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Student reasoning about ratio and proportion in introductory physics[1]

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To many students, introductory physics must seem a fast-moving parade of abstract and somewhat mysterious quantities. Most such quantities are rooted in proportional reasoning. Using ratio, physicists construct the force experienced by a unit charge, and attach the name electric field, or characterize a motion with the velocity change that occurs in a unit time. While physicists reason about these ratios without conscious effort, students tend to resort to memorized algorithms, and at times struggle to match the appropriate algorithm to the situation encountered. Although the term "proportional reasoning" is prevalent, skill in reasoning with these ratio quantities is neither acquired nor applied as a single cognitive entity. Expert ability seems to be characterized by the intentional use of a variety of components, or elements of proportional reasoning, by a fluency in shifting from one component to another, and by a skill in selecting from among these components. Based on this perspective, it is natural to expect students to develop proportional reasoning ability in fits and starts as various facets are acquired and integrated into existing understandings. In an ongoing collaboration between Western Washington University, New Mexico State University, and Rutgers, we are attempting to map the rich cognitive terrain of proportional reasoning, and to use our findings to guide the design of instruction that develops fluency. This talk will present a provisional set of proportional reasoning components, along with research tasks that have been developed to measure student ability along these components. Student responses will be presented as evidence of specific modes of thinking. The talk will conclude with a brief outline of our approach to improving student understanding.

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