Auto Feedback 3DLP

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

How AI supports teachers and students in science learning?

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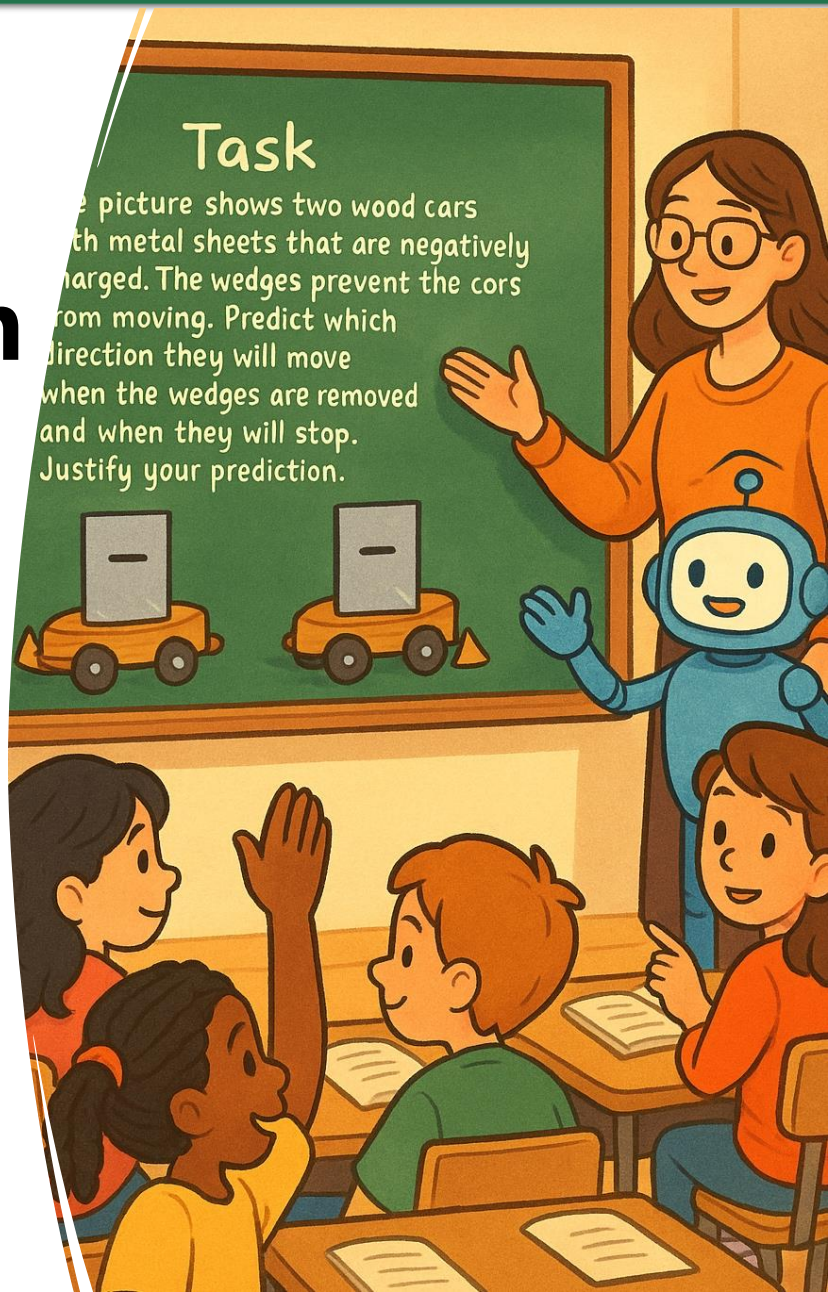
CREATE for STEM Institute

