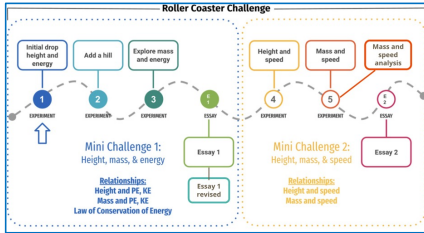


NLP to Support Middle School Science Writing in a Digital Roller Coaster Curriculum

Rebecca J. Passonneau¹, Zhaohui Li², Mahsa Sheikhi¹, Adithya Tanam¹, Chengning Zhang¹, ChanMin Kim¹, Eunseo Lee¹, Xuesong Cang², Dana Gnesdilow², William Goss², Sadhana Puntambekar²
¹Penn State University; ²University of Wisconsin Madison



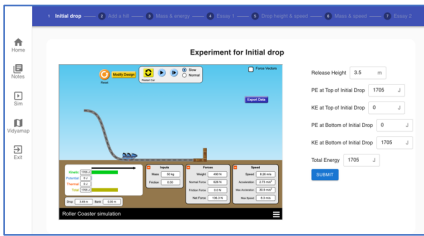
Mechanics and Energy Relationships



Electronic Notebook:

- Students navigate through their challenges
- Engage in experiments, record keeping
- Teachers helped design the notebook
- Used in Wisconsin middle schools in spring 2022, and 2023

Electronic Notebook: Web-based Curriculum



Students:

- Build roller coaster simulations
- Carry out experiments to vary initial drop, track, cart, and hills
- Save data about mass, speed, and height from their simulation experiments

Two Kinds of Science Writing: Short Answers, and Essays

Six Main Ideas in Challenge #1

1. The greater the height, the more potential energy
2. When the cart moves down a, potential energy decreases and kinetic energy increases
3. Total energy (PE + KE) is constant
4. LCE: Energy cannot be created or destroyed, only transformed
5. The initial drop must be the highest point
6. A cart with more mass translates to more total energy

Constructed Response and Multiple Choice Questions

Q: How did changes in PE and KE affect the total energy, and what does that tell you about the Law of Conservation of Energy?

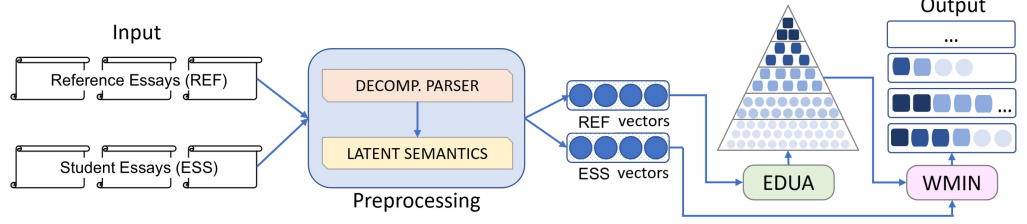
A: As the PE and the KE went up the total energy also rose. This shows that because energy is never created or destroyed then they got the energy from around them. So the higher the drop the greater the PE, KE, and total energy.

Assessment Scale: 0, 1, 2

Essays: Prompt for All Six Main Ideas

The height we found best was having the Initial drop height at <X> meters so it has enough potential energy that will transfer into kinetic energy going down the hill which is <Y> meters high that will continue to transfer back into potential going up the hill. The relationship between PE and KE is inverse. This means that when one goes up the other goes down. . . . Even though PE and KE are constantly changing between one another, total energy always stays the same. . . .

