A Comparison of Two Instructional Models Using Contrasting Cases

Min Chi, Doris B. Chin, Nicole Hallinen, Daniel L. Schwartz
Stanford University School of Education

Introduction

- By using computer simulations, students experiment in physics topic areas, creating 'contrasting cases' of results.
- Juxtaposing multiple cases or instances of a phenomenon in instruction can positively influence learning & transfer.
- Inventing a general solution to explain the structure in these phenomena is an effective learning strategy.[1]
- Invention uses specific examples that highlight key features and implicitly asks students to compare and contrast across the cases.

Is Compare & Contrast alone enough?

- We hypothesize that Compare & Contrast is necessary for inducing structure, but not sufficient.

Methods

Participants

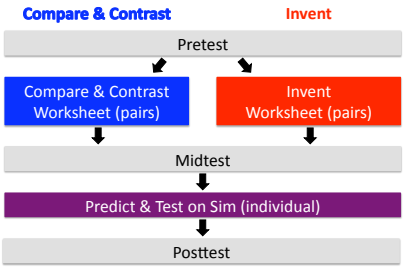
- Two 6th-grade advanced math classes from two high-SES schools with the same math teacher
- Intact classes randomly assigned to the two treatments:
  Invent (n = 19)
  Compare & Contrast (n = 21)
- No significant difference between classes ($p \geq 0.55$, teacher test grades)

Learning Context

- PhET Projectile Motion sim[2]
- Content: Projectile motion with no air resistance, distance = rate * time

Procedure

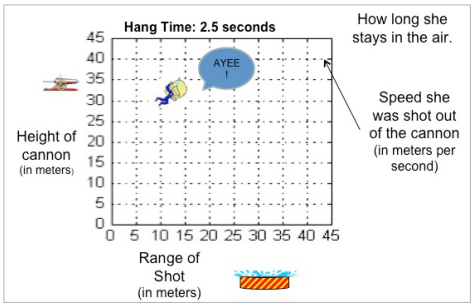
- Study sessions took place on consecutive Fridays during class time (50 minutes per period). Students completed worksheets for 15 minutes.

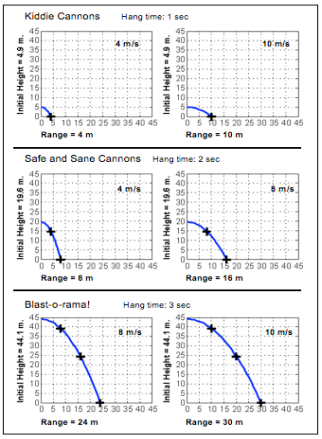


Instructional Materials: Contrasting Cases

- Both conditions received the same cover story and contrasting cases.

Cover story: an amusement park shoots visitors out of cannons. Figure out the right place for the water tank such that each visitor has a good landing!





- With the contrasting cases, each group received a different task orientation.

Invent

"Invent a single method to figure out where to put the pool no matter which company and speed a visitor chooses."

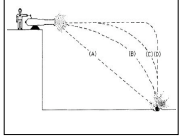
Compare & Contrast

"Compare and contrast the examples and companies. Explain the similarities and differences."

Results

- Two assessments were administered:

A. Which of the shot paths in the diagram below best represents the path of the cannon ball?



Pre- and Post (FCI item)

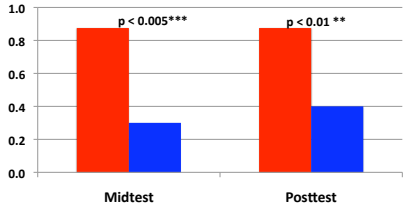
B. A bowling ball is shot out of a cannon straight out at a speed of 18 m/s. The cannon is at a height of 11 m. The ball has a mass = 9 kg and diameter = 0.3m. The ball lands in 1.5 seconds. There is no air resistance.

i) How far does the ball go before landing (what is its range)? _____

ii) How do you know?

Mid- and Post

- FCI Item: Both groups at ceiling on pre- and post-tests
- Mathematical Assessment: **Invent** significantly outperformed **Compare & Contrast**.



Why Does Inventing Work?

- To further investigate the effects of the task orientation (**Compare & Contrast** vs. **Invent**), students' responses on the contrasting cases worksheets were coded based on the number of physics factors involved.

Code	Example Student Statements	Average Number of Statements*	
		Compare & Contrast	Invent
Zero Factor	They are different companies. They are all cannons.	0.5 (SD = 0.71)	0 (SD = 0)
Single Factor	They start at different heights. They go different speeds	3.0 (SD = 1.05)	0 (SD = 0)
Double Factor	More speed = further distance More height = further	0.9 (SD = 1.28)	0 (SD = 0)
Triple Factor	d=rt(distance=rate X time) To find where the person will land, you multiply the hang time by how many meters per second.	0.1 (SD = 0.32)	1.0 (SD = 0)

* Significant difference between groups on each type of statement, $p < 0.01$

- In general, **Compare & Contrast** led students to produce mostly single-factor statements
- The **Invent** treatment led to the production of the triple-factor statement.
- Production of the triple-factor statement was found to correlate with performance on the assessment items.

Conclusions

- **Invent** outperformed **Compare & Contrast**.
- Asking students to find the similarities and differences across cases leads them to notice discrete, surface features of the cases. **(Compare & Contrast)**
- To get strong learning effects, students still need to be encouraged to produce a comprehensive explanation of the similarities and differences; that is, they must be tasked with finding an underlying structural similarity that explains all contrasting cases. **(Invent)**
- Compare and contrast is necessary but not sufficient for noticing mathematical structure in experimental results.

The study was replicated the next year using random assignment to condition.

- Again, **Invent** outperformed **Compare & Contrast** on test items and Triple Factor generation.
- The production of Triple Factor statements led to higher *quantitative & qualitative* problem solving.

References

1. D.L. Schwartz, C.C. Chase, M.A. Oppezzo, and D.B. Chin. "Practicing versus inventing with contrasting cases: The effects of telling first on learning and transfer." *Journal of Educational Psychology*, **103**(4), 759-775 (2011).
2. http://PhET.colorado.edu