Effects of Visual Cueing on Beginner Problem Solvers in Physics

Tanner Stevens[1], Adrian Carmichael[2], N. Sanjay Rebello[2]

[1]University of Minnesota
[2]Kansas State University

1

Motivation

- Multimedia in science education
- Guide students' attention
- Activate prior knowledge
- Create deeper conceptual understanding

2

Research Question

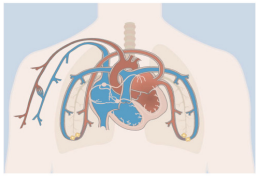
- Does visual cueing influence problem solving ability?
- Does visual cueing activate prior knowledge?
- Do students reason differently after visual cueing?
- Does visual cueing affect students' eye movements?

3

Previous Research (1)

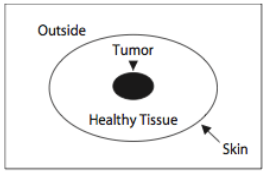
Attentional Cueing

- Visual cues on animation of cardiovascular system enhanced comprehension and transfer performance.[1]



1. B. Koning et. al. (2007)

- Participants whose eyes were guided while solving Duncker's radiation problem solved more quickly.[2]



2. L. Thomas & A. Lleras (2007)

4

Previous Research (2)

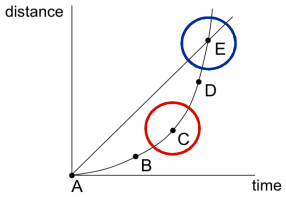
Visual Attention Differences

- Participants who responded correctly visually attended to the diagram differently.[3]

Percentage of Time Spent in Viewing Area

Relevant Area	
Correct: 30%	
Incorrect: 18%	
Salient Area	
Correct: 13%	
Incorrect: 25%	

The motion of two objects is represented in the graph below. When are the two objects moving with the same speed?



(1) Point A (2) Point B (3) Point C (4) Point D
(5) Point E (6) At all points

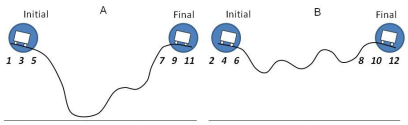
3. Carmichael et. al. (2010)

5

Visual Cueing

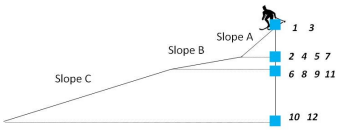
- Can we guide novices' attention to relevant parts of a diagram using visual cues to help activate correct prior knowledge and answer correctly?

If frictional effects can be ignored, how does the final speed of roller coaster cart A compare to the final speed of roller coaster cart B, if the mass of the carts is the same and they both start at rest?



(1) The cart A is moving faster at the final position
(2) The cart B is moving faster at the final position
(3) Carts A and B have the same speed at the final position
(4) There is not enough information to decide

Rank the changes in potential energy during the skier's descent down each slope from greatest to least.



(1) $\Delta PE_A > \Delta PE_B > \Delta PE_C$
(2) $\Delta PE_C > \Delta PE_A > \Delta PE_B$
(3) $\Delta PE_A = \Delta PE_B = \Delta PE_C$
(4) $\Delta PE_A = \Delta PE_B > \Delta PE_C$
(5) $\Delta PE_B > \Delta PE_C = \Delta PE_A$

6

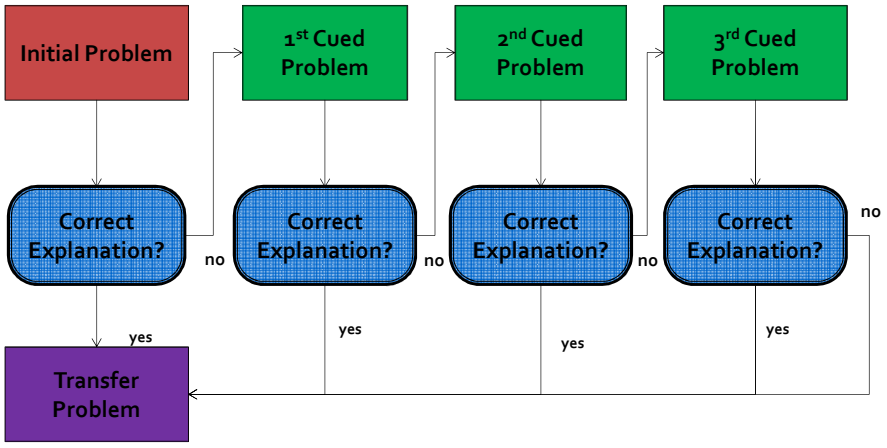
Participants

- N=15 participants (8 cued, 7 non-cued)
- Students had taken at least one physics course
- Prior course taken varied between students
- Varying scientific backgrounds, different majors