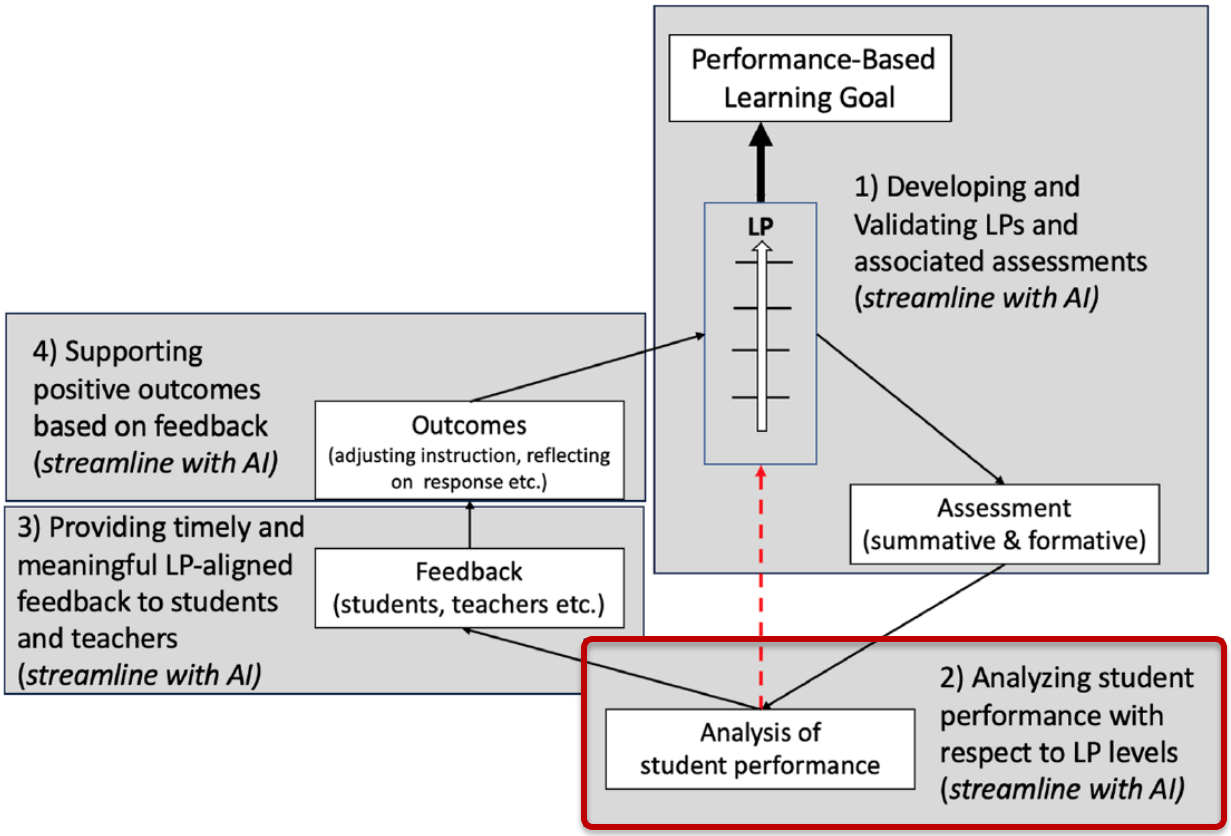
The Role of AI in Science Classroom

- **Analyzing student performance**
  - Assessing students' generated model by Machine Learning

