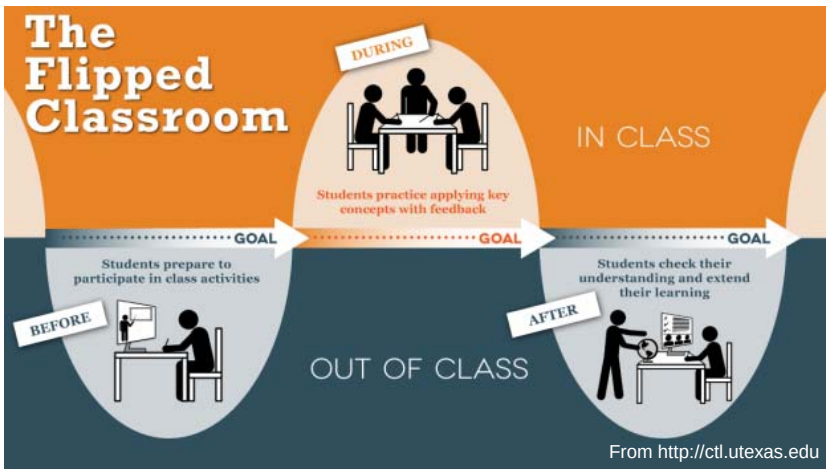
Chemical, Biological & Environmental Engineering

COLLEGE OF ENGINEERING

Strategies for Inquiry-Based Learning Tasks in a Flipped Classroom

Milo Koretsky, Sam Mihelic
Oregon State University

Mike Prince, Margot Vigeant, Katharyn Nottis
Bucknell University



This study investigates ***teaching strategies*** in a flipped classroom directed at cultivating deep conceptual understanding

COLLEGE OF ENGINEERING | Chemical, Biological & Environmental Engineering

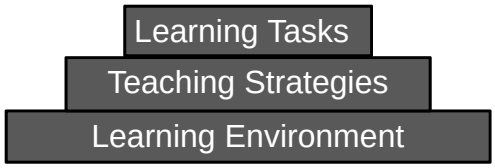
Framework

Learning Environment provides the affordances for activities and support needed for learning.

Teaching strategy guides the overall design and sequence of instructional activities.

Learning tasks comprise the specific activities students are asked to complete to promote conceptual change.

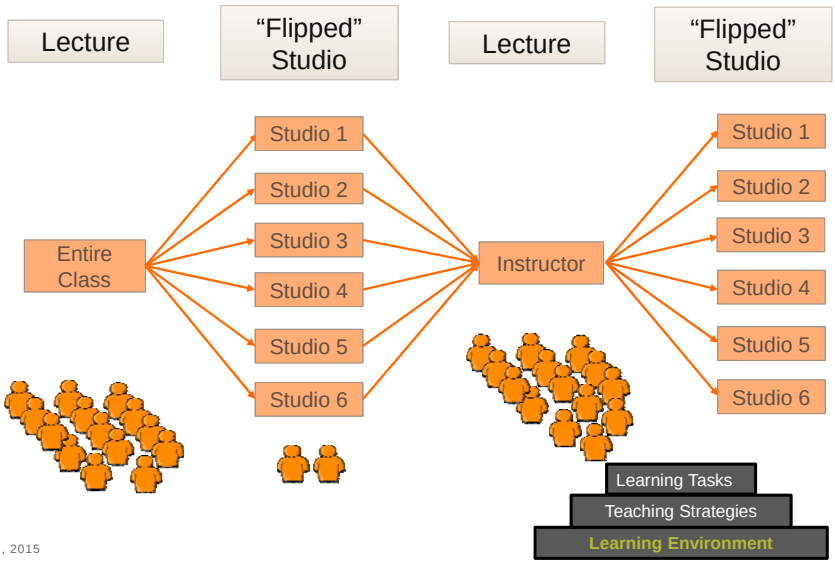
Scott, Asoko, and Driver (1991)



3
6/20/2015

COLLEGE OF ENGINEERING | Chemical, Biological & Environmental Engineering

Learning Environment - Studios



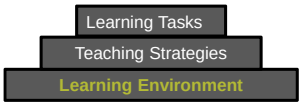
4
June 20, 2015

Learning Environment - Studios

COLLEGE OF ENGINEERING Chemical, Biological & Environmental Engineering

Learning Environment - Studios

- Activity is sustained through completion of a worksheet as students work individually and then in teams.
- Instruction is intended to be “facilitative” with a GTA or instructor circulating around the room and interacting with students and student teams
- Designed to engage all students; help them learn that it is ok to be “stuck” and develop strategies to get “unstuck.”



