Evaluating Effects of Student Automatic Feedback Aligned to a 3D Learning Progression to Promote Knowledge-In-Use

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Background

Science education should promote students' knowledge by engaging them in making sense of compelling phenomena or designing solutions to complex problems using scientific practices, like modeling, along with key disciplinary ideas and using crosscutting concepts.This project examines the effect of an assessment system that automatically generates feedback based on students' open-ended assessment responses in chemistry and physics consistent with a previously-developed learning progression that describes the successively more complex understandings students can develop about electrical interactions. We are designing and testing an automated assessment scoring system using artificial intelligence that can score student text explanations and electronically drawn scientific models and subsequently provide feedback to students.

Research Questions

1) What is the effect of automatic feedback on student performance along a previously validated learning progression for physical science aligned with the Next Generation Science Standards?

2) What is the effect of automatic feedback on how students connect ideas to advance in learning progression levels?

Process

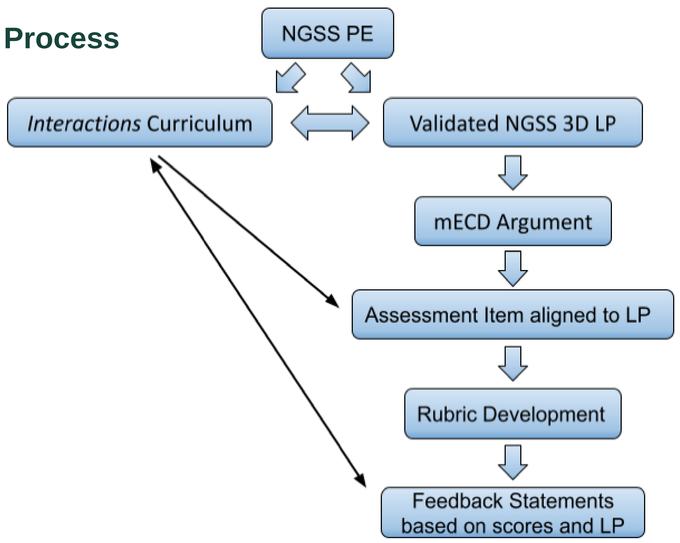


Table 1. *Levels of NGSS LPs for Electrical Interactions combining the Coulomb's law and Energy ideas from Kaldaras, 2020.*

Level 3: Models and explanations represent causal relationships that integrate ideas of Energy and Coulombic interactions at the atomic-molecular level to explain phenomena.
Level 2: Models and explanations represent causal relationships that use but do not integrate (or inaccurately integrate) the ideas of Energy and/or Coulombic interactions at the macro or atomic-molecular level to explain phenomena with some inaccuracies.
Level 1: Models and explanations represent partially causal relationships that use ideas of Coulombic interactions or Energy with inaccurate/incomplete ideas to explain phenomena.
Level 0: Models and explanations that don't represent causal relationships don't use Coulomb Law and/or Energy with significantly inaccurate/incomplete ideas to explain phenomena.

3D Curriculum for High School Physical Science

The Interactions curriculum engages students in modeling and scientific explanation to explore the unseen world of atomic level interactions and energy transformations.

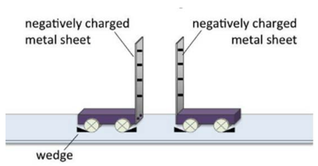
Example Units:

- Why do some clothes stick together when they come out of the dryer?
- How does a small spark trigger a huge explosion?

https://interactions.open3d.science/home

3D Assessments

The picture shows two wood cars with metal sheets attached. Both metal sheets are negatively charged. The wedges prevent the cars from moving. When the wedges are removed, the carts will move.



Predict which direction they will move and when they will stop. Use ideas about forces and energy as appropriate.

Results

Table 2. *Analytic coding category descriptions from Kaldaras et al., 2022.*

Category Description	mECD component
1, Prediction about movement	1a
2. Use fundamental property of electric charge to construct a causal account	1a
3. Prediction about when carts stop	1b
4. Use Coulombic relationship to construct causal explanation	1b
5. Construct causal relationship using Energy only	4a, 3a, 3b
6. Construct causal relationship using Energy and Coulombic interactions	2a
7. Usable knowledge related to phenomenon is not evident	N/A

Level 1: *They will move away from each other because the metal sheets are both neg, and the same charges push each other away. They will stop once they are far enough apart because they will not sense each other.*

Score: Category 1 + Category 2 + Category 3 + Category 7

Possible Feedback: *In your response relate ideas of electric force and energy to distance and explain when the carts will stop and why*

Level 3: *The cars will move in opposite directions because they are of the same charge. There is a lot of energy when they are very close together like that, because they want to repel. When the wedges are moved and the cars go away from each other, they will move until there is no more repulsive force between them. The farther they move, the less energy they have and the less force they have between each other*

Score: Category 1 + Category 2 + Category 3+ Category 6

Possible Feedback: *The key aspect of your response involves relating ideas of electric force and energy to distance between the carts when explaining when they will stop and why*

Table 3. *Preliminary results of text scoring machine learning models for seven analytic coding categories.*

Category	1	2	3	4	5	6	7
Responses present (human)	1067	652	661	387	68	37	323
Responses present (machine)	1086	672	662	348	18	2	167
Cohen's Kappa	0.811	0.827	0.912	0.686	0.191	0.100	0.391

Next Steps

- Evaluate feedback statements with students and teachers
- Begin automatic scoring model development of more assessment items
- Pilot items and automatic scores in classrooms

Acknowledgements

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References

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