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Abstract Title: **Introductory and advanced students' difficulties with heat transfer using a validated conceptual survey instrument**

Abstract Type: Contributed Poster Presentation

Abstract: We use the Survey of Thermodynamic Processes and First and Second Laws-Long (STPFaSL-Long), a research-based survey instrument with 78 items at the level of introductory physics, to investigate introductory and advanced students' difficulties with heat transfer. We present analysis of data from 12 different introductory and advanced physics classes at four different public institutions of higher education in the US in which the survey was administered in-person to more than 1000 students. We find that not only introductory but also advanced physics students have many common difficulties with these introductory thermodynamic concepts after traditional lecture-based instruction. These findings are consistent with prior research in this area, but our results incorporate a variety of new problem contexts and are obtained from large numbers of both introductory and advanced students. Here, we discuss difficulties related to heat transfer in isothermal processes, cyclic processes, and multiple processes sharing common initial and final states.

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