Knowing When It No Longer Works: One Benefit of Inducing a Solution

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Introduction

- A goal of instruction across domains is to promote transfer to new contexts [1,2]
- A risk is negative transfer
  - Overgeneralization of methods to contexts where they no longer fit [3,4]
- Inventing to learn has been shown to lead to positive transfer as compared to tell & practice [5]

Will inventing a solution buffer against negative transfer?

- Hypothesized mechanism:
  - Inventing a solution may help learners link symbols and operations to their referents.
  - Tell & practice may lead to knowledge of the symbolic procedure without an understanding of how it applies to the referent.

Learning Content: The Polygon Problem

What is the perimeter of a row of regular polygons? (The length of each side of the polygons is 1.)
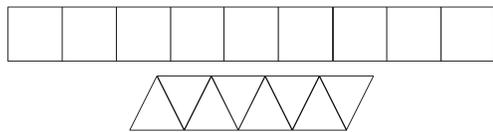
- Algebra problem describing a linear growth pattern
- Used in curricula and professional development [6]

- Can be solved by counting or using a formula that accounts for varying numbers and types of shapes

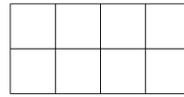$$(s - 2) * n + 2$$

$$(6-2) * 4 + 2 = 18$$

Design

- 54 self-paced trials in 3 blocks
- 3-10 shapes per row with 3-6 sides
- Trials presented in a fixed random order
- 2 instructional conditions, between-subjects

Procedure

Invent-Tell Condition	Count	Induce Formula	Use Given Formula
Tell Only Condition	Count	Use Given Formula	Use Given Formula

Transfer Task

- Figure created to test for overgeneralizing
- Task administered after all 3 blocks
- More shared sides; formula must be adapted

2 question formats, between-subjects:
1. Here is a new shape. What is the perimeter?
2. Here is a new shape and here is the formula you have been using. Use or adapt the formula to find the perimeter.

Strategy Code	Example	Answer
Overgeneralize	(s-2)*n + 2	18 ✗
Adapt	(s-3)*n + 4	12 ✔
Other	Counting, etc.	12 ✔

Study 1

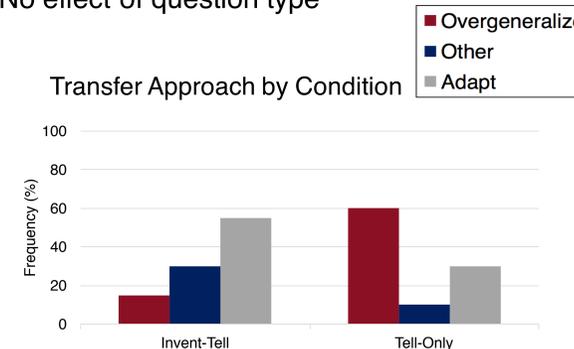- 40 participants from research university paid pool: undergrads, grads, community members

Study Task Results

- Invent-Tell: 85% found a formula
- No condition differences on blocks 1 or 3
- Block 2: Inventing formula slower than applying given formula
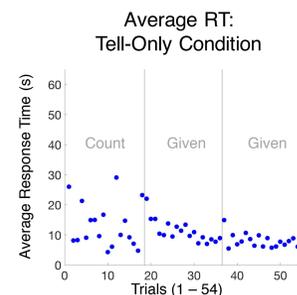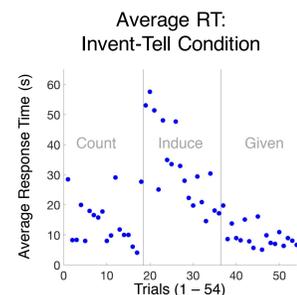
Transfer Results

- Invent-Tell participants less likely to overgeneralize formula than Tell-Only $\chi^2 (2, N = 40) = 8.87, p = .01$
- No effect of question type

Average RT: Invent-Tell Condition

Average RT: Tell-Only Condition

Transfer Approach by Condition

Study 2

- 72 participants from research university credit pool: undergraduate psychology students
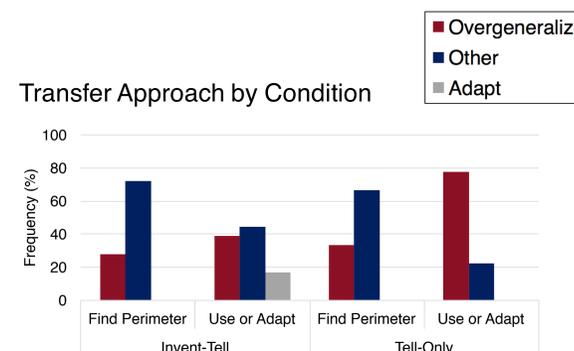
Study Task Results

- Only 17% of Invent-Tell participants found a general formula
  - 28% do not find a formula, 56% created a formula tied to the referent (e.g. "2L + 2W")
- RT results: slower, consistent with Study 1
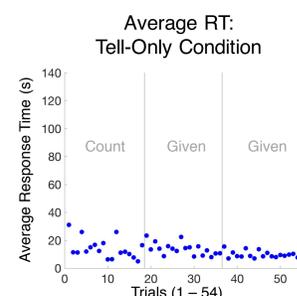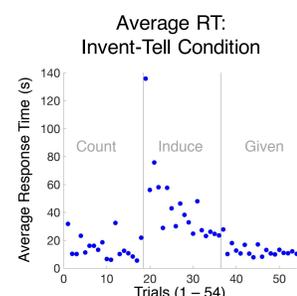
Transfer Results

- Invent-Tell leads to more counting strategies
- Tell-Only participants overgeneralize when given formula to use or adapt $\chi^2 (6, N = 72) = 20.74, p < .01$

Average RT: Invent-Tell Condition

Average RT: Tell-Only Condition

Transfer Approach by Condition

Conclusions

Study 1:
- Induction buffers against negative transfer
  - Constrains the space of where solution applies
  - Applying a given solution leads to "plug & chug" pushing of symbols

Study 2:
- Population with less math experience
  - More counting across all conditions

- Fewer participants able to induce general formula
  - Many believed they had induced a formula, though it was not general ("2L + 2W")
  - Hypothesis: Productive failure [7] requires more engagement with the material

- Lower rates of adapting for transfer task
  - Participants realized formula did not work, but were not able to adapt it

- Showing formula at transfer posttest lured Tell Only participants into overgeneralizing
  - Implications for assessment design

Future Work

- To support inventing during the study task:
  - Create a training about formulas
  - Emphasize general abstractions over counting specific referents

- To facilitate adapting on the transfer task:
  - Design feedback or create Preparation for Future Learning [1] materials that can be used as a resource for learning to adapt

References & Acknowledgements

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