

Why Direct Instruction Earns a C- in Transfer

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Over
there



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Outline

- ☐ Why direct instruction fails to transfer.
 - ☐ Why it matters.
 - ☐ What can be done about it.
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Why Direct Instruction Fails to Transfer

- ❑ Many techniques for improving memory.
 - ❑ Fewer techniques for improving knowledge of situations that might call for those memories.
 - ❑ But, we know a necessary condition for useful transfer...
 - Knowledge of deep structures that generalize across incidental differences.
 - Appearances can obscure deep structures.
 - ❑ Some have found that we should exclude surface features by presenting relatively abstract lessons.
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Why Direct Instruction Fails to Transfer

- ❑ Issue of surface features at learning is due to direct instruction, not just surface features.
 - ❑ Typical Direct Instruction model: Tell-and-Practice.
 - 1. Students are told what to do or think.
 - ❑ Lecture; worked example; written instructions; etc.
 - 2. Students practice on a set of cases.
 - ❑ Word problems; visual problems; readings; etc.
 - ❑ Students focus on procedure.
 - They encode procedure and the obvious surface features of cases.
 - Never encode the deep structures (why bother looking for them?)
 - No deep structures, no transfer.
-



Methods

- Topic: Speed and Density – deep ratio structure.
 - Four science classes totaling 120 high-diversity 8th-graders.
 - Each class split (stratified random assignment)
 - Half received Tell-and-Practice treatment.
 - Half received “Control” treatment (Invent).
 - Study spanned 28 days (but only 4 days of instruction).
 - Class level explanations.
 - Small group seat work.
 - Assessments done in “test” mode.
 - Following effects occurred for all four classes.
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Lessons

Tell-and-Practice

Invent

Density Explanation
+ Worked Example

Index Explanation

Work on Clown Cases



Day 1 (Mon)



Tell & Practice

Density is how much stuff is packed into a space. Density can be the number of people in a room, the density of feathers in a pillow, and many other things.

Density is very important in chemistry. Density is a property of **matter**. Gold is denser than carbon, because more matter is packed into each atom of gold compared to each atom of carbon.

When working with density, the trick is to use the simple equation:

$$D = \frac{M}{V} \quad \text{or} \quad \text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

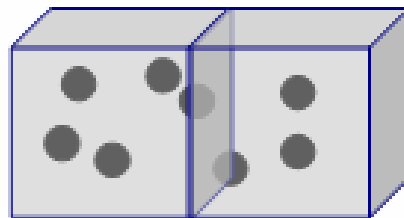
Density is a measure of the mass of a substance per unit of volume.

Sometimes **Mass** can be found by counting.

Volume is the amount of space. Volume is harder to find, because a volume can take many shapes – a sphere, a balloon, a bottle.

To make it easier, we will tell you the volume. We will measure it in cubes.

In the example below, there are two cubes. There are 8 objects spread across the cubes. Density is the average number of objects per unit of volume.



Density = mass / volume
= 8 objects / 2 cubes
= 4 objects / cube
= 4 objects per cube

Control: Inventing an Index

An **index** is a number that helps people compare things.

Miles per gallon is an index of how well a car uses gas.

Batting average is an index of how well a baseball player hits.

Grades are an index of how well you are doing in school.

Star rating is an index of how efficient an electrical appliance is.

We want you to invent a procedure for computing one kind of index.

THE CROWDED CLOWNS INDEX

Companies send clowns to parties, circuses, amusement parks, sporting events, and so on.

To get the clowns to the event, each company packs the clowns into a bus.
Some companies make the clowns more crowded than other companies.

The more crowded the clowns are, the grumpier they will be.

People who order clowns want to know a company's crowded clown index.

Invent a procedure for computing a crowded clown index for each company



RULES FOR THE INDEX

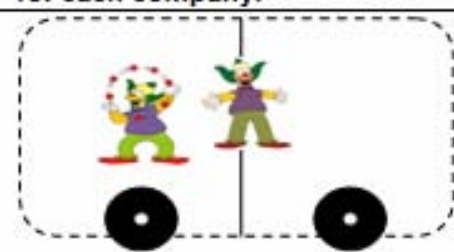
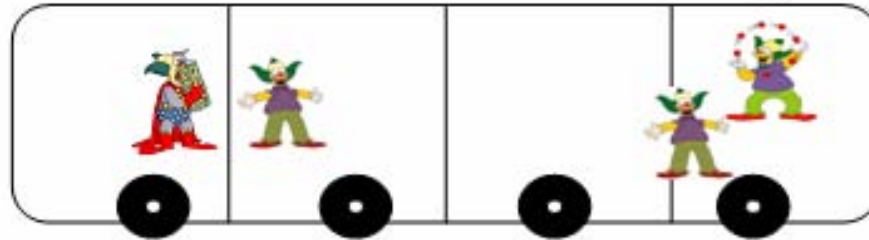
1. The same company always crowds the clowns the same amount, no matter how many clowns get ordered. So a company only gets a single crowded clown index.

2. You have to use the exact same procedure for each company to find its index.

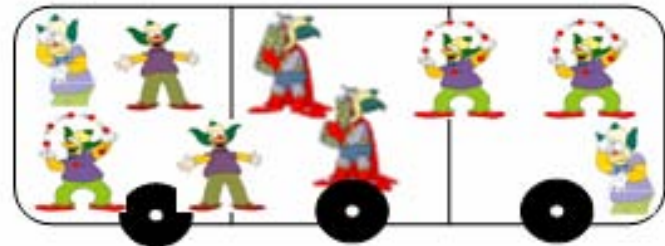
3. A big index value should mean that the clowns are more crowded. A small index number should mean that the clowns are less crowded.

