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Investigation of students' reasoning regarding heat, work, and the first law of thermodynamics in an introductory calculus-based general physics course

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Students in an introductory university physics course were found to share many substantial difficulties related to learning fundamental topics in thermal physics. Responses to written questions by 653 students in three separate courses were consistent with the results of detailed individual interviews with 32 students in a fourth course. Although most students seemed to acquire a reasonable grasp of the state-function concept, it was found that there was a widespread and persistent tendency to improperly over-generalize this concept to apply to both work and heat. A large majority of interviewed students thought that net work done or net heat absorbed by a system undergoing a cyclic process must be zero, and only 20% or fewer were able to make effective use of the first law of thermodynamics even after instruction. Students' difficulties seemed to stem in part from the fact that heat, work, and internal energy share the same units. The results were consistent with those of previously published studies of students in the U.S. and Europe, but portray a pervasiveness of confusion regarding process-dependent quantities that has been previously unreported. Significant enhancements of current standard instruction may be required for students to master basic thermodynamic concepts. ©2004 American Association of Physics Teachers.

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