- **Providing Feedbacks**
  - Generating meaningful feedback by Generative AI



AI Support Across Stages of LP-Based Assessment

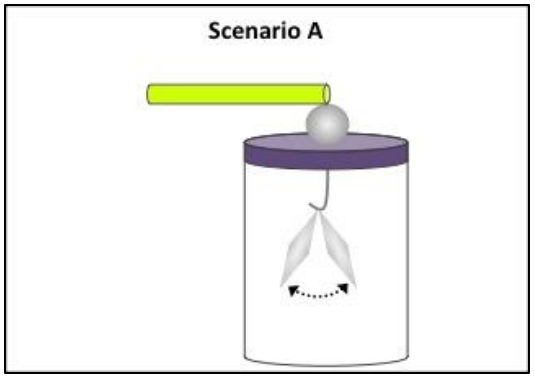


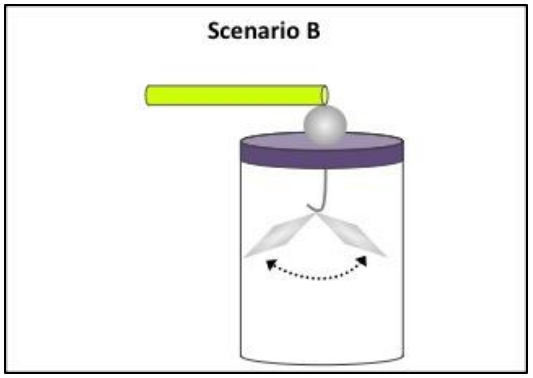
Kaldaras, L., Haudek, K., & Krajcik, J. (2024). Employing automatic analysis tools aligned to learning progressions to assess knowledge application and support learning in STEM. *International Journal of STEM Education, 11*, Article 57. https://doi.org/10.1186/s40594-024-00516-0

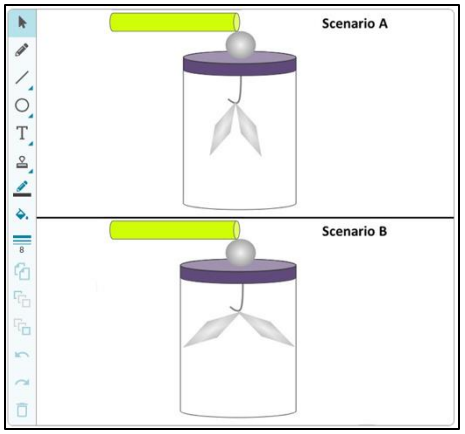
Electroscope Task

Scenario A below shows a diagram of what occurred in the video when a charged rod touched the ball.

In Scenario B, a rod touches the ball and makes the leaves move much further apart.







Task 1: Modeling

Draw a model to show what the differences are in the rod and foil leaves in the two scenarios.

