis. Collaboration is not permitted. This allows us to measure individual skill levels and retention.

Assessment

For this study, all three assignments were evaluated on a rubric based on information from Stevens and Levi (2005) that ranks tables and figures as good/moderate/poor on five criteria: organization, calculation, proper use of controls, format, and visual clarity. The same rubric is utilized for each assignment to maintain consistency in evaluation although the actual grading is done on a different scale. At the end of the quarter, students also self reported their level of comfort before and after the workshop.

Description of the Data Analysis Workshop

This is typically a 3-4 hour workshop in which students work with one or more partners to analyze data. In preparation for this workshop, students provide feedback on the first dataset, identify their problems with Excel™,

and read ahead on the background to the new dataset. We start the workshop by going over common problems and errors on the first assignment and identifying the goals for the workshop. These include identifying the question/hypothesis of the experiment, determining the appropriate controls and the criteria by which they would choose to sort the data, doing several practice sorting exercises, and constructing at least one sample graph or figure. This is an opportunity to address as many questions as possible, as group exercises, through individual or peer instruction, or through short lecture segments. Students complete the data analysis independently.

Keywords: peer instruction, data analysis

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Notes For the Instructor

Research shows that students make more rapid gains in problem solving through peer instruction and collaborative work. We have found that students working with partners go much further in suggesting and testing approaches than they do when working independently. Measurable gains have been recorded based on a comparison of pre- and post-workshop homework, and lab reports, as well as student self-evaluation. As measured, student performance improved four- to five-fold on all criteria except in clarity; the largest gains occurred in calculation skills. The improvement was significant pre-workshop to post-workshop with continued gains in skills up to the last assignment. The sole exception was the category *controls* which saw some apparent loss of skills between the post-workshop assignment and the last dataset. This was likely due to the greater complexity of controls required for the enrichment experiment but this has yet to be tested. The gains in skills may be attributed to the extensive feedback students received after each assignment, and the highly directed assistance given to help solve student-specific issues Students self-reported increased expertise in spreadsheet use and statistical analyses and an increase in confidence in all aspects of quantitative data analysis.

The workshops were successful beyond anything we had expected. Student response was very positive and the gains in proficiency were significant. This module also helped us identify immediate and larger issues and address them in a timely manner. Both students and instructors benefited from the interaction and students participated much more in follow-up discussions. We plan to implement this module in future quarters.

Literature Cited

Stevens Danielle D. and Levi Antonia J. 2005. An introduction to rubrics: an assessment tool to save grading time, convey effective feedback, and promote student learning. Stylus, Sterling, VA. 232pp.

Mission, Review Process & Disclaimer

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