- The Cases:
- a) Practice Density.
 - b) Invent an Index.

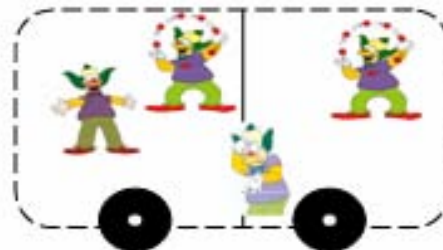
Clowns 'r Us = _____



Bargain Basement Clowns: = _____



Krusty Clowns = _____



Lessons

Tell-and-Practice

Invent

Density Explanation
+ Worked Example

Index Explanation

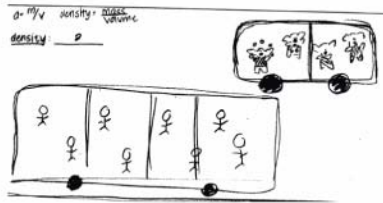
Work on Clown Cases



Day 1 (Mon)



Clown Cases
Free Recall



Day 2 (Tues)



Coded Recall for:

Deep Structure
Proportionate Ratios

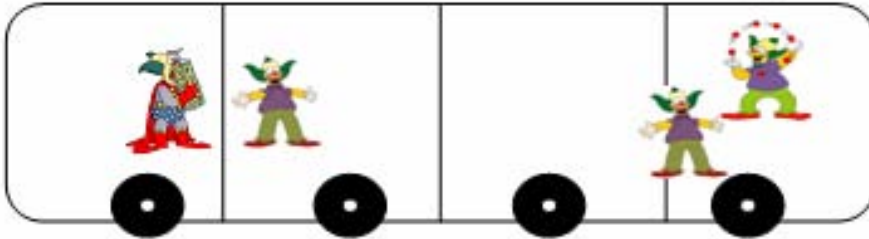
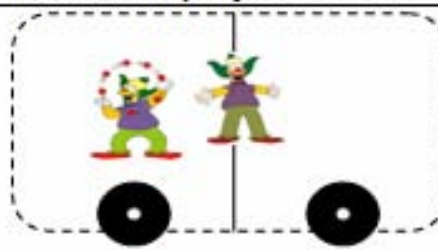
(3 pts possible)

Surface Features

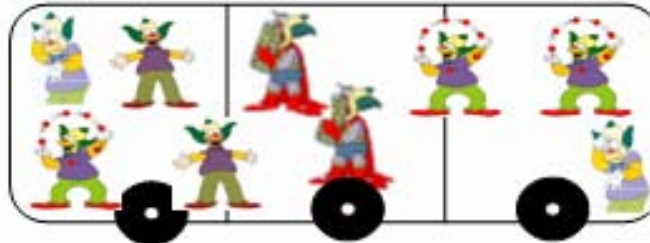
- Clown elaboration
- Clowns on lines
- Bus outline
- Wheels (not on count)
- Excessive text recall
- “Krusty clowns...”

(6 pts possible)

