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Necessary vs. Sufficient Reasoning as an Instructional Tool to Improve Student Data Analysis Skills

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The learning of scientific reasoning skills, including the abilities to think critically, interpret data presented in figures and tables, and form hypotheses, are critical to an undergraduate education in the biological sciences. Data interpretation skills are particularly critical; as students advance through their courses they are required to analyze and draw conclusions from increasingly complex data representations. It is clear that students benefit from instruction in how to interpret complex representations in cell and molecular biology, and much of this benefit comes from understanding the experimental design. As students continually encounter experimental designs that are new to them, it would be useful to identify teachable analytical skills that would benefit students in interpreting a variety of different data representations. To address this, we are assessing how instruction in necessary vs. sufficient reasoning affects students' abilities to interpret data representations from different experimental designs. This reasoning skill, based on the role an intermediate factor in question plays in facilitating a defined effect from a defined stimulus, is applicable to interpreting data sets from many fields of biology. Students in an upper division biochemistry lab class were assessed for their ability to interpret data representations of increasing complexity, before and after completing an instructional module that focuses on necessary vs. sufficient reasoning. The average student score increased from 68.6% to 75.3% following completion of the module ($p < 0.01$). More importantly, the largest gains were found for interpreting more complex data representations and for experiments that were not designed to determine necessary vs. sufficient. This suggests that instruction in necessary vs. sufficient reasoning could increase students' analytical skills across a range of data representation categories.

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