College of Engineering, Oregon State University

SHARED RESOURCES: ENGINEERING STUDENTS' EMERGING GROUP UNDERSTANDING OF THERMODYNAMIC WORK

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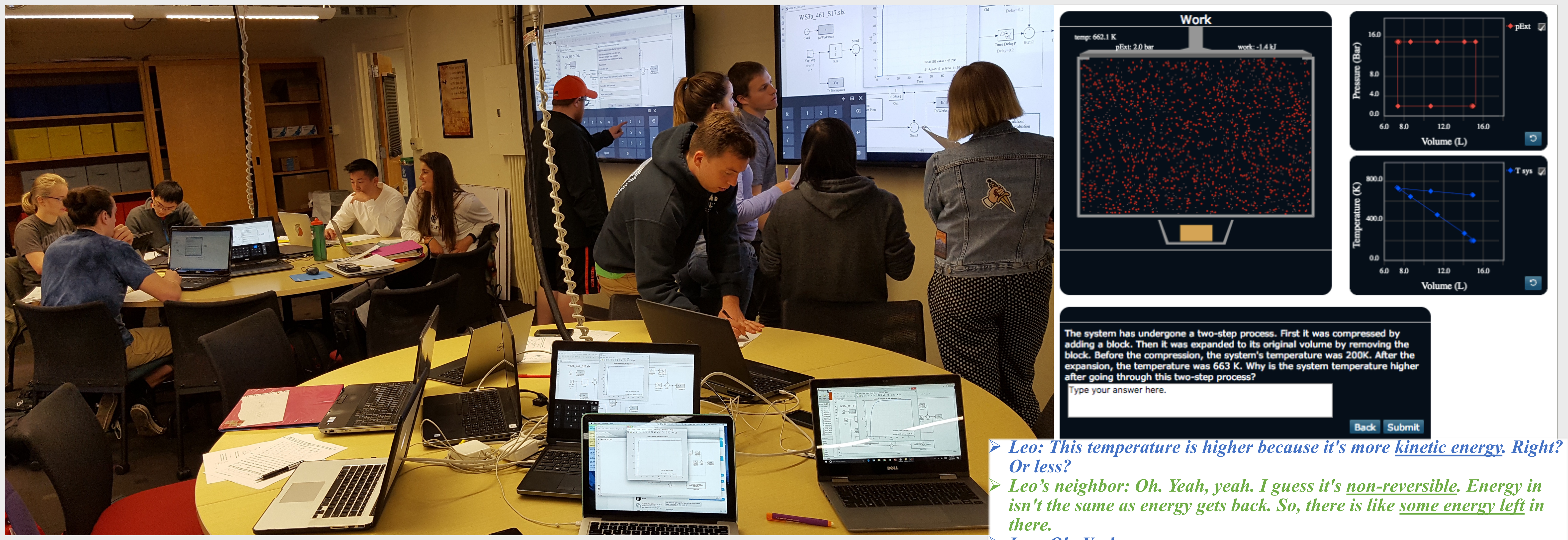


- *Leo: This temperature is higher because it's more kinetic energy. Right? Or less?*
- *Leo's neighbor: Oh. Yeah, yeah. I guess it's non-reversible. Energy in isn't the same as energy gets back. So, there is like some energy left in there.*
- *Leo: Oh. Yeah.*

INTERACTIVE VIRTUAL LABORATORIES

Table 1. Frames in the Work Interactive Laboratory (IVL).

Frame	Description	Question prompt
1	Equation: PV work	Multiple choice
2	Equation: 1st Law of Thermodynamics	Multiple choice
3	Single molecule simulation	Text (conceptual)
4	Single molecule simulation	None
5	Gas compression: simulation, graphs	Number (work)
6	Gas compression: simulation, graphs	Number (temperature)
7	Gas compression: numbers, compare results	Text (compare)
8	Graph and slopes, comparison	Number and text
9	Gas expansion: predict work and temperature	Number
10	Gas expansion: simulation, numbers, graphs	None
11	Gas expansion: simulation, numbers, graphs	Text (conceptual)
12	On concepts (work and energy)	Text (conceptual)
13	On the Virtual Lab	Text
14	Exit	None

Available IVLs
Work
Reversibility
Heat Capacity
Rate Equilibrium
Rate Equilibrium (short)
Hypothetical Paths: Reaction Enthalpy
Hypothetical Paths: Phase Change

RESOURCES

Students compile explanations in real time by activating resources (Hammer et al., 2005) to form ideas. The ideas are at a finer grain-size than concepts and are not inherently right nor wrong.