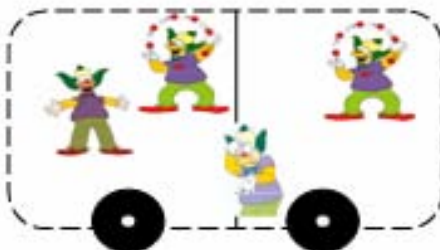
Clowns r Us = _____



Bargain Basement Clowns: = _____



Krusty Clowns = _____

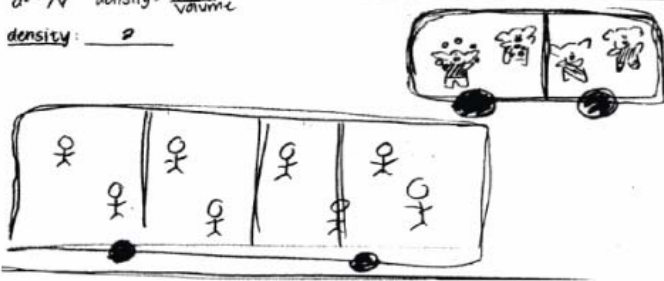




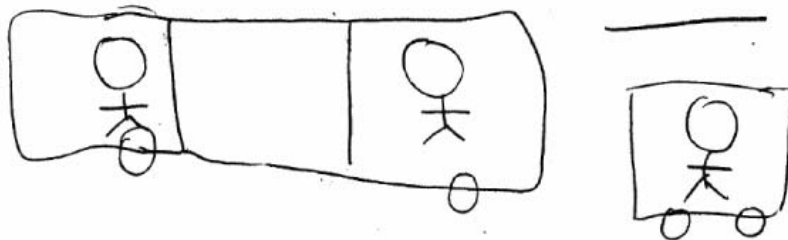
Encoding Results

High Structure and High Surface

$d = m/v$ density = $\frac{\text{mass}}{\text{volume}}$
density: 2



Low Structure and Low Surface



Average Elements Recalled

3

2

1



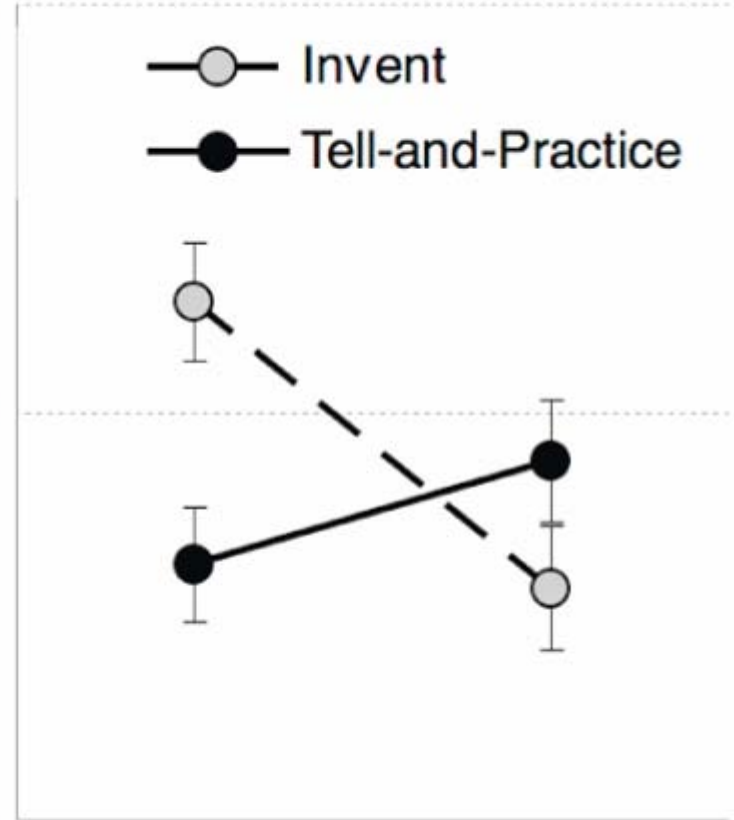
Invent



Tell-and-Practice

Deep
Structure

Surface
Features





Review of First Results

- ❑ Students in Tell-and-Practice only encoded surface features.
- ❑ Students in Invent condition encoded ratio structure and surface features.
 - Surface and deep were not trading off.
 - ❑ ($r = -.08$)
- ❑ Instruction also had consequences for transfer.

Lessons

Tell-and-Practice

Invent

Density Explanation
+ Worked Example

Index Explanation

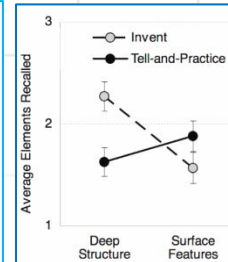
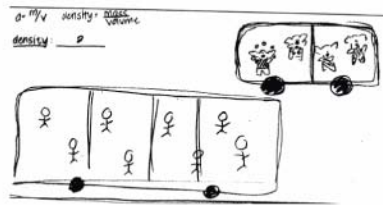
Work on Clown Cases



Day 1 (Mon)



Clown Cases
Free Recall



Day 2 (Tues)

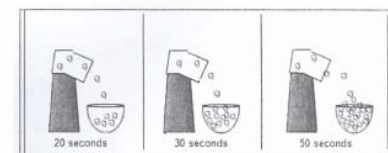
Tell & P

Invent

Lecture on Ratio.
Speed Explanation
+ Worked Example

Popper Intro

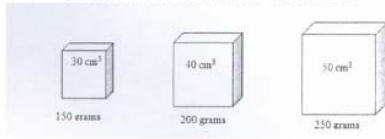
Work on Popper Cases



Density Explanation
+ Worked Example

Gold Purity Intro

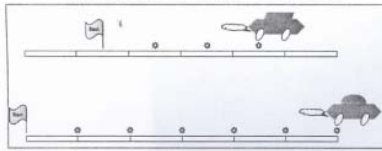
Work on Metal Cases



Speed Explanation
+ Worked Example

Car Speed Intro

Work on Car Cases



Day 5 (Fri)





By this time...

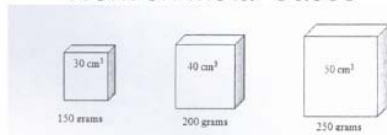
- Tell & Practice had received:
 - 2 x 2 ratio analogs
 - Density and Speed
 - Continuous and Discrete versions
 - Explicit instruction that ratio is an important structure in physics.

 - Transfer still poor.
-

Density Explanation
+ Worked Example

Gold Purity Intro

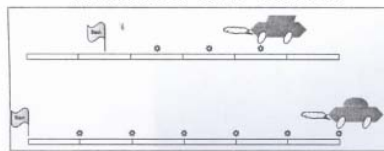
Work on Metal Cases



Speed Explanation
+ Worked Example

Car Speed Intro

Work on Car Cases

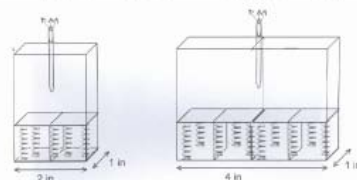


Day 5 (Fri)



Day 8 (Mon)

Transfer
(Surface Pressure)