7

Experimental Design

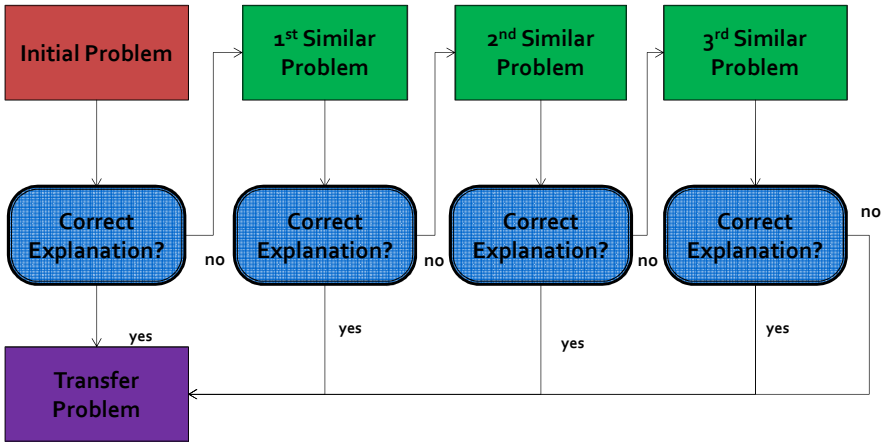
Cued Group



8

Experimental Design

Non-Cued Group



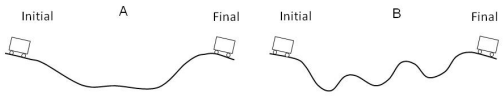
9

Experimental Design

Similar problems

– same concept, similar surface features

If frictional effects can be ignored, how does the final speed of roller coaster cart A compare to the final speed of roller coaster cart B, if the mass of the carts is the same and they both start at rest?



(1) The cart A is moving faster at the final position

(2) The cart B is moving faster at the final position

(3) Carts A and B have the same speed at the final position

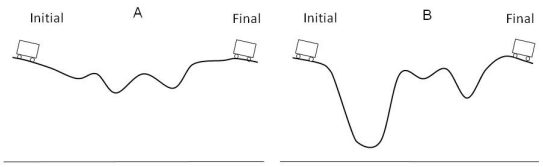
(4) There is not enough information to decide

10

Experimental Design

Example Cues

If frictional effects can be ignored, how does the final speed of roller coaster cart A compare to the final speed of roller coaster cart B, if the mass of the carts is the same and they both start at rest?



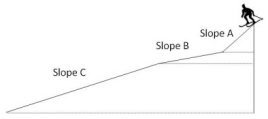
(1) The cart A is moving faster at the final position
(2) The cart B is moving faster at the final position
(3) Carts A and B have the same speed at the final position
(4) There is not enough information to decide

11

Experimental Design

Initial Problem

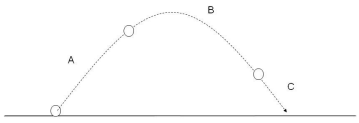
Rank the changes in potential energy during the skier's descent down each slope from greatest to least.



(1) $\Delta PE_A > \Delta PE_B > \Delta PE_C$
(2) $\Delta PE_C > \Delta PE_A > \Delta PE_B$
(3) $\Delta PE_A = \Delta PE_B = \Delta PE_C$
(4) $\Delta PE_A = \Delta PE_B > \Delta PE_C$
(5) $\Delta PE_B > \Delta PE_C = \Delta PE_A$

Transfer Problem

A ball is thrown upward from the ground. Ignoring the effects of air resistance, compare the change in potential energy in each segment of the ball's flight path.



(1) $\Delta PE_A > \Delta PE_B > \Delta PE_C$
(2) $\Delta PE_B > \Delta PE_C > \Delta PE_A$
(3) $\Delta PE_A = \Delta PE_B = \Delta PE_C$
(4) $\Delta PE_A > \Delta PE_C > \Delta PE_B$
(5) $\Delta PE_B > \Delta PE_A > \Delta PE_C$

– same concept, different surface features.

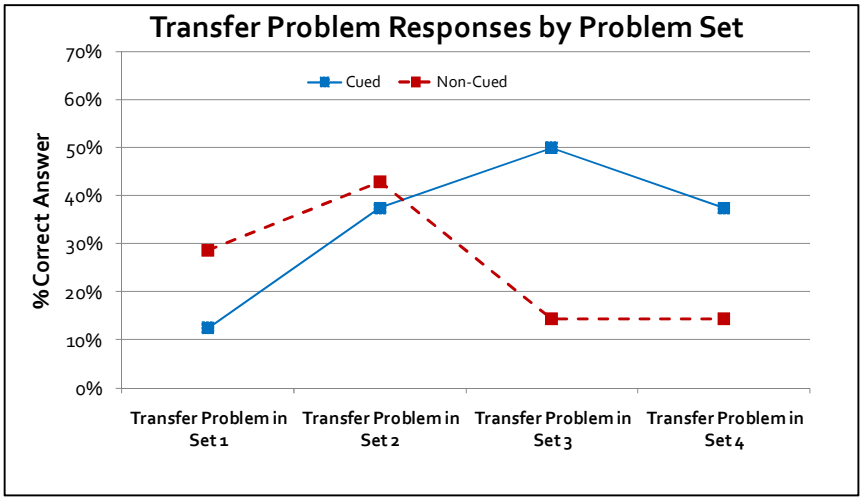
12

Analysis

- Comparisons between cued vs. non-cued groups:
  - Transfer problem responses
  - Number of similar problems needed
  - Changes in verbal explanation
  - Eye-Movements on initial/transfer problems

