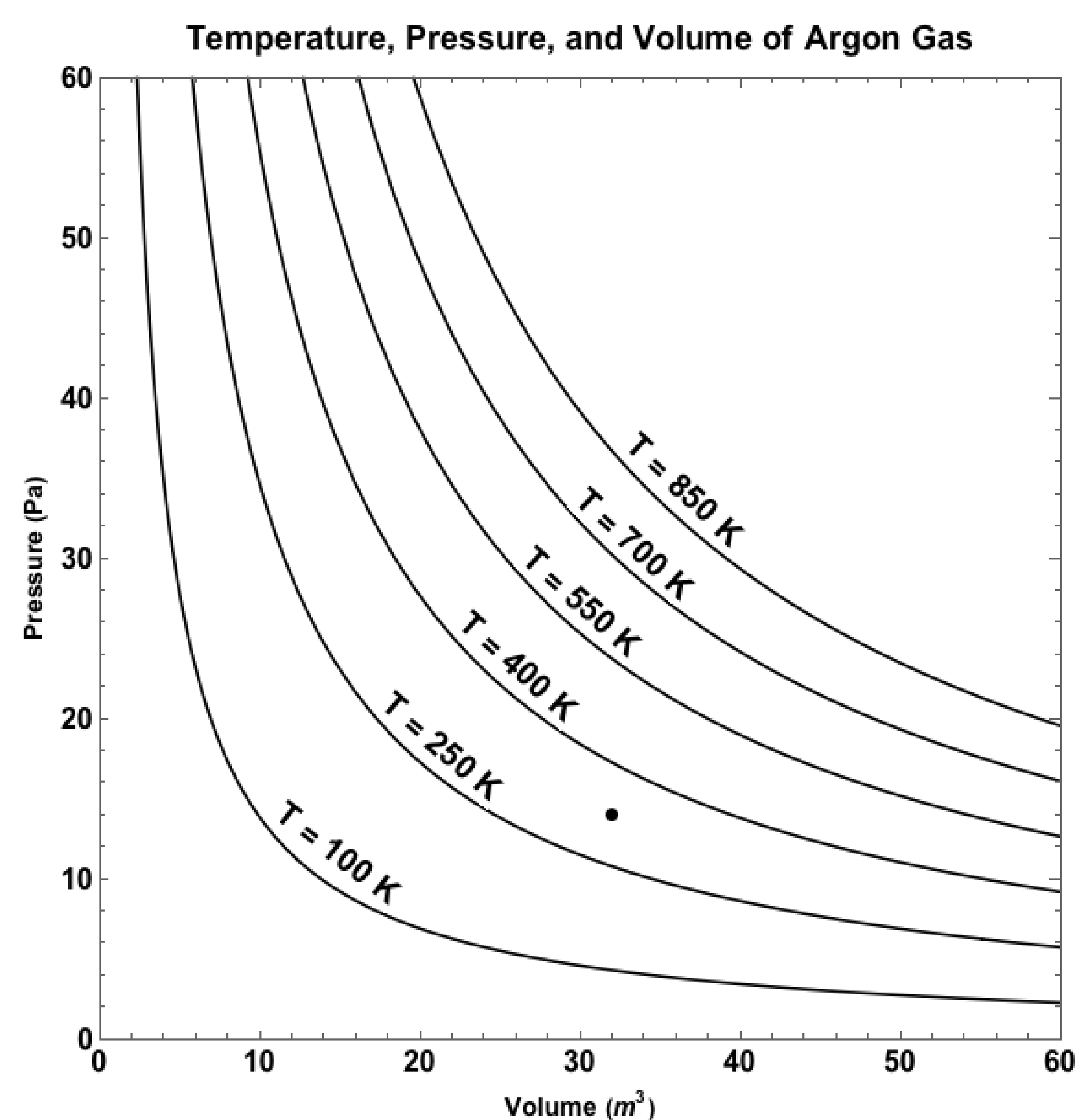


Students do not consider all possible changes when reasoning about thermodynamic variables.

Student Reasoning about Multivariable Covariation in Thermodynamics

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Pretest Questions

1. At the indicated point, suppose p increases by 15 Pa. What can you say about the change in T ? Explain your reasoning.
2. At the same point, as you increase V , how might T change? Explain your reasoning.

Covariational Reasoning

“The cognitive activities involved in coordinating two varying quantities while attending to the ways in which they change in relation to each other.” [1]

Multivariable Reasoning

Many students relate 2 variables directly, ignore possible changes in a 3rd variable, or hold variables constant incorrectly [6-7].

Background and Methods

- Junior-level thermo students ($N = 45$)
- No prior thermo in a physics course
- Iterative Thematic Analysis [12,13] focused on distinct steps in student reasoning

Categories of Student Reasoning

Referencing features of the graph (60%)

T increases by 400 K
Contour line at (30, 30) is 700 K

Using physical knowledge about the gas (49%)

Using the ideal gas law, $PV=nRT$, with an increase in pressure by we would see an increase in temperature since pressure and temperature have a proportion relationship. The graph agrees.

Specifying a change in the 3rd variable (40%)

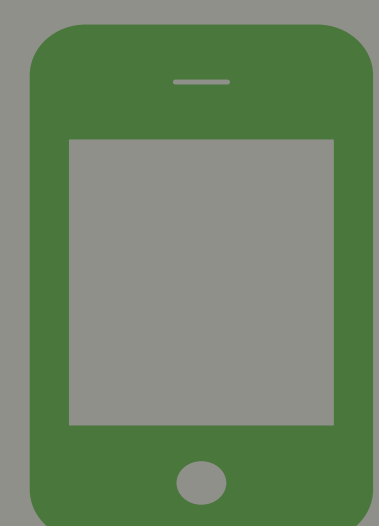
The temperature will increase, as the volume remained the same, but pressure increased.

Implications for Instruction

We suggest giving students the opportunity to examine tacit assumptions about what can be held constant.



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