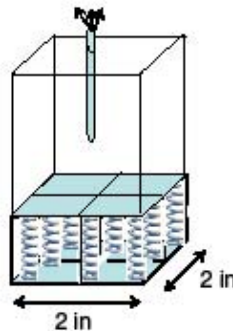
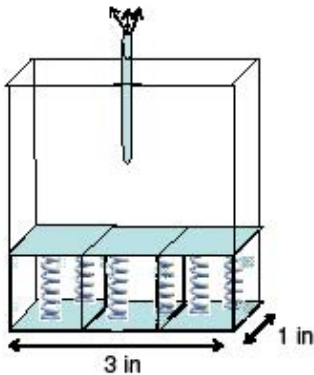
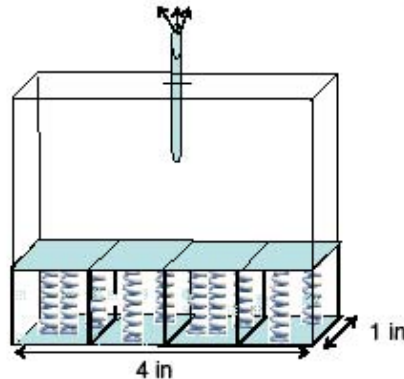
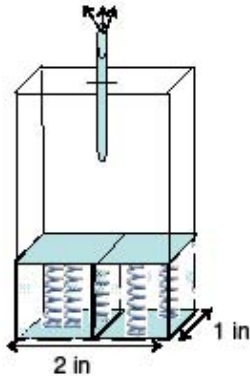


Name _____

Period _____

Two companies make aerosol containers for people who produce paint, bug spray, air freshener, and other products. Aerosol cans have pressure that pushes the spray out through the nozzle. Describe the *pressure* that each company uses in their aerosol cans.

Company #1



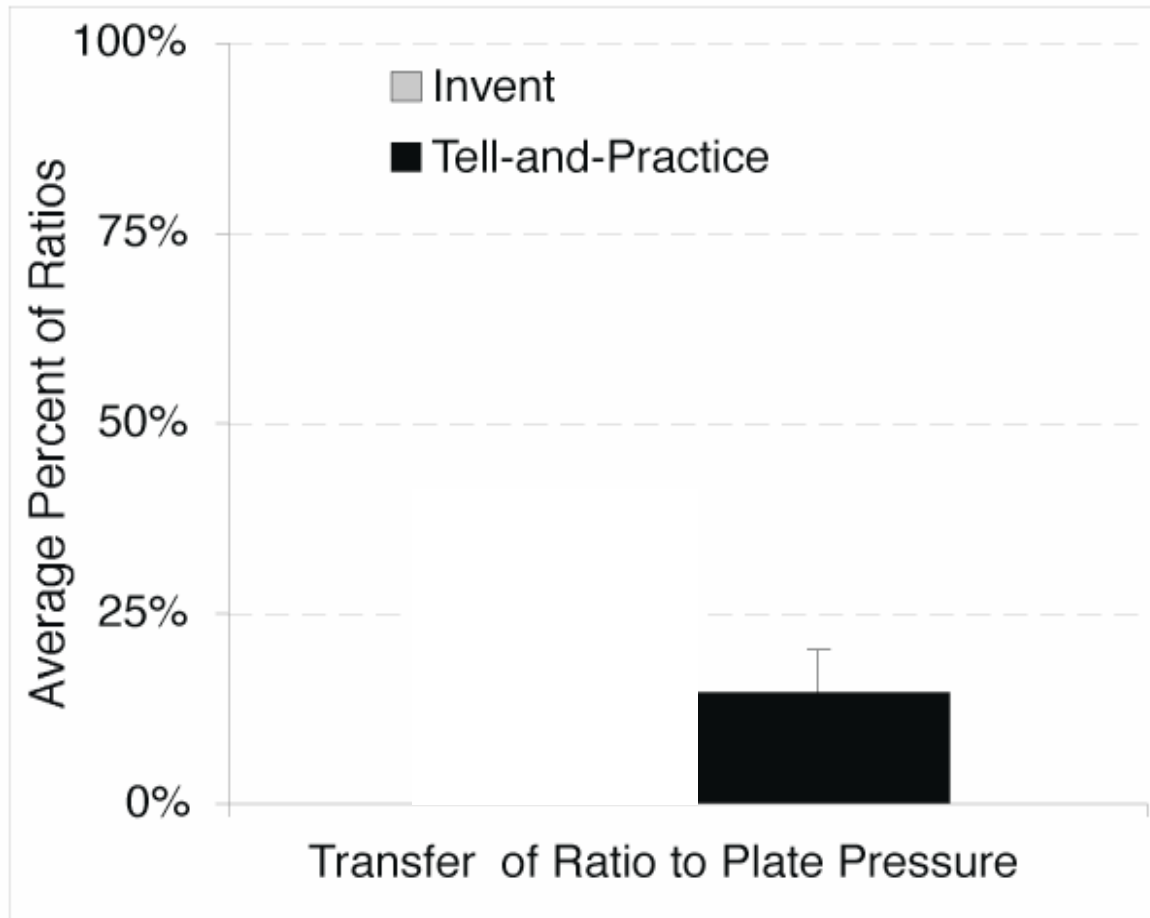
“Describe the pressure that each company uses in their aerosol cans.”

Surface pressure on plates is ratio of Springs (force)/Area.

Coded for use of ratio in description.
(4 pts = 100%)



Transfer Results





Direct Instruction

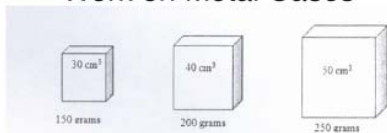
- Problem is not direct instruction *per se*.
 - Telling people things is important!
 - Problem occurs when direct instruction shortcuts need to see deep structure of cases.
 - Direct instruction is fine if it happens after students have a chance to engage structure.
-



Density Explanation
+ Worked Example

Gold Purity Intro

Work on Metal Cases



Speed Explanation
+ Worked Example

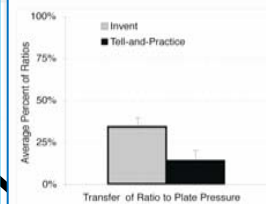
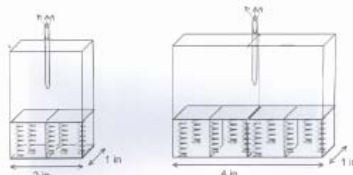
Car Speed Intro

Work on Car Cases



Day 5 (Fri)

Transfer
(Surface Pressure)



Day 8 (Mon)

1. Time = 3 hours. If speed = 36 mph, what is the distance traveled?

2. Brenda packs 120 marshmallows into 4 soda cans. Sandra packs 300 marshmallows into 11 soda cans. Whose soda cans are more densely packed?

