

# Context Matters: Insights from transfer research on teaching physics with examples from astronomy

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# Context Matters: Insights from transfer research on teaching physics with examples from astronomy

Noah: Context = teaching-learning environment  
(classroom, lab,, ...)

Wolfgang: Context = the scientific situation in which the physics or astronomy is applied

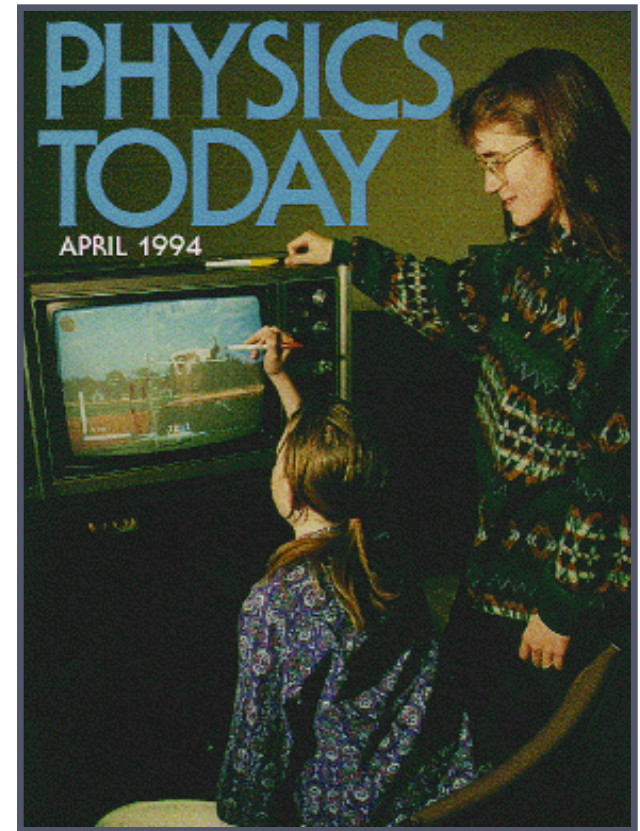
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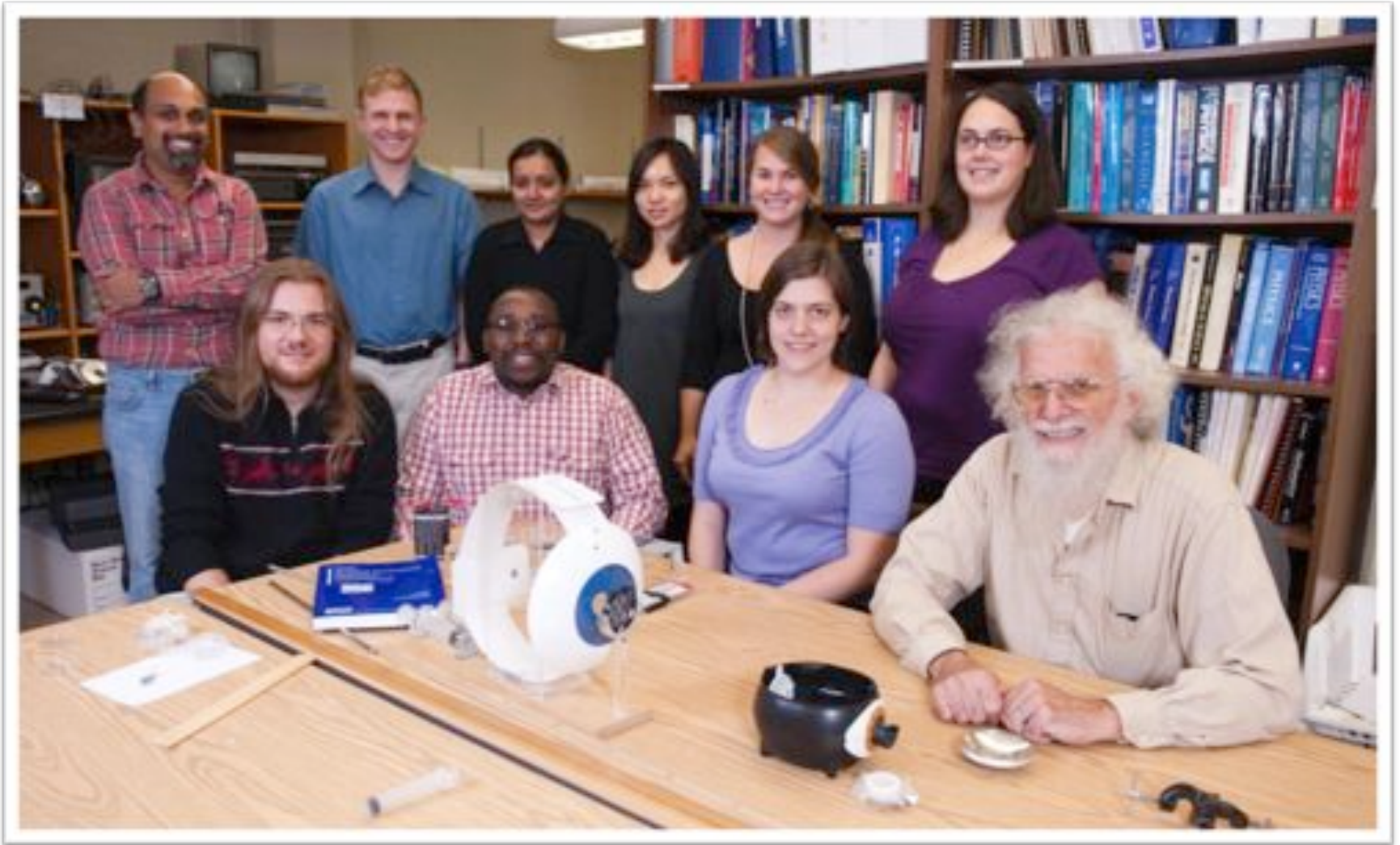
# With significant help from Sanjay Rebello

