Characterizing high school physical science students' explanations for an assessment item requiring an understanding of electrostatics and energy MICHIGAN STATE

UNIVERSITY

Background

Electrical interactions and energy are core disciplinary ideas in high school Physical Science classes.¹ It is important to support students in developing a deep understanding of these ideas.

Assessment item

Research **Questions:**

- 1. How do students use disciplinary ideas about electrostatic interactions and energy when explaining this phenomenon?
- 2. How frequently do students leverage these different ideas?



The picture shows two wood cars with metal sheets attached. Both metal sheets are negatively charged. The wedges prevent the cars from moving.

Question #4

When the wedges are removed, the cars will move. Predict which direction they will move and when they will stop. Justify your prediction. Use ideas about forces and energy as appropriate.

Ideal response:

The carts will move away from each other when the wedges are removed, because similar charges repel. The potential energy is high when the carts are close together, because of the strong repulsive force. As the carts separate, the force weakens, and the potential energy decreases as it converts to kinetic energy. Once all of the energy has converted to thermal energy, the carts will stop. At this point, the electric fields are no longer impacting each other, and the potential energy is at a minimum.

Methods

N = 1603 high school chemistry student responses <u>Analytic Coding Rubric (previously developed)</u>

11 Categories, coded as 0 or 1, depending on the presence/absence in student response

Categories 1 – 6 capture accurate ideas **Categories 7 – 11 capture inaccurate ideas**

Two coders met weekly to discuss discrepancies and ways to improve the rubric.

Coders coded 100 student responses each week. Inter-rater reliability: 86% – 99% agreement between coders

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Analytic Coding Rubric

Categories 1 – 6 (accurate ideas)

Category 1: Prediction about the movement of direction of the carts N1142: "When the wedges are removed, the two negatively charged metal sheets will push away form each other..."

N1147: "The car on the left will move to the left and the car will move to the right..."

Category 2: Use fundamental property of electric charges to construct causal account that supports the prediction for which direction the carts will move

N1368: "...the cars are both negatively charged..." N1897: "...cause the metal sheets are both neg..."

Category 3: Prediction about when the carts will stop N1742: "... they stop when..." N1535: "...I think they would probably stop..."

Category 4: Use Coulombic relationship to construct causal explanation that supports the prediction for when the carts will stop N1473: "They will stop when the force in the electric field is too weak to repel each other..."

N1396: "The field is what causes the charges to interact with each other, and when the fields are too far apart they will stop interacting."

Category 5: Construct causal relationship using Energy only to explain when the carts will stop

N1680: "...so their potential energy is high when they're close. as they move apart, the energy transforms into kinetic energy, ..."

Category 6: Construct causal relationship between Energy and **Coulombic interactions between charged plates**

N1812: "They will move far away from each other and they won't stop until they reach their most stable points (point with the lowest amount of potential energy)... They have a repulsive force right now and wish to become more stable because they have such a high level of potential energy because they're objects of the same charge so close to each other."

Categories 7 – 11 (inaccurate ideas)

Category 7: Incorrectly labeling the force/field as "magnetic" N1052: "when they are far apart when they are out of each other magnetic

Category 8: Conflation, vague or misuse of charge, force, field terms N1011: "...Like forces repel..."

Category 9: Incorrect interpretation of Coulomb's law N1594: "I think that since they are both negative they will attract, but not at a fast pace like the positive and negative."

Category 10: Unmeaningful/ inaccurate mention or use of energy N1270: "because when there is the same forces and same energy type the cars will push far from each other."

Category 11: Recognizing that PE is high but no/incorrect explanation for why

N1314:"the energy between them is strong..."