13

Results



14

Results

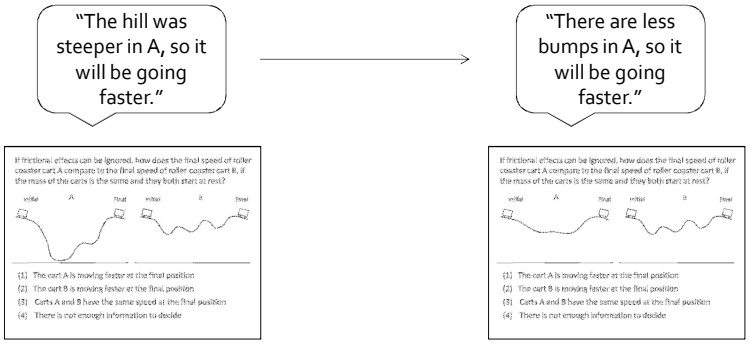
- Students who correctly moved to the transfer problem after a given number of similar problems

	1st Similar Problem	2nd Similar Problem	3rd Similar Problem
Cued Group	4 (of 25)	0 (of 21)	2 (of 21)
Non-cued Group	3 (of 19)	0 (of 16)	0 (of 16)

15

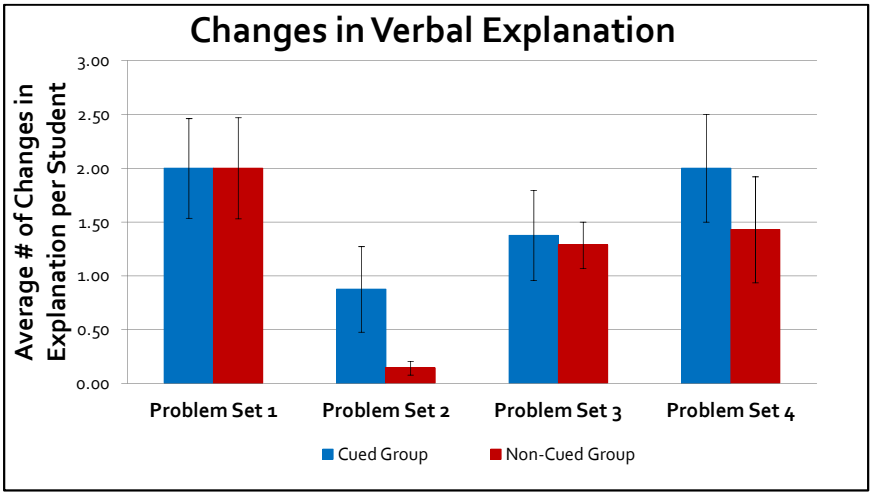
Results

- Categorized participants verbal explanations to analyze changes in conceptual reasoning.



16

Results



17

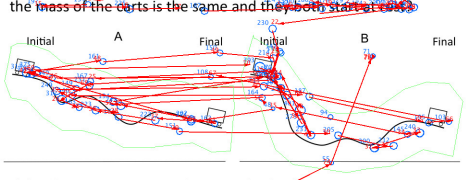
Results

- Eye Movements:

Initial Roller Coaster Transfer Problem:

	Transitions from Track A to Track B	N
Cued	9.71	7
Non-cued	6.25	4

If frictional effects can be ignored, how does the final speed of roller coaster cart A compare to the final speed of roller coaster cart B, if the mass of the carts is the same and they both start at rest?



(1) The cart A is moving faster at the final position
(2) The cart B is moving faster at the final position
(3) Carts A and B have the same speed at the final position
(4) There is not enough information to decide

18

Conclusions

- Some transfer problem improvement, overall cueing effect on transfer problem accuracy.
- No notable difference in number of similar problems.
- Differences in verbal explanation changes in Problem Sets 2 and 4.
- Cueing causes similar eye-movements on transfer problems.

Note: Due to small sample size, Mann-Whitney test shows no significant difference in transfer problem responses and changes in explanation.

19

Future Research

- Repeat with more students.
- Vary cue type.
- Increase cue duration.
- Increase number of similar problems.
- Control more precisely for differences in prior knowledge.

20

Acknowledgements

Special thanks to:

Adam Larson
Lester Loschky
KSU-PER Group
Kansas State Physics REU Program
The National Science Foundation

21

Thanks for listening!

Further questions?

Contact me @:
steve461@umn.edu

22

References

1. B. Koning, H.K. Tabbers, R. Rikers & F. Paas, Applied Cognitive Psychology **21,** 731-746 (2007).
2. L. Thomas & A. Lleras, Psychonomic Bulletin & Review **14,** 663-668 (2007)
3. A. Carmichael, A. Larson, E. Gire, L. Loschky & N. S. Rebello, submitted to AIP Conf. Proc. (accepted for publication, 2010).

23