Shared resources are resources activated by individuals, expressed in ideas, and through discursive correspondence in language and through other representations, shared among learners. These shared resources provide a common foundation for the group to construct conceptual understanding that a single individual working alone would not likely develop within the same period of time.

PARTICIPANTS

Participants: 187 chemical, environmental, and biological engineering students enrolled in a junior-level engineering course titled "Thermodynamics" at a large, public university in the Northwestern United States. 159 valid student answers.

CODING

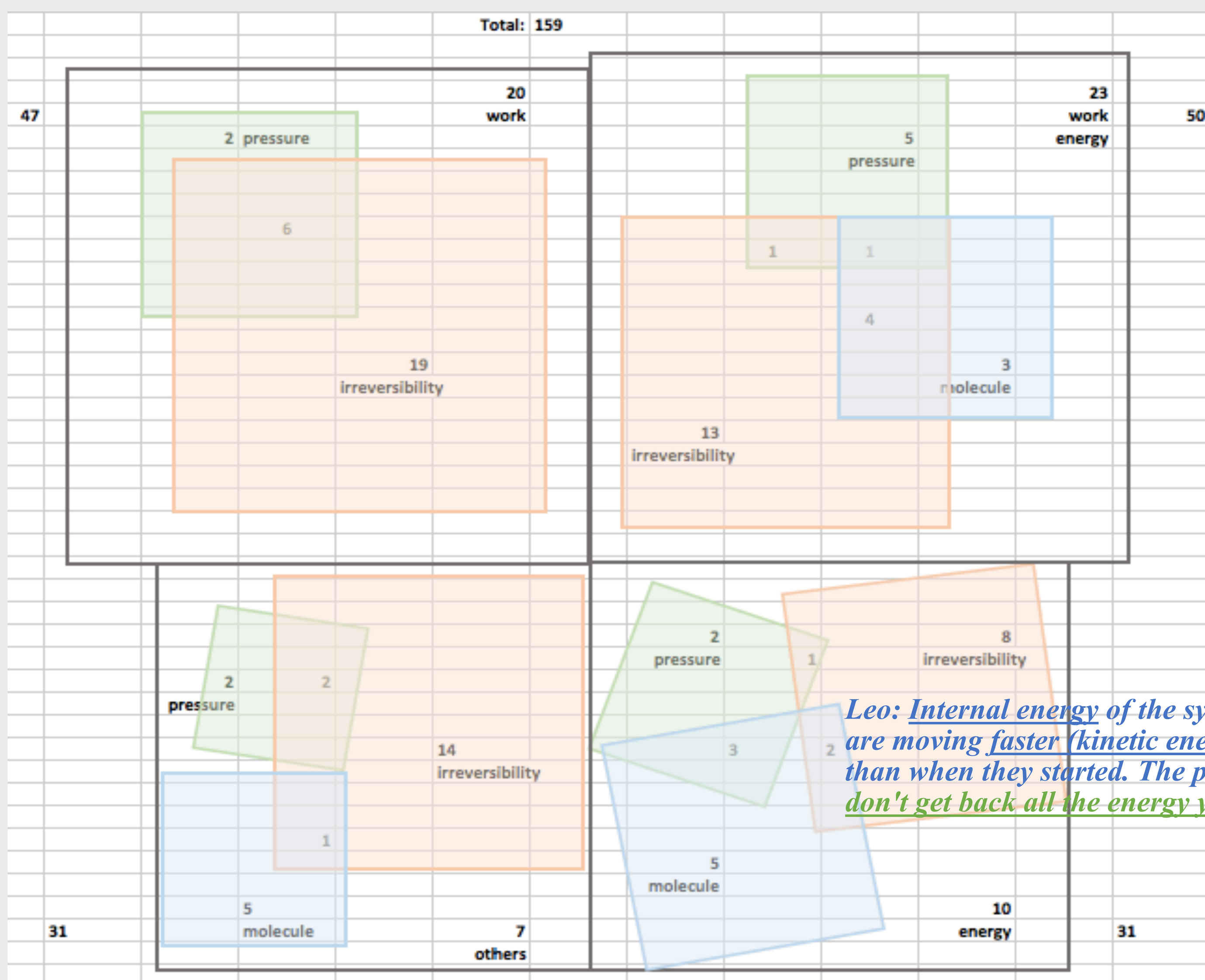
Table 2. Codes of frame 11.

Code	When student response contains	Example
Work	work	Student response: *It's a non-reversible process, and the work done to the surroundings is less than the work the surroundings did to the system initially.*
Pressure	pressure, Pext, p(ext), p =, 15, 2, bar, area	
Irreversibility	irreversible, not a reversible, non reversible, isn't a reversible, non-reversible, isn't reversible, not going through a reversible, path, not a state function	
Molecule	molecule, particle, molecular	Received codes: work, irreversibility.
Energy	energy	

ACTIVATING RESOURCES

Table 3. Coding results of frame 11 (total=159).

