Abstract

The concept of entropy is often introduced in the context of the second law of thermodynamics, which specifies that the entropy of an isolated system must always increase in any real process. To date, there have been no published investigations that specifically probed physics students' thinking regarding this concept. We report here a two-year study of students in an introductory calculus-based physics course in which they responded to a variety of questions that dealt with entropy changes of an arbitrarily defined system and that system's surroundings. We present free-response, multiple-choice, and interview data that reflect students' thinking as to how entropy must change during an arbitrary real process. We found that pre-instruction fewer than 10% of all students were able to give completely correct responses to relevant questions posed in both general and

concrete contexts, and nearly two thirds of all students showed evidence of conservation-type reasoning regarding entropy. These outcomes persisted even after instruction that attempted to address these conceptual issues. However, we found that targeted instruction that *specifically* guided students to recognize that entropy is not a conserved quantity has appeared to yield improved performance on qualitative questions related to this concept.