

A Case Study of the Efficacy of Various Methods of Argumentation in Physics

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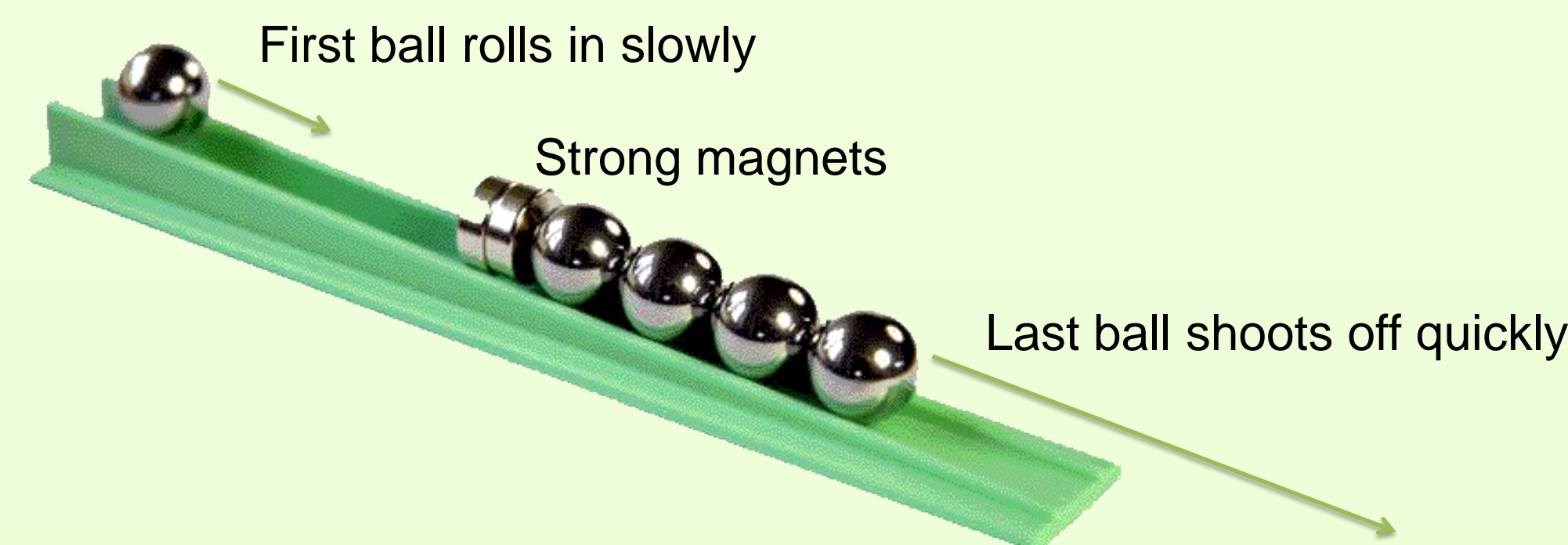
Context for Discussion

Participants

Secondary-school teachers in the Energy II summer course at SPU

Goal

Explain energy transfers and transformations in a Gaussian Gun



All participants agreed ...

Energy can change forms [transform] and change locations [transfer], but it cannot be created or destroyed

Since the last ball shot out with greater speed (more kinetic energy) than the first, the participants concluded that the first ball must also contain another form of energy ► magnetic energy

The participants chose to explain magnetic energy by comparing it to gravitational energy, which they had previously encountered

Source of Disagreement

Two small groups had two different conceptions of the nature of gravitational energy (GE)

Group 1's Argument

GE is positive

Objects touching ► GE=0

Objects far away ► GE very positive



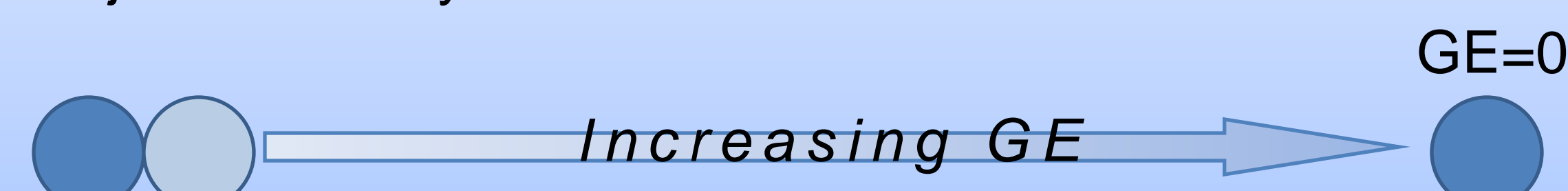
Participants: Sally, Laura, Marion, Lisa, and Josh

Group 2's Argument

GE is negative

Objects touching ► GE very negative

Objects far away ► GE=0



Participants: Lucy, Mark, and Victoria

Though Group 2's conclusion is the convention used by most physicists, both arguments are compatible with the physical evidence.