Chemical, Biological & Environmental Engineering

COLLEGE OF ENGINEERING

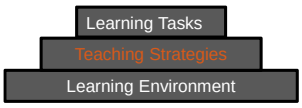
Teaching Strategies

Teaching Strategy: Cognitive Conflict

Cognitive Conflict Mental discomfort produced when the learner is confronted with new information that contradicts her/his prior beliefs and ideas (Posner et al., 1982; Laws, Sokoloff, & Thornton,1999).

The learner will typically seek to reduce this discomfort either by:

- Changing their ideas, or
- By avoiding (e.g. ignoring) the new information.



Teaching Strategy: Analogy

Analogy connects a new concept or topic, the target domain, to situations or experiences which are more familiar, the source analogy (Duit, 1991; Gentner, 1983).

This strategy focuses more on providing scaffolding for students to learn new concepts.

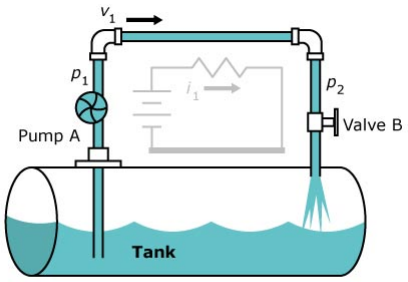
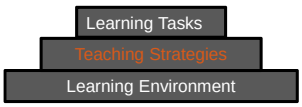


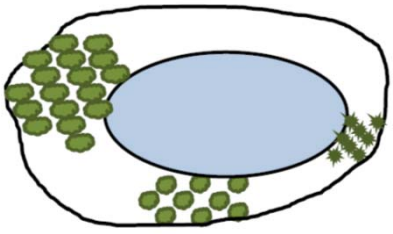
Figure 1—Water circulates endlessly around this closed loop much like elecrical current.



Teaching Strategy: Analogy

- Some instructional designers (e.g., Brown, 1993) argue that analogies are more effective when taken from **concrete examples in everyday life**
- Analogy of children in a school yard facing the possibility of ice cream (source) for Drude's free electron model (target) to promote students' understanding of electric circuits in lower secondary school (de Almeida, Salvador, & Costa, 2014).

Source ***Target***



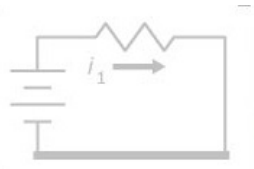
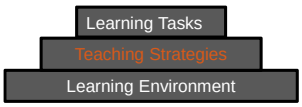


FIG. 1. School yard with a central lake and bunches of trees.

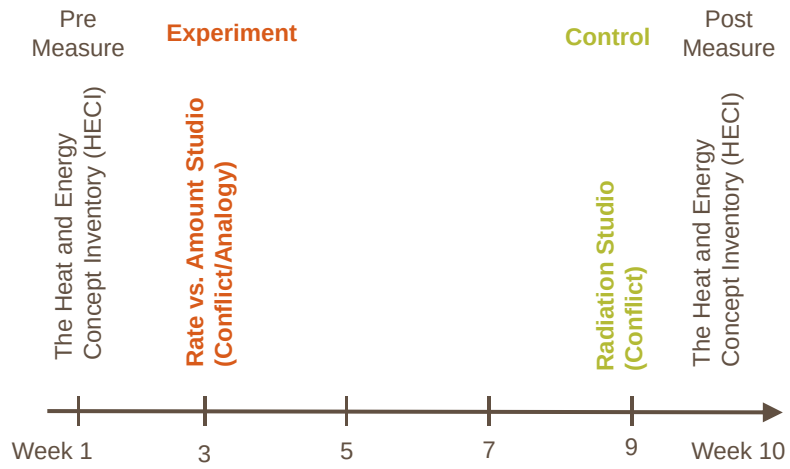


Study Design: Research Question

How do the measured learning gains of the *Rate vs. Amount* concept compare when students complete an inquiry-based activity developed with a cognitive conflict strategy to one developed with an analogy strategy?

