Investigating Introductory Student Difficulties Reading Equipotential Diagrams

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Goals:

1. Identify student issues using equipotential diagrams
2. Test effect of modified images

Grounded cognition theory: when we think about an abstract concept we activate our perceptual system as a way to help us mentally create, or symbolize, the concept.

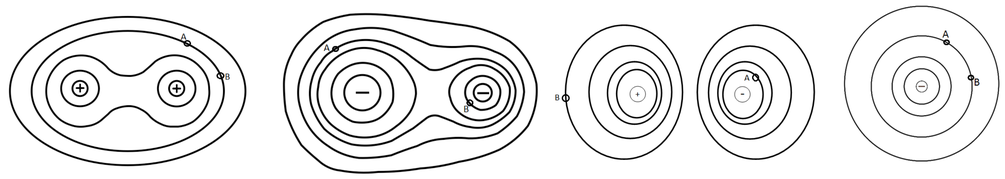
Implication: improve physics diagrams by visual representations that are perceived in a way that supports the construction of the correct physics concepts.

Use color and line thickness to visually indicate greater positive/negative potential.

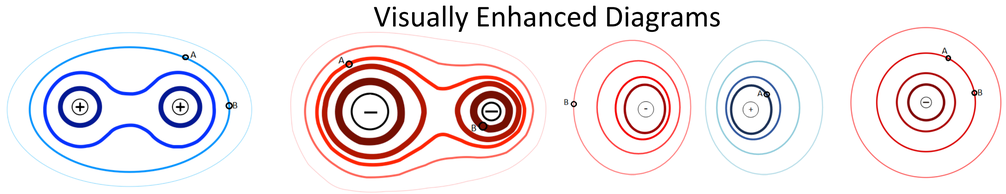
Sets of equipotential diagrams were created. Charges are positive and negative, equal size and unequal sizes, same and opposite sign. Points indicated for ranking were close to the same charge, on the same line, and close to different charges.

Students were asked:
Which is the correct statement about the electric potential at points A and B?
A. The electric potential at point A is greater than the electric potential at B
B. The electric potential at point A is less than the electric potential at B
C. The electric potential at point A is equal to the electric potential at B

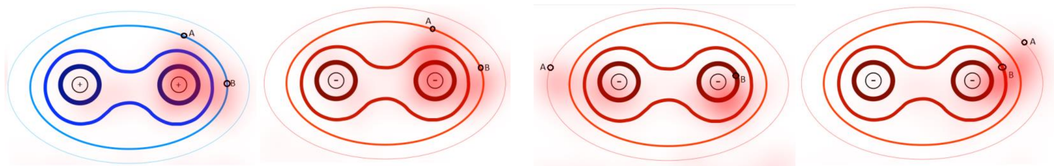
Traditional Diagrams



Visually Enhanced Diagrams



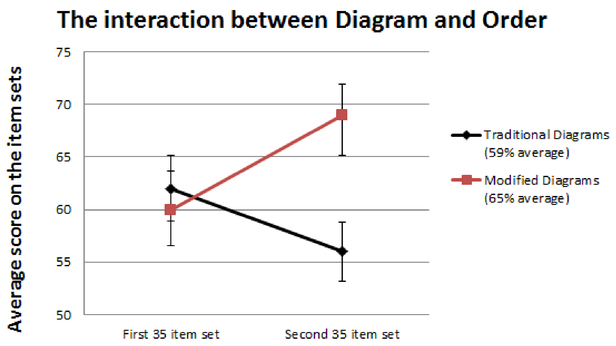
Heat Maps of Student Gaze Time



Students' gaze time spent between points and the close charge

Pretest Responses

- No main effect of diagram or order but an interaction effect is seen
- Students use a response scheme of closer is greater, same line are equal
  - 80% of responses explained by this
- Only 15% (4 of 27) use a conditional rule accounting for charge sign



Condition A					
Order	Diagram	Negative	Positive	Same Line	Total
First 35 Items	Traditional	27%	85%	95%	62%
Second 35 Items	Modified	20%	98%	94%	69%
Condition B					
Order	Diagram	Negative	Positive	Same Line	Total
First 35 Items	Modified	12%	88%	84%	65%
Second 35 Items	Traditional	8%	90%	85%	56%

Conclusions

- Even after instruction, 80% of these algebra-based physics students do not understand negative electric potential
- Students' response choices and their stated rule(s) are in strong agreement
- Illustrates students' issues learning conditional rules
  - 1/4 of students shift from incorrectly applying the rule "closer-is-greater" to applying "closer-is-less" to all charge arrangements
- Eye tracking data and the results of the modified images demonstrates that students' visual attention within these diagrams is uncorrelated with correctness
  - This suggests that modifications to the diagrams based on students' visual attention may not be useful

Posttest Responses

Condition A: Traditional Images used for Training				
Item	Negative	Positive	Same Line	Total
Pretest	23%	92%	92%	64%
Posttest	83%	51%	94%	75%
Condition B: Modified Images used for Training				
Diagram	Negative	Positive	Same Line	Total
Pretest	9%	89%	85%	58%
Posttest	79%	48%	90%	71%

- Post training, around 30% (8 of 27) are consistently correct
- An additional 26% (7 of 27) respond correctly most of the time
- 25% (7 of 27) change their rule from "closer-is-greater" potential on the pretest to "closer-is-lower" potential on the posttest
- No differences seen between the traditional diagrams and the color modified diagrams in students responses on the pre or posttest

Student Rules & Responses Compared

Rule	Negative	Positive	Same Line	N
Completely Correct	94%	61%	95%	15
Distance only Negative Rule	91%	11%	85%	7
Distance only Positive Rule	3%	97%	91%	3