Investigating context dependence of introductory and advanced student responses to introductory thermodynamics conceptual problems

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We use a validated conceptual multiple-choice survey instrument focusing on thermodynamic processes and the first and second laws of thermodynamics as covered in introductory physics to investigate the context dependence of introductory and advanced student responses to introductory thermodynamics problems after instruction. The survey has conceptual problems that incorporate many contexts with the same underlying principles and concepts involving internal energy, work, heat transfer, and entropy. Here we focus exclusively on entropy. This study used data from over 1000 college students in introductory-level algebra- and calculus-based physics courses as well as upper-level thermodynamics courses. In addition to prior research, think-aloud interviews with a small subset of students in which they were asked to answer the survey problems while thinking-aloud were useful for understanding the context dependence of student responses in some situations, and why students may have greater difficulties in some contexts than in others. Here we present analysis of data in multiple contexts reflecting students' ideas about the change in entropy of a gas in spontaneous/irreversible processes and in cyclic processes. We find that a persistent belief in the constancy of entropy even for spontaneous/irreversible processes is a common difficulty among introductory students across problems with different contexts, while upper-level students had great difficulty across contexts in which identifying entropy as a state variable is important. For example, overall, upper-level students struggled somewhat more than introductory students with the fact that the entropy of the system does not increase, e.g., in cyclic processes after one complete cycle. Our findings using a validated survey confirm the findings of prior research in multiple contexts.

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