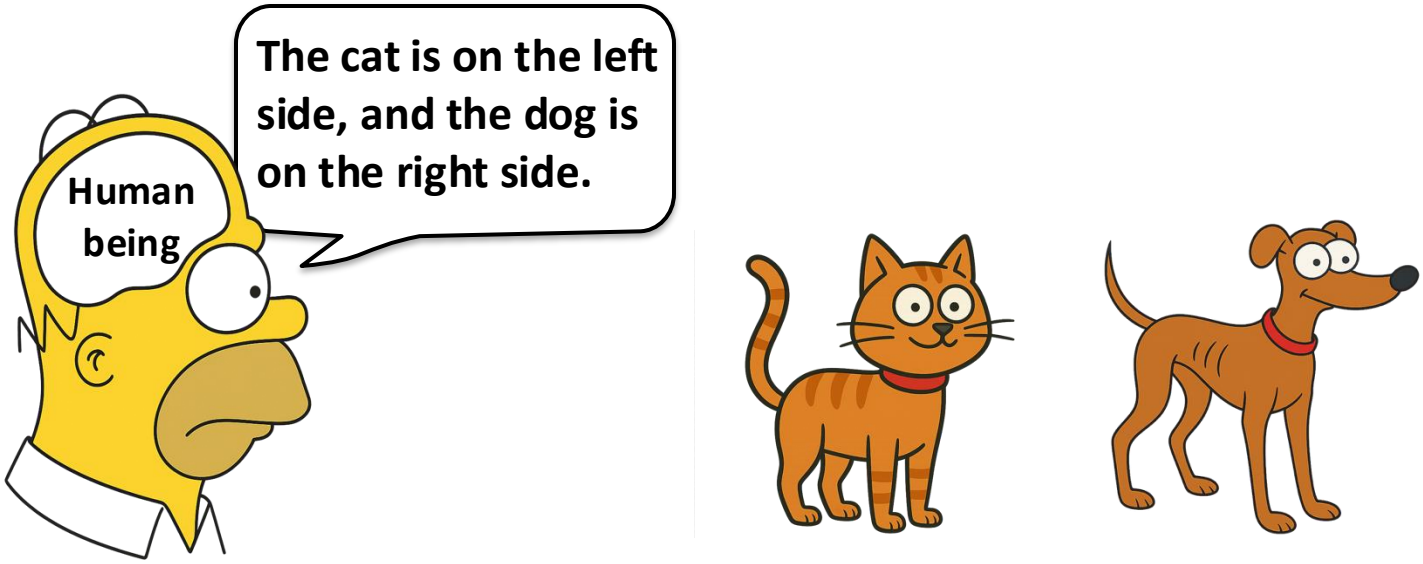
Task 2: Justification

What is different about Scenario A and Scenario B? Justify your answer.

Rubric	
Category	**Statement**
1	Point charge (either + or –) on the rod in scenario A
2	Point charge on the metal ball. The charge must be the same type as shown in the rod in scenario A.
3	Point charge on the hook of the electroscope. The charge must be the same type as shown on the rod in scenario A.
4	Point Charge on the leaves of the electroscope in scenario A. The charge must be the same type as shown in the rod in scenario A.
5	Clearly indicates repulsive Electric force causes leaves to move, by using arrows or force representations and pointing in opposite directions between the leaves in scenario A.

Challenge in this study… …

- How can machine “read” images?
- How can machine “understand” meaning of images?



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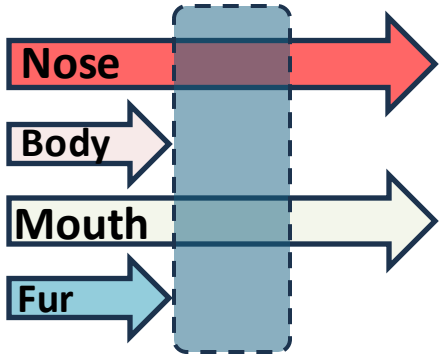


It is a Dog!
Not a Cat !