Extra
Word Problems

Lecture on Ratio.
Speed Explanation.
Density Explanation.

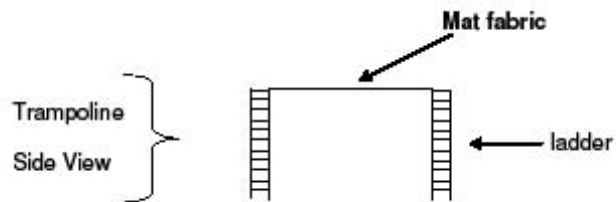
Work on Word Problems



Quantitative & Qualitative Test
Delayed Transfer (Springs)



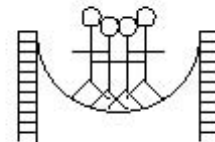
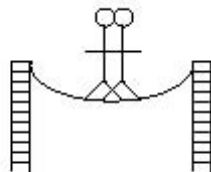
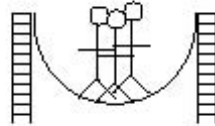
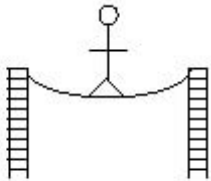
Day 29 (Mon)



Trampolines are made with mats using different fabrics.

Stiffer mats make the trampoline bouncier.

Determine the stiffness of the mat fabric for each trampoline.

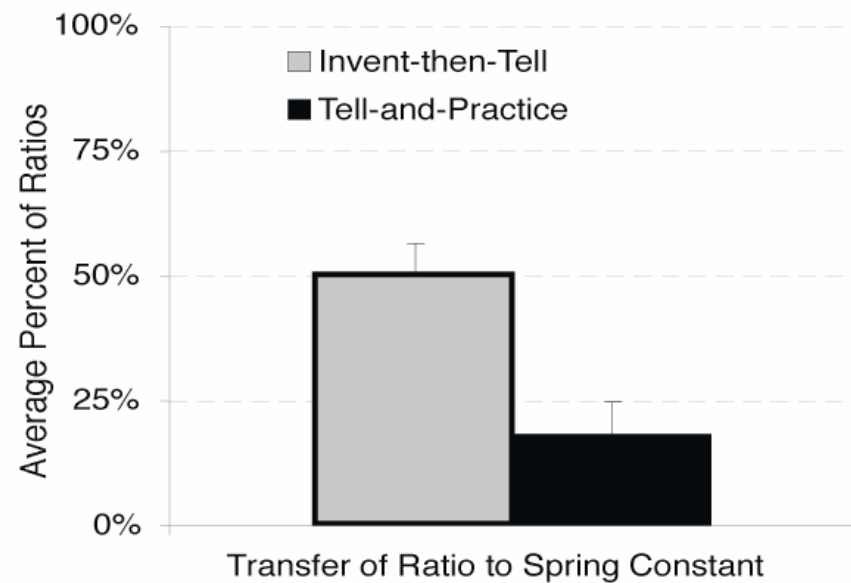


“Describe the stiffness of the mat fabric for each trampoline.”

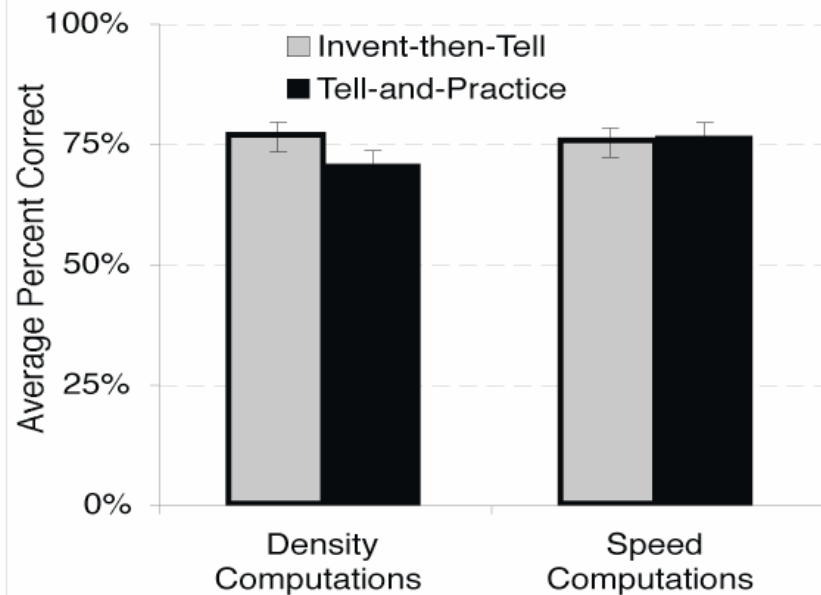
Application of spring constant ratio of stretch by people (weight)

No mention of “companies” or paired cases.

