Solving The Puzzle: Designing Games And Assessment For Young Children’s Physics Learning

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Overview

- Games for learning and assessment
- Design and development
- Research study
Part One

Games for learning and assessment
Why Do Kids Like To Play (Good) Games?

Learning

- Escape
- Mastery and challenge
- Intuitive activities
Why Use Games For Learning?

*Escape…*

Place them in situations that are not easily experienced or easy to manipulate

- **Frictionless Environment**
- **Sloping Hills**
Why Use Games For Learning?

Mastery And Challenge...

Support complex problem-solving through guided exploration

Scaffolded sequencing

Non-player game characters
Why Use Games For Learning?

**Intuitive Activities**

Explore innovative learning and assessment mechanics

- **Free body diagram to control motion**
- **Draw predicted path**
Why Do Kids Like To Play (Good) Games?

Assessment

Evaluation of performance

Adaptivity
Why Use Games For Assessment?

**Evaluation of Performance**

**Formative Assessment:**
Use and interpretation of *task* performance information with intent to adapt learning, such as provide feedback.  
(*Baker, 1974; Scriven, 1967*)

**Games:**
Use and interpretation of *game* performance information with intent to adapt learning, such as provide feedback.
Why Use Games For Assessment?

Adaptivity

Front-end efforts support ability to identify key events to capture

Rich data source

Capture process of learning
Part Two

Design and development
Integrated Assessment, Learning, and Technology

Instructional requirements

Assessment requirements

Technology requirements
Evolution Of Design Process
What We Have Done

Determined targeted concepts and types of thinking

Instructional sequence and task specifications

<table>
<thead>
<tr>
<th>Instructional Goals / Background Knowledge</th>
<th>Example Objectives</th>
<th>Physics Concepts / Pertaining to Goals / Misconceptions</th>
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</thead>
<tbody>
<tr>
<td>Students are able to explain that resultant forces arise when two or more forces in different directions are added together, and that when applied to an object, the object’s resulting direction of motion and rate of acceleration will be determined by the magnitude and direction of the resultant force applied.</td>
<td>Forces are composed of magnitude and direction.</td>
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<td>Students are able to model a solution where by applying a force opposite to the direction of an object’s motion, the object will experience a slowing and/or stopping of motion, depending on magnitude of the supplied force and duration of time it was applied.</td>
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<td>Students understand that for objects in motion (all moving at the same velocity), the more massive the objects, the more force in the opposite direction of motion is required to bring the objects to rest within a given amount of time.</td>
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<td>Given different objects in motion having the same velocity, each with different mass, the player will estimate which objects require more/less force to come to rest within a given amount of time.</td>
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Challenges Driving Assessment Innovation

1. Children in grades K-3
2. Classroom and online context
3. Integrated science content, cognition, and SEL

- Gamelike
- Graphical icons
- Nonverbal prompts
- New combinatorial design
- Assessment mechanics
- Automated scoring
- Comparable tasks
Innovative Learning and Assessment Game Mechanics

Comparison using contrasting cases

Complex problem-solving through guided exploration

Active reflection through graphic prompts

Free body diagram to control motion

Physics and SEL integration

Graphical formalizations of underlying physics laws
Part Three

Research study
What Did We Want Kids To Learn?

• Improved understanding of physics concepts: force and motion
  ✓ Force magnitude
  ✓ Force direction
  ✓ Friction
  ✓ Mass
  ✓ Gravity
  ✓ Slope

Case Five: Mass on Incline with Friction

Freebody Diagram

0 = 25°
How Were They Going To Learn?

• Play a set of physics games

Go Vector Go

RoboBall
How Would We Know They Learned?

Kid-friendly assessments

Meaningful gameplay data

Case Five: Mass on Incline with Friction

Freebody Diagram

$\theta = 25^\circ$

$F_N = \frac{F_g \times \cos(\theta)}{(\sin(\theta))}$
Timeline of Activities

- Pretests
- Gameplay
- Posttests
Results (Go Vector Go)

- Scores increased significantly after playing the game
- Even the kindergarten and 1st grade students!

**PRETEST**
(M = 2.41, SD = 1.03)

**POSTTEST**
(M = 3.20, SD = 0.82)
Results (RoboBall)

Third graders got further and advanced more quickly between two gameplay sessions.
Conclusions And Next Steps

Conclusions

• Results are promising…

• Improved student performance on science assessments even for the kindergarten and 1st grade students!

Next Steps

• Crowdsource different adaptivity rules

• Test games in multiple contexts including closer classroom integration
Thank You!