Select Features

Organize Information

Make Prediction

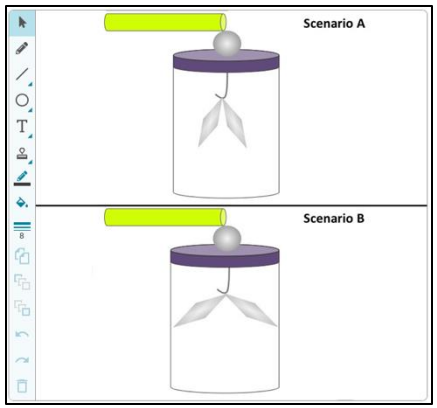
Object Detection

+

Multi-label classification

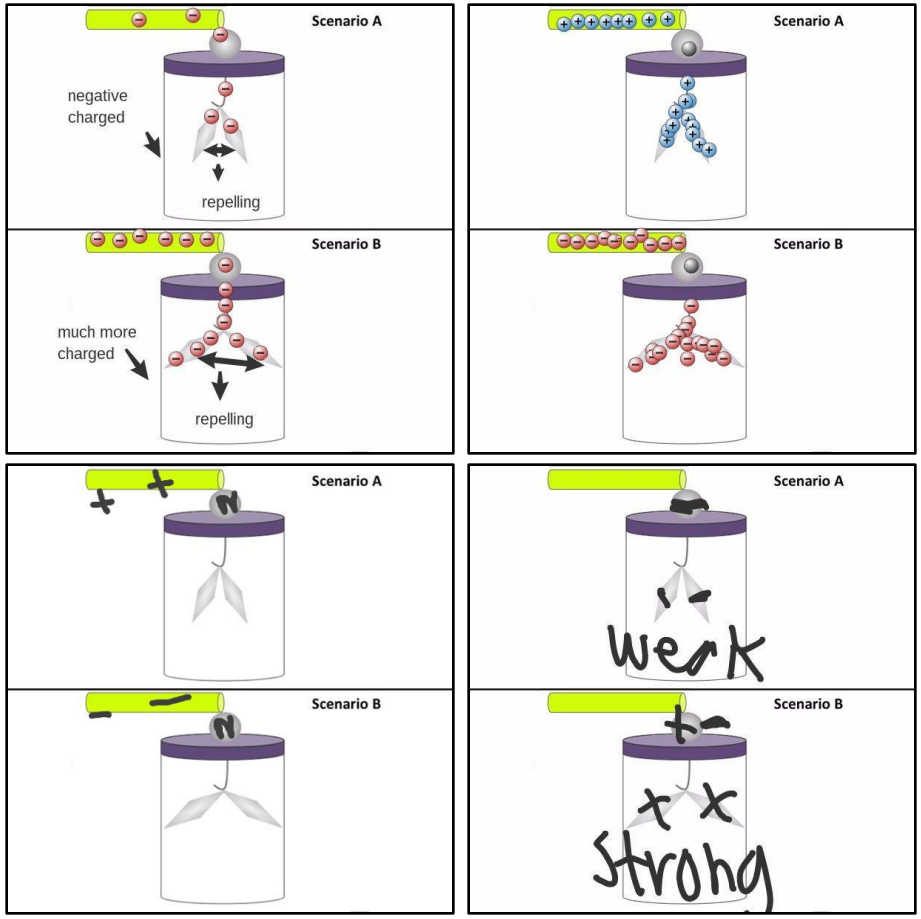
Dual-model scoring system

Students' generated model



Task 1: Modeling

Draw a model to show what the differences are in the rod and foil leaves in the two scenarios.



What are the features of the students' generated model?

Object detection task

- **Select features**
- **Provide the feature's Label and Location**

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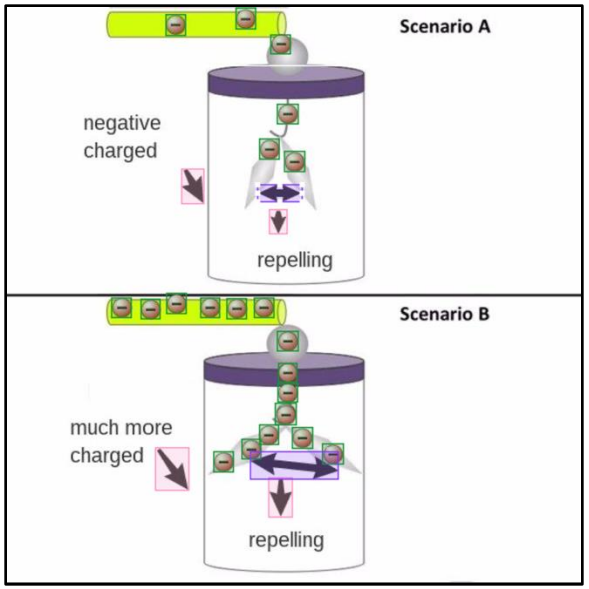
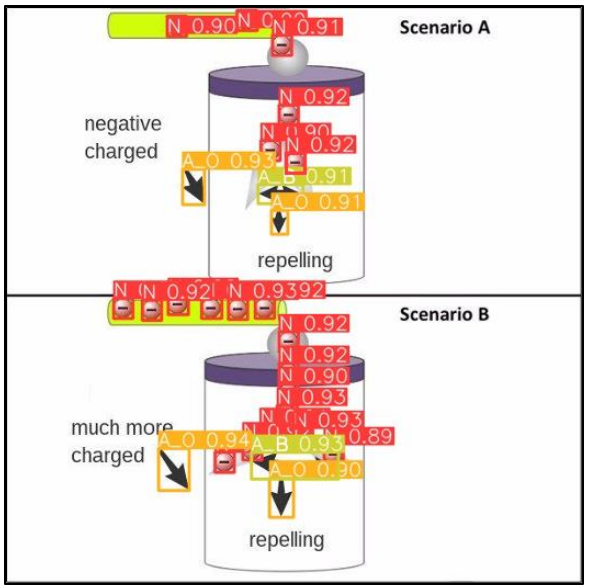