***Rate vs. Amount*:**
Failure to distinguish between how **fast** energy transfers and how **much** energy transfers.

Study Design



$$Normalized\ Gain = \frac{\bar{x}_{post} - \bar{x}_{pre}}{x_{\max} - \bar{x}_{pre}}$$

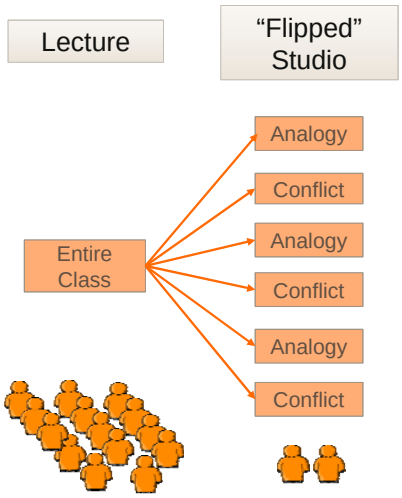
The Heat and Energy Concept Inventory (HECI)

The HECI is a valid and reliable concept inventory (Prince, Vigeant, & Nottis, 2012)

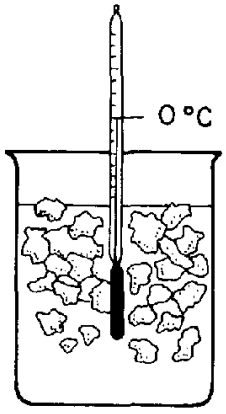
The HECI measures student misconceptions in four categories

1.	Rate vs. Amount (Experiment)	8 items	KR20 = 0.76
2.	Radiation (Control)	11 items	KR20 = 0.75
3.	T vs. Feeling	9 items	
4.	T vs. Energy	10 items	
	Entire Instrument	36 Items	KR20 = 0.85

Study Design

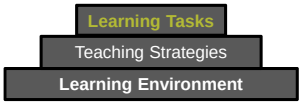


Learning Tasks – Cognitive Conflict



1. Consider adding the same mass of ice, either as a single block or as fine crushed ice particles, to a beverage. Which option will **cool the beverage to a *lower* temperature**? Why? (Answer on your worksheet)

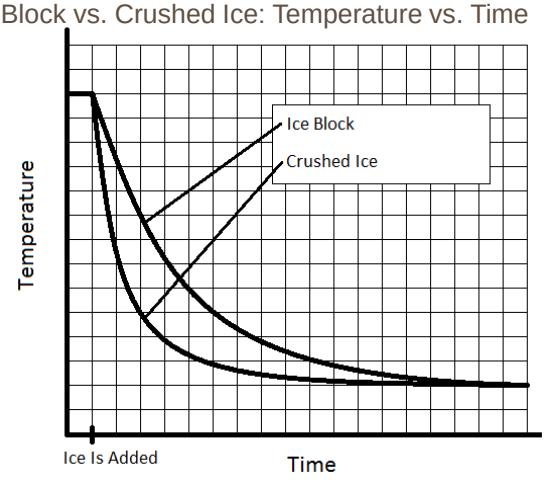
2. Which option, if either, will **cool the beverage more *quickly*?** Why? (Answer on your worksheet)



COLLEGE OF ENGINEERING Chemical, Biological & Environmental Engineering

Learning Tasks – Cognitive Conflict

Ice Block vs. Crushed Ice: Temperature vs. Time

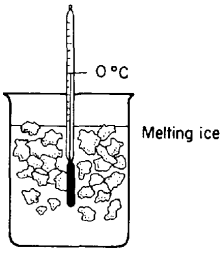


How do your predictions compare with these data?