Coded for use of ratio in description.
(4 pts = 100%)



Delayed Transfer Rates



Correct Answers for
for Simple Word Problems



Density as discrete objects per volume (clowns)

Free Recall of Clowns Worksheet

Ratio Lecture for **Tell & Practice**

Speed as discrete events over time (popcorn)

Density as continuous weight over volume (gold)

Speed as continuous distance over time (cars)

Transfer test on surface pressure (aerosol)

Ratio, speed, density lecture for **Invent**

Word problem practice

Transfer test on spring constant (trampoline)

Qualitative and qualitative word problem test



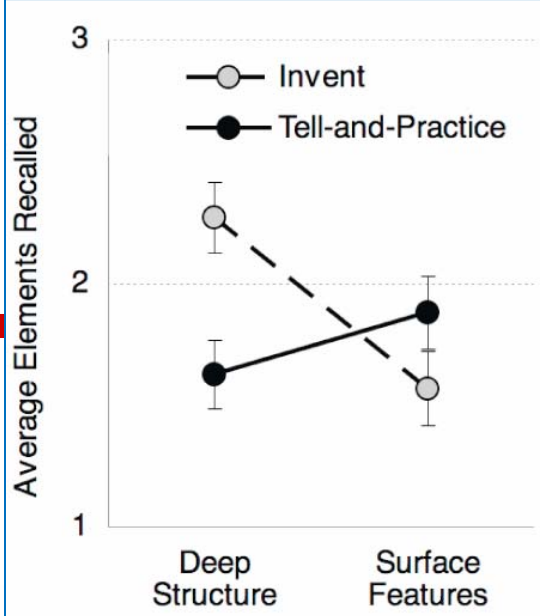
Treatment in effect.
(same problem cases)



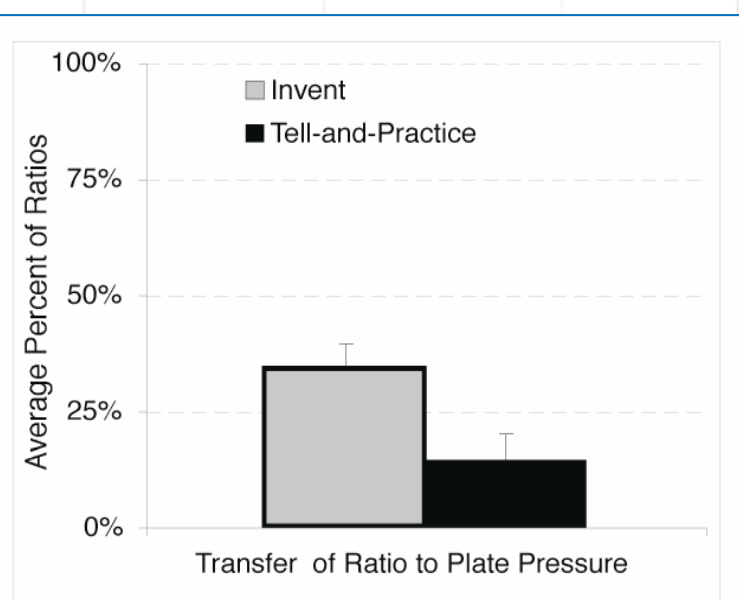
Measurement point.



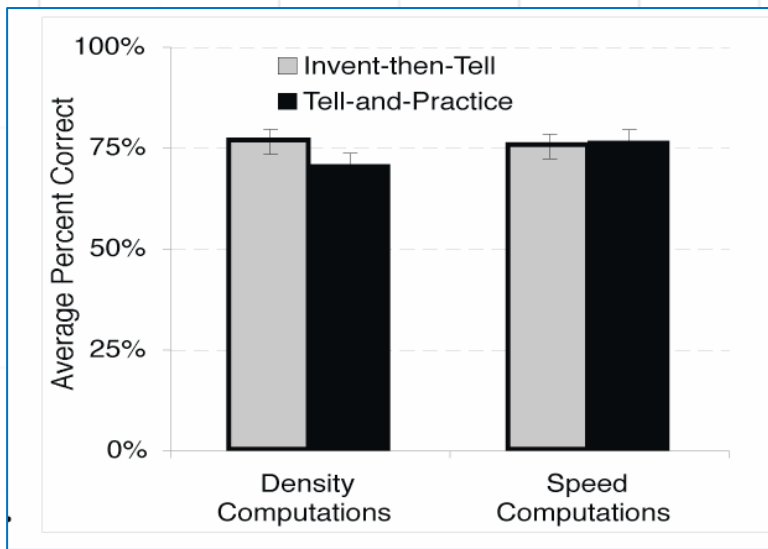
Lecture on ratio in science
(same content)



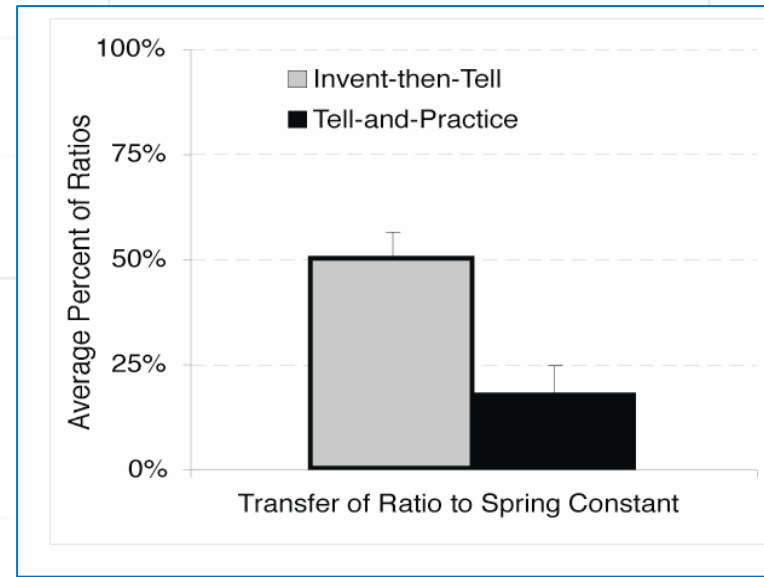
Memory 24 hours later



Transfer before Invent is “told”



Delayed word problem test



Delayed transfer after Invent is “told”

Across conditions, students who encoded the structure were twice as likely to transfer.