PyrEval: An AI Tool for Content Assessment of Short, Written Passages



PyrEval Preprocessing

- Reference essays and student essays
- Decomposition Parser: converts complex sentences into distinct propositions
- Latent Semantics: verbal propositions converted to 100D numeric vectors

PyrEval Content Model Construction: EDUA algorithm

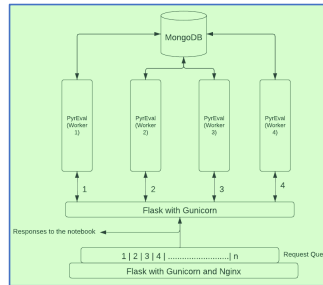
- EDUA groups vectors from different reference essays when they express the same idea
- Each "idea" group is a content unit (CU) with one to five members
- Each weight 5 CU corresponds to a Main Idea in the roller coaster curriculum

PyrEval Application of Content Model: WMIN algorithm

- Cosine similarity of ESS vector to the vectors in a CU measures semantic similarity (in [-1,1])
- WMIN constructs a graph where nodes are potential matches from ESS vectors to CU vectors
- WMIN greedily chooses the best overall alignment of ESS vectors to the content model

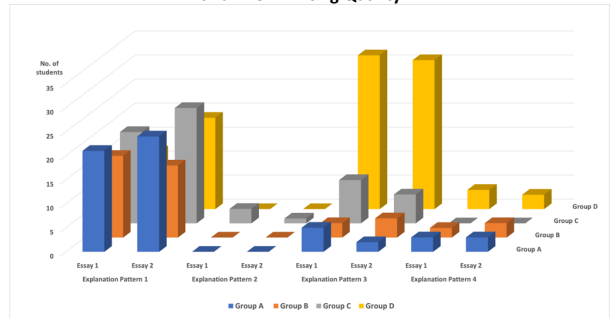
PyrEval Workers in a MongoDB - Flask Environment

- Notebook sends student essays to MongoDB
- PyrEval workers fetch the essays, process them, and send the results back to the MongoDB
- Notebook retrieves a checklist of matches from an essay to the Main Ideas



CONTENT CHECKLIST	ASSIGNED SCORE	MY COMMENTS
Height and Potential Energy	✓	Medium
Relation between Potential Energy and Kinetic Energy	✓	High
Total energy	✓	Low
Energy transformation and Law of Conservation of Energy	?	High
Relation between initial drop and height	?	Medium
Mass and speed	✓	High

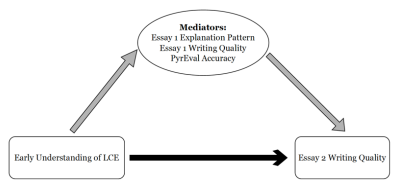
Students' Early Understanding of Law of Conservation of Energy (LCE) and Their Writing Quality



Group A = Answered the first and second experiment short answer questions
 Group B = Answered only the first experiment short answer question
 Group C = Answered only the second experiment question
 Group D = Answered neither

Explanation Pattern 1 = Explained LCE and related concepts
 Explanation Pattern 2 = Explained LCE only
 Explanation Pattern 3 = Explained related concepts only
 Explanation Pattern 4 = Explained neither

Factors Mediating the Impact of Early Understanding of Law of Conservation of Energy (LCE) on Essay 2 Writing Quality

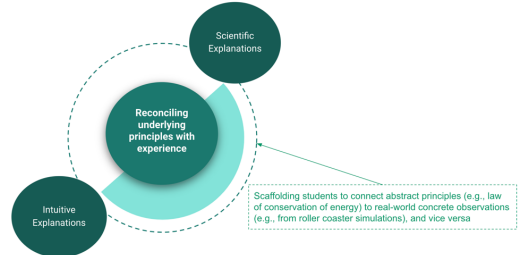


Current Work on Offline Automated Short Answer Assessment

- SFRN: Semantic Feature-Wise Transformation Relation Network
- State-of-the-art accuracy on benchmark datasets
- What if we lack labeled training data?
 - Collect expert human labels ~400 items of short answer data
 - Combine a related dataset (7K items) to train SFRN to moderate quality
 - On 400 additional items with expert human labels, train a logistic regression when to defer to a human
 - Use the resulting human-in-the-loop to label the remaining 3,381 items



Ultimate Potential Role of Automated Feedback in Science Learning



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