Based on foundational work by Bransford and Schwartz: “Rethinking Transfer: A Simple Proposal with Multiple Implications”, *Review of Research in Education* 24, 61–100 (1999)

# Kansas State University Physics Education Group

- 3 Professors
- 1 Visiting Professor
- 3 Post-docs
- 5 Physics Ph.D. Students
- 2 Science Education Ph.D. Students





# Transfer

- ▶ The ability to use your knowledge in a context different from the one in which you learned it.
  - Apply concepts
  - Solve problems
  - Develop new ideas
  - ...
- ▶ Previous learning is defined very broadly
  - Classroom
  - Informal
  - Everyday life



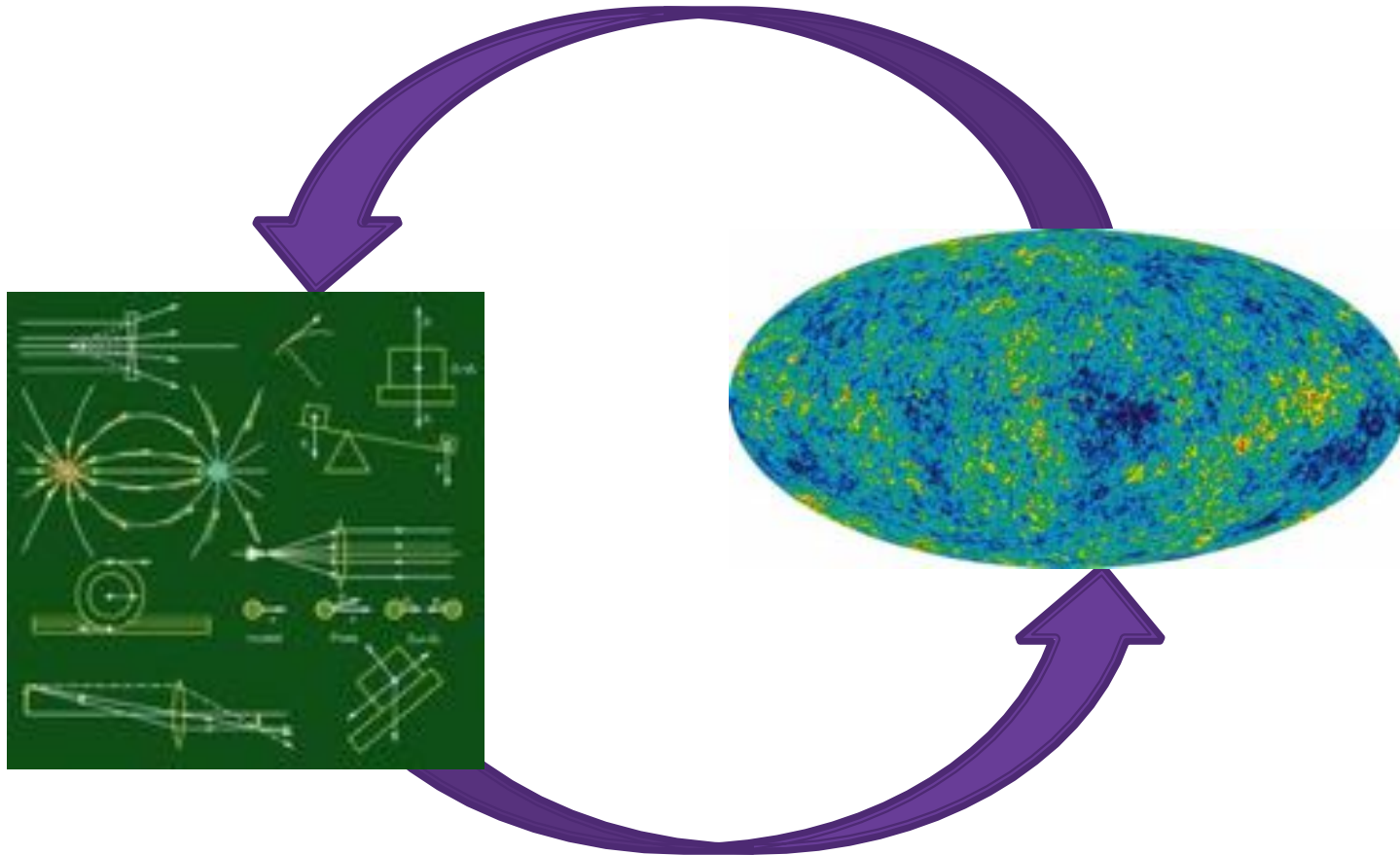
# FoxTrot

by Bill Amend



January 25, 2009

# Using Astronomy & Cosmology to teach Physics



Applying Physics to teach  
Astronomy & Cosmology



# Two views of Transfer

- ▶ One big step
  - Teach an idea; present a related problem
  - Students solve with no help
  - Sequestered Problem
  - Seldom works for most students
  - Example
- ▶ Transfer is small steps
  - Bring pieces of knowledge to bear on the new situation
  - Knowledge from different sources
  - Receive help from others
  - Happens frequently

# Two ways to teach transfer

- ▶ **Direct Application (DA)**
  - Help students learn a topic
  - Give them a transfer problem
  - Expect them to solve it
- ▶ **Preparation for Future Learning (PFL)**
  - Help students learn a topic
  - Teach them to make use of existing resources
  - Provide additional resources (scaffolding) as needed
  - Assess abilities to learn in knowledge-rich environment

Bransford & Schwartz (1999)

*Review of Research in Education* 24, 61–100.