Resources	work	energy	Irreversibility	pressure	molecule	other
# of students	91	81	72	25	24	7
Percentage	61%	51%	45%	16%	15%	4%



Leo: Internal energy of the system is higher. The molecules are moving faster (kinetic energy) and their speed is higher than when they started. The process is not reversible, so you don't get back all the energy you put it.

Figure 1. Codes co-occurrence in frame 11

SHARING RESOURCES

We infer two ways of interest to engineering educators that sharing resources can contribute to building conceptual understanding:

(1) In *co-construction*, where ideas from multiple people are presented and generatively lead to new understanding that it would be unlikely for individuals alone to develop, and;

(2) In *transfer*, where a student takes up an idea introduced earlier by another student such that she uses it in her thinking about a new situation.

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ABSTRACT

Background

We have developed several Interactive Virtual Laboratories (IVL) to help students construct conceptual understanding in thermodynamics. We previously analyzed learning in the IVLs from a cognitive perspective seeking to repair students' misconceptions, but that perspective provided us limited information to iteratively improve the IVLs.

Purpose

In this study, we shift to a sociocultural perspective where we identify student learning resources activated during their engagement in the IVL. We seek to identify the productive social and environmental triggers through which students develop conceptual ideas with technology in a social setting.

Method

First, we conducted content analysis on a cohort of 187 students' textual responses as they completed the Thermodynamic Work IVL in a studio setting. Second, we analyzed in detail the discursive and technology interactions of four students in different groups using audio and video recordings.

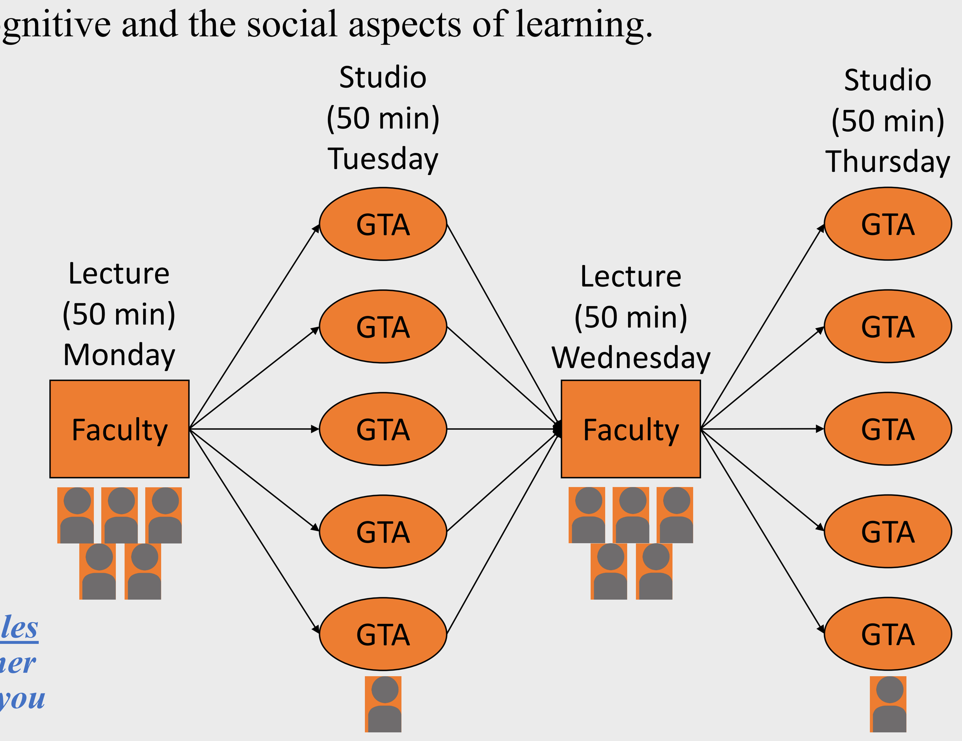
Results

Coding results show students activate different resources during the activity. Almost all of the students demonstrated productive thinking but also almost all were missing key ideas. Through the detailed studies, we illustrate the moment-by-moment interaction of students and technology to provide thick descriptions of how they activate and share resources. These interactions are conceptualized and illustrated through the construct of shared resources. We relate shared resources to processes of knowledge co-construction and knowledge transfer and discuss implications for instructional practice and educational technology design.

Conclusions

The resources framework helps us recognize productive ideas in student's evolving understanding of thermodynamic work. Shared resources allows for elaboration of the interwoven cognitive and the social aspects of learning.

STUDIO



Selected references:

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