Why does direct instruction earn a C- ?

- Articles in Web of Science using transfer measures in the past 5 years.
 - 75% used Tell-and-Practice for treatment and control.
 - Of those that used only Tell-and-Practice, 40% did not mention method of instruction in the abstract.
 - Impressive numbers indicate entrenchment of Tell-and-Practice.
 - Direct instruction is the average.
 - It makes sense that surface features appear to be a problem.
 - But the average transfer results still earn less than a “C”
 - Research on informal learning (and some education) has repeatedly said...
 - The context of psychological research matters for educational questions.
 - Should not assume “all things equal,” and manipulate favorite variable.
 - Cognitive research for education can do better. C-
-



Outline

- Why direct instruction fails to transfer.
 - □ Why it matters.
 - What can be done about it.
-



Why transfer matters.

- For stable domains and contexts, it does not.
 - Reading always occurs with spaces between words, left-to-right on the page.
 - Does anybody fail to transfer decoding when given a text?
 - Goal is Hatano's *Routine Expertise*

 - For variable contexts that cannot be exhaustively taught, transfer does matter.
 - “Fast-changing technological world” thing.
 - Goal is Hatano's *Adaptive Expertise*.
 - Especially important to transfer for learning.
-



Preparation for future learning

- Inventing activities prepared students to transfer for future learning.
 - Kids of this age have intuitions about pressure and springs.
 - Invent students began learning they are relational concepts at transfer.
 - Tell-and-Practice students tended to think in single features.
 - Trampoline stiffness as stretch but not weight.
-

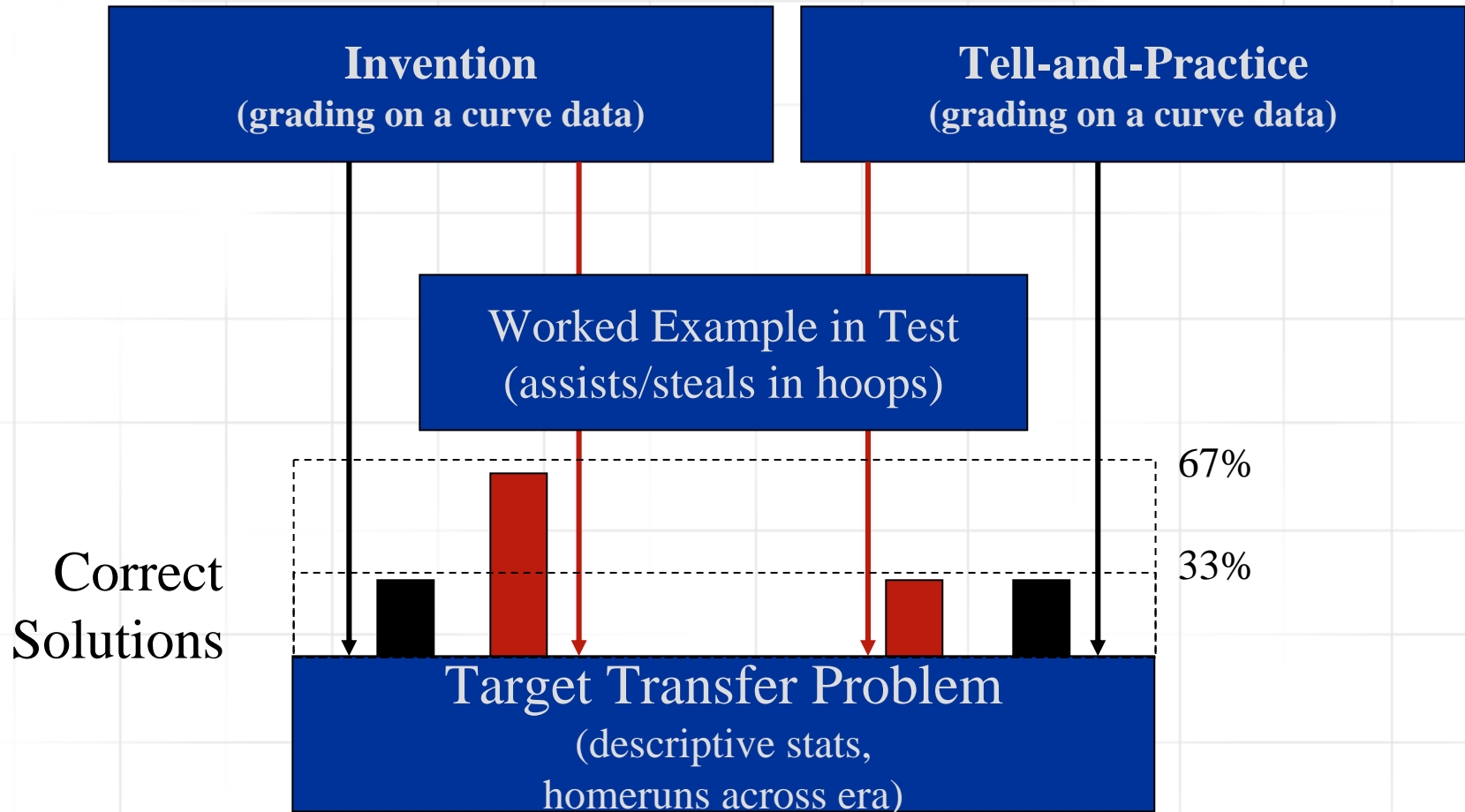
A better demonstration

(w/ Taylor Martin)