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**SELDOM HAPPENS**

Bransford & Schwartz (1999)

*Review of Research in Education* 24, 61–100.

# Two ways to teach transfer

- ▶ Direct Application (DA)

- Happen
- Give
- Expect them to solve it

**SELDOM HAPPENS**

- ▶ Preparation for Future Learning (PFL)

**FREQUENTLY HAPPENS**

- Assess abilities to learn in knowledge-rich environment

Bransford & Schwartz (1999)

*Review of Research in Education* 24, 61–100.

# Two types of transfer

## ▶ Horizontal

- Activating and mapping a pre-constructed model to a new situation.
- Associations between information of a situation & elements of model.

## ▶ Vertical

- Constructing a new model to make sense of a situation.
- Association between knowledge elements to create model.

# Two types of transfer

## ▶ Horizontal

- Activating and applying knowledge to a new situation.
- Associations between elements of model.

Typical end-of-chapter problems

## ▶ Vertical

- Constructing a new model to make sense of a situation.
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# Two types of transfer

## ▶ Horizontal

- Activating and applying knowledge to a new situation.
- Associations between elements of model.

Typical end-of-chapter problems

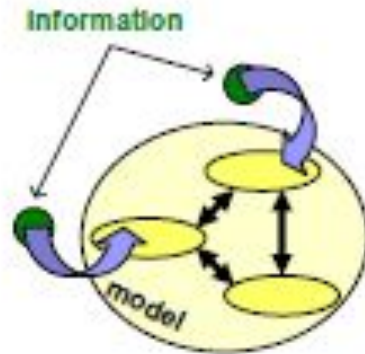
## ▶ Vertical

- Constructing a new situation.
- Association between elements to create model.

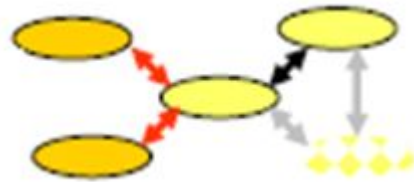
Typical research problems

# Transfer

- ▶ Horizontal



- ▶ Vertical

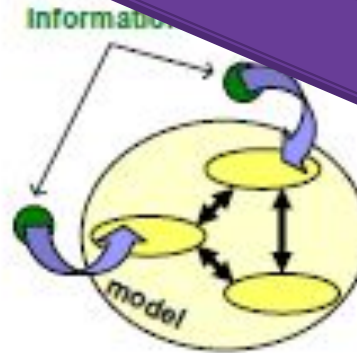


New knowledge elements are incorporated to modify the model or create a new one.