Football Stadium Analogy

Source → **Target**

Fans



Energy

… You finish your drink and head to the sold-out game. As you wait in line in the scorching sun, you begin to think that the problem of cooling your drink is not a whole lot different than the problem of entering the stadium. How could you redesign the stadium to **fit more fans**? How could you redesign the stadium so that **fans are able to enter more quickly**?

17
June 20, 2015

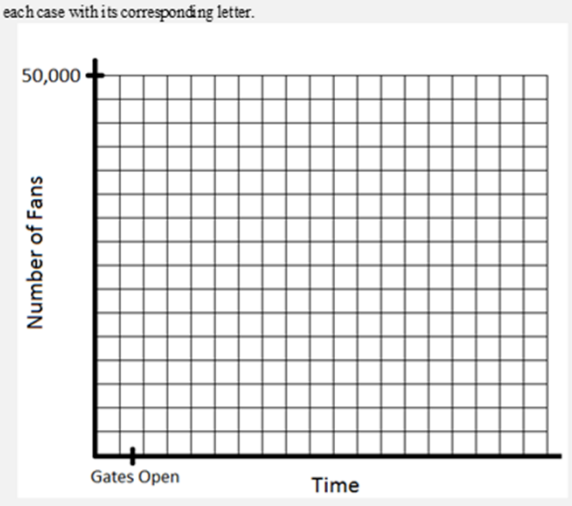
OSU Oregon State University

COLLEGE OF ENGINEERING | Chemical, Biological & Environmental Engineering

On the graph below plot the number of fans inside the stadium vs. time for the following cases:

A. 25,000 seat stadium with 5 gates
B. 25,000 seat stadium with 25 gates
C. 50,000 seat stadium with 5 gates
D. 50,000 seat stadium with 25 gates

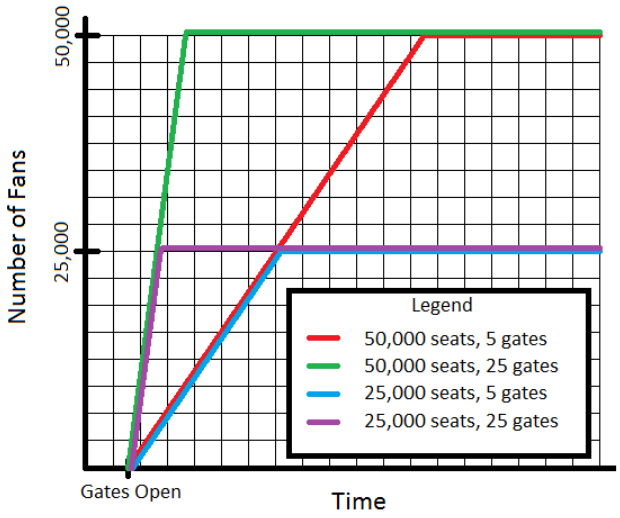
Label each case with its corresponding letter.



18

COLLEGE OF ENGINEERING | Chemical, Biological & Environmental Engineering

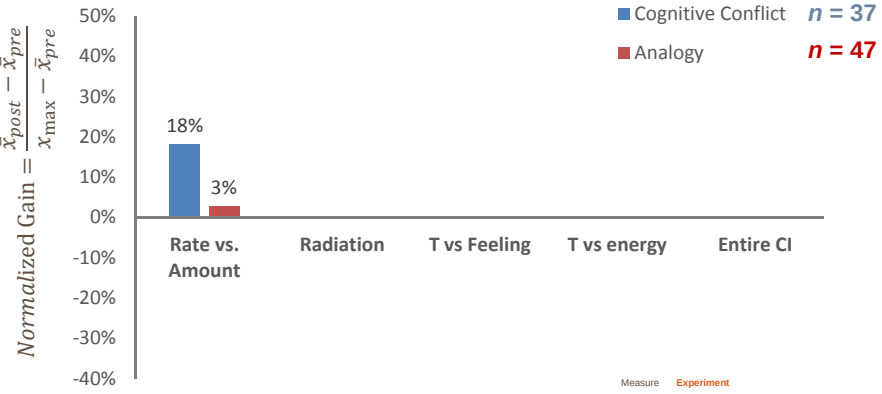
Analogy Model - Solution

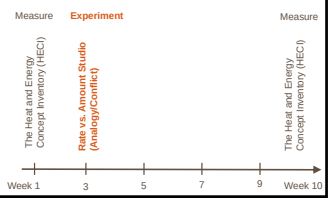


COLLEGE OF ENGINEERING | Chemical, Biological & Environmental Engineering

Results: Normalized Gain

$$Normalized\ Gain = \frac{\bar{x}_{post} - \bar{x}_{pre}}{x_{max} - \bar{x}_{pre}}$$