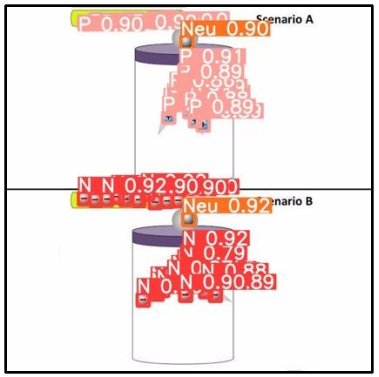
Rubric

Manual labeling

Machine detection the features

Object detection task

- We organized 496 images for training machine.
  (training: 396 images, validation: 50 images, and testing: 50 images)
- Object detection model performed well across individual features.
  - ✓ most achieving high mAP(mean Average Precision) values (> 0.7).



Features	Training stage		Testing stage	
	F1	$mAP_{.50}$	F1	$mAP_{.50}$
Overall performance	0.881	0.914	0.876	0.886
1. Negative charge	0.916	0.957	0.941	0.953
2. Positive charge	0.943	0.968	0.882	0.900
3. Neutral charge	0.769	0.808	1	0.995
4. One-directional arrow	0.823	0.877	0.637	0.650
5. Bidirectional arrow	0.921	0.959	0.915	0.931

Multi-label classification task

Rubric		Human scoring
Category	Statement	
1	Point charge (either + or –) on the rod in scenario A	1
2	Point charge on the metal ball. The charge must be the same type as shown in the rod in scenario A.	1
3	Point charge on the hook of the electroscope. The charge must be the same type as shown on the rod in scenario A.	1
4	Point Charge on the leaves of the electroscope in scenario A. The charge must be the same type as shown in the rod in scenario A.	1
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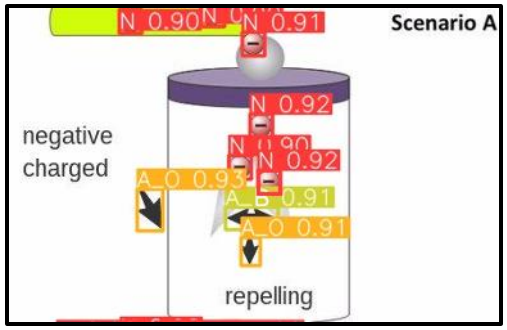

- Human scoring
- Type of Features
- Location

Category 1

Point charge (either + or –) on the rod in scenario A

	Training stage			Testing stage		
Category	F1	Accuracy	Kappa	F1	Accuracy	Kappa
1	0.943	0.941	0.882	0.916	0.930	0.856
2	0.886	0.933	0.838	0.815	0.950	0.786
3	0.870	0.950	0.838	0.778	0.960	0.756
4	0.907	0.941	0.864	0.889	0.960	0.865
5	0.959	0.975	0.941	0.966	0.980	0.951

- ✓ Train machine
- ✓ Make prediction

Takeaway

Dual-model scoring system

Enhanced Interpretability

- The system measures a student's performance by identifying specific, meaningful symbols in their models. This symbol-level interpretability helps educators understand the specific conceptual components students are demonstrating.

Robust Transparency

- The system aligns object detection and classification with the rubric to assign meaning to findings. This provides the necessary transparency to build a robust validity argument for the AI-generated scores.

Providing meaningful information for teachers

- It provides evidence-based information that helps teachers reorganize their instruction and plan follow-up activities.
- Automated scoring reduces teachers' workload, and AI-based scoring increases teachers' willingness to adopt modeling practices in science classroom.

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Wenxiu Tang · Steve Bennett · Mao-Ren Zeng

MICHIGAN STATE UNIVERSITY

ICER

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Thank You!

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