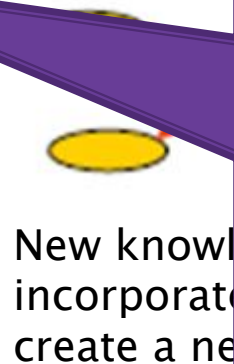
# Transfer

## ▶ Horizontal

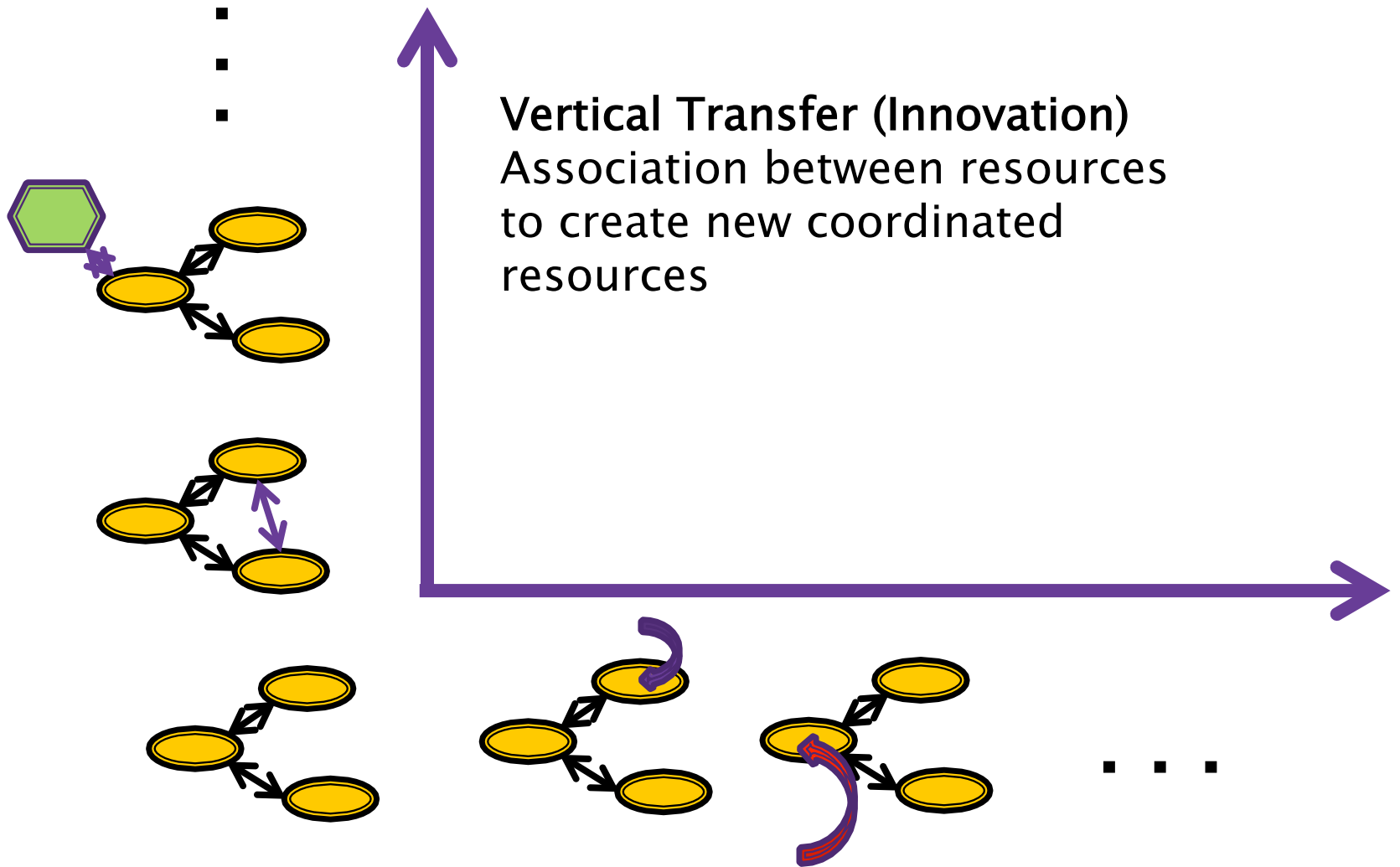


Creates efficiency at solving certain types of problems

## ▶ Vertical

