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

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Introduction and Methodology

The knowledge structure and the context in which the knowledge is learned can affect an individual's ability to apply knowledge flexibly across different contexts

Experts: Characterize by principles or concepts
Novices: Characterize by surface features

Consistency of transfer can be measured by investigating how consistently students perform across different contexts.

STPFaSL-Long

The Survey of Thermodynamic Processes and First and Second Laws-Long is a 78-question validated survey for introductory-level concepts.

Each question asks one thermodynamic variable during a process, no alternative conceptions.

N=550 Introductory Algebra
N=492 Introductory Calculus
N=89 Upper-level

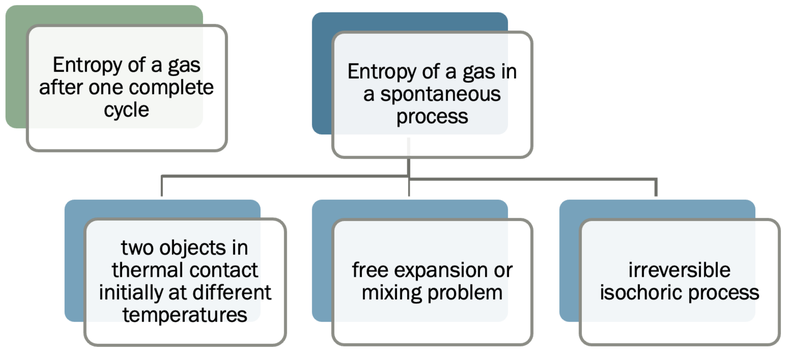
Consistency: <10% difference in correct response rate

Research Questions

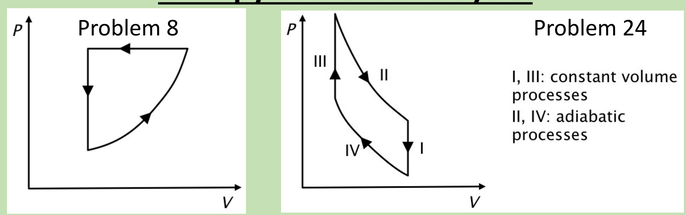
To what extent are introductory and upper-level student responses dependent on the context for problems with the same underlying concepts related to entropy? — Similar contexts

How different are the context dependencies of introductory and upper-level student performance on entropy problems across different contexts sharing a common theme? — Dissimilar contexts

Physics Concepts vs Context Dependencies

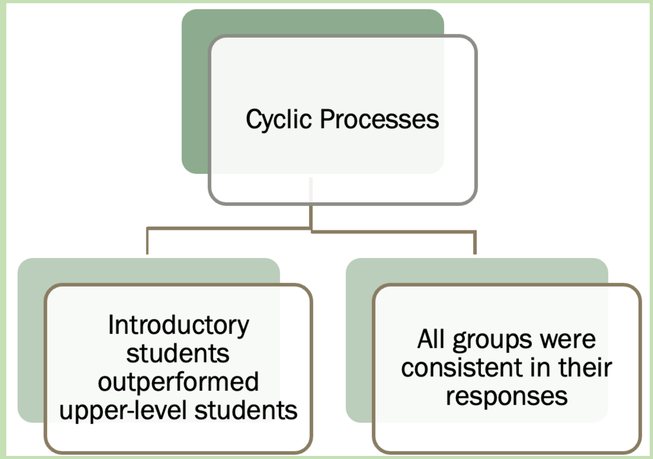


Entropy of a Gas in a Cycle:



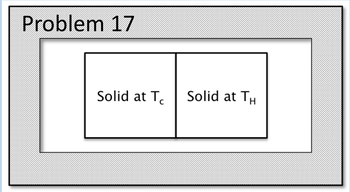
Entropy in a Cycle	Problem #	Prevalence (%) Upper Level	Intro Calc	Intro Alg
ΔS=0 after a reversible cycle (correct)	**8**	**49**	**54**	**65**
	24	**57**	**63**	**67**
Entropy of a system after a full cycle increases	8	36	25	19
	24	38	27	22

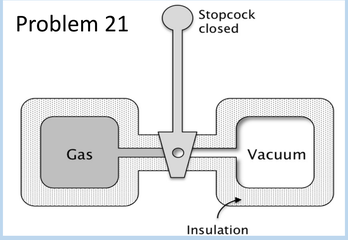
Entropy of a Gas in a Cycle

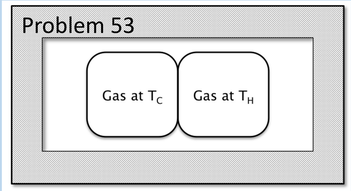


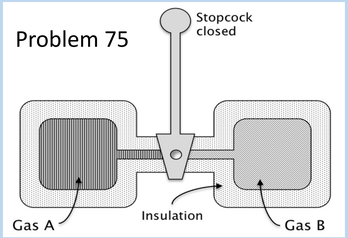
Change in the Entropy of the Universe in a Spontaneous Process

In each of the following 5 problems, does the entropy of the universe **increase**, decrease, or remain the same?









Problem 67: irreversible, isochoric process

Spontaneous Processes	Problem #	Prevalence (%) Upper Level	Intro Calc	Intro Alg
Entropy of the universe in a spontaneous process increases (Correct)	17	78	23	20
	53	84	23	21
	21	87	47	50
	75	85	35	43
	67	83	40	47

Entropy of the Universe in a Spontaneous Process