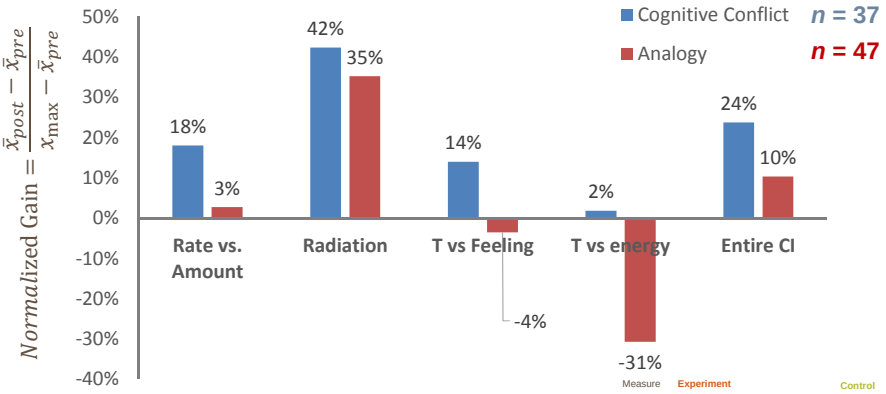


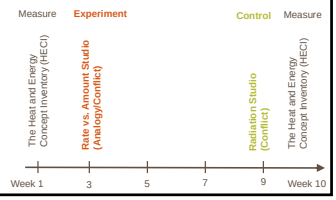


COLLEGE OF ENGINEERING | Chemical, Biological & Environmental Engineering

Normalized Gain

$$Normalized\ Gain = \frac{\bar{x}_{post} - \bar{x}_{pre}}{x_{\max} - \bar{x}_{pre}}$$





ANCOVA: **Significant** main effect for intervention group with a **small effect size** [$F\ (1, 84) = 4.99$, $p < .05$, partial $\eta^2 = .06$]

COLLEGE OF ENGINEERING | Chemical, Biological & Environmental Engineering

Gender bias in the analogy?

Average Scores (questions correct) of the eight *Rate vs. Amount* items of the HECI

		Post HECI $\overline{x}_{post}$	Pre HECI $\overline{x}_{pre}$	Number of students
Cognitive conflict	Female	3.2	1.3	11
	Male	4.4	4.2	26
Analogy	Female	3.9	3.5	21
	Male	3.8	3.9	26

Univariate ANCOVA which controlled for pre-test scores indicates no significant main effect for gender.

Discussion

- Cognitive conflict strategy appears slightly more effective than the analogy strategy
- Improvement in both conditions is similar to change observed in “normal instruction” with no special intervention.
- Gains of the radiation activities are similar to that observed with inquiry-based activities.

Plausible Explanation

- Temporal component where learning gains are stronger in proximity to the activity
- Prerequisite course, “Energy Balances,” which is taught using concept-based instruction and would cover concepts related to both rate of energy transfer and amount of energy transfer. Thus the higher pre-HECI scores on the Rate vs. Amount scale could actually be from learning gains in this prior course.
- The interventions presented in this study consisted of thought experiments rather than hands-on or simulation activities. We conjecture that the students in Energy Balances who are better abstract thinkers would be disproportionately likely to conceptualize the differences in rate vs. amount from that prior course.

A recommendation

- The analogy activities in this study may be improved by having students generate their own analogies. However, such a task would take additional time.

Acknowledgments

We are grateful to funding from the National Science Foundation under grant DUE 1225221 and 1225031

*Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Questions?