- ❑ Crowded clowns study designed to show limitations of direct instruction
 - Modest demonstration of how transfer can support learning.
 - ❑ A better demonstration.
 - 9th-graders had completed a couple of weeks on statistics.
 - Last lesson involved normalizing data.
 - Received data for grading on a curve.
-

Replicated study with 100's of high school students learning statistics.





One reason transfer matters

- ❑ Transfer can help students learn from expository materials that run through school (and beyond).
 - ❑ Good activities can create a time for telling.
-



Outline

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-



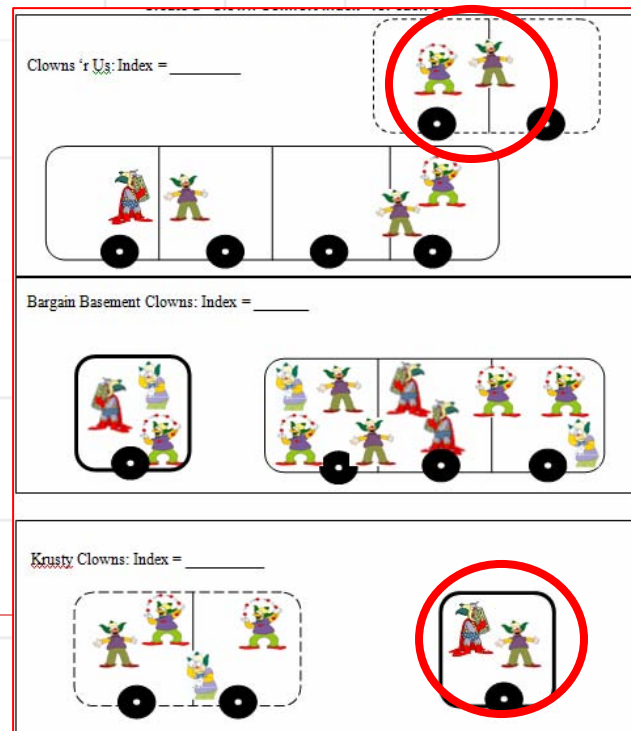
What can be done about it -- #1.

- ❑ Many alternatives to tell-and-practice.
 - Inquiry-, project-, problem-based.
 - ❑ Inventing differs.
 - Does not replace direct instruction.
 - Complements it.
 - ❑ Elements of good invention activity...
-



Contrasting cases.

- Highly structured cases make tasks brief.
 - Help students discern differences,
 - and find deep structures amidst them.





Inventing compact representations

- ❑ Contrasting cases important but not sufficient.
 - Tell-and-Practice received crowded clowns.

 - ❑ Inventing activity
 - Orients students to deep structure that generalizes across cases.
 - Need to create compact representation prepares students to appreciate elegance of expert solution.
-



What can be done about it -- #2.

- Change our current assessment practices.
 - Current measures play into folk psychology of what counts as learning, and instructors follow it.
 - More of our chemistry students are learning much better than they used to when we used the traditional textbook/lecture/recitation pedagogy. We base our assessment on the dropout rate at semester and on the students' performance on the American Chemical Society HS Chemistry Exam. However, we face a continual pushback from parents that want us to teach the way they themselves were taught. These are usually parents who are engineers, doctors, and scientists - the folks for whom a traditional method "worked just fine, thank you." They want to be able to refer to a text book for problem examples and then show their children how "to do" such a problem. There seems no room in their worldview to accommodate the 50% of students for whom the traditional pedagogy is a huge failure. Most of these pushback folks see chemistry as a filter that only allows the brightest through - and honestly, this may be a comforting view if you happen to be one of the people who made it through! Unfortunately, not all of their progeny are in the correct 50% to make it through.
- Need new metrics of meaning.

Metrics of Meaning.

(w/ John Bransford)



- Standard educational assessments emphasize sequestered problem solving.
- A better metric is preparation for future learning assessments (PFL).
 - Include opportunities to learn in the test, and see if students transfer to learn.
 - It is what we really care about for much of education... did school prepare students to learn once they leave the confines of school.
- Lots of ways to develop PFL, especially with new technologies...
 - A reduced web to find information during the test.
 - Simulations to use during the test to help answer problems.



Summary

- Why does direct instruction fail to transfer?
 - It orients students towards instruction and not situation.
 - Why does it matter?
 - Transfer helps people learn from future opportunities.
 - What can be done?
 - Simple inventing activities that prepare students to learn and transfer.
 - Change educational assessments to be better metrics of meaning, and instruction will follow..... hopefully.
-



Conclusion

- Time to eat and drink.... Please?
 - Thank you.
-



	Surface Area (Aerosol)			Spring Constant (Trampoline)	
	Invent	Tell-Practice		Invent-then-Tell	Tell-Practice
Physical Ranking	35%	15%		51%	25%
Quantities extracted into numbers	1.3	0.8		1.2	0.8
Factors in Description	1.2	1.0		1.4	1.1