Lucy ► Authority-Based

She uses the board to explain her viewpoint

- Standing at the front of the room while the others remain seated
- Traditional lecture setup



"If there is no force between these two because this is so far away, what would the potential be in this configuration?"

- An instructional-type question

Sally's response

"You tell me. I mean, I can say what you want me to say."

Lucy tries to lead others to the conclusion she has reached without offering substantial reasons why the opposing view is invalid. Others are unresponsive.

Mark ► Evidence-Based

"So I can put the magnet there ... and it's not attracting the ball. So to me that, there's no interaction."

- Demonstrates with physical, tangible objects

Sally's response

"Maybe the force is just so little, it's not enough to move it."

"Well, exactly, though, isn't that kind of the point of all this, that it's significantly far away that the force is so weak that there's no interaction."

- Because the effect is not observable, he concludes that there is no potential energy there
- For Mark (but not Sally), "insignificant" == "nonexistent"

Mark's effort to highlight physical evidence gets little response, perhaps because evidence cannot distinguish between the two (correct) conclusions.

Classic Argumentation Analysis: Toulmin, 1958

	What is Analyzed	A Good Argument ...
Toulmin Analysis	Claim-evidence-warrant	Is Rational
Our Analysis	Reaction of others	Causes progress in the discussion

In a discussion among peers, making arguments from an authoritative position or based on an irrelevant type of reasoning can be less effective than arguments made by guiding others through personal reasoning.

We can tell this even from a single case. As we have established that this pattern can exist, we now can consider it during future argument analyses.

Sally and Laura ► Personal Reasoning-Based

S: "I mean I don't think that the field ever goes away. I mean it sounds like you're saying, OK I've got this outside the field, so that there's no interaction. But I'm saying that I don't think there's ever a case where there's never any interaction."

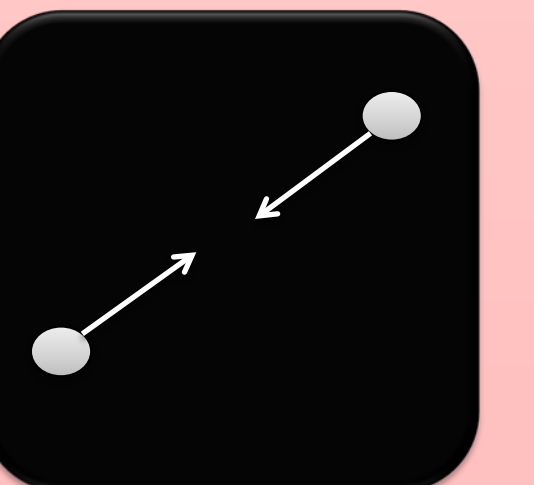
- Restates opposing argument to show she understands it
- "I think:" engages argument on personal level (whereas Group 2 makes more unqualified statements)

Marion: "What's your evidence that there is still an interaction between the two different things?"

S: "I don't have any evidence that there is."

- Uses logic, not evidence, as support for her reasoning

L: "If we took away everything in the universe except for that ball and that magnet, couldn't we anticipate that as you farther and farther apart you could still see an interaction? We get farther and farther apart and we don't see an interaction because gravity's having a greater effect on those than the magnet itself. But if we eliminated the Earth, wouldn't that magnet continue to have an effect on the ball as it got farther and farther away?"



- Question encourages others to come to her conclusion on their own
- Gets directly to the heart of the theoretical argument

L: "I believe that they would come back together, and I believe the kinetic energy is my evidence that there was potential energy when they were farther apart."

- Addresses the opposing argument
- "I believe:" a stronger statement than "I think"

Sally and Laura share their reasoning process (not just conclusion), inviting others to interact with their ideas. Others are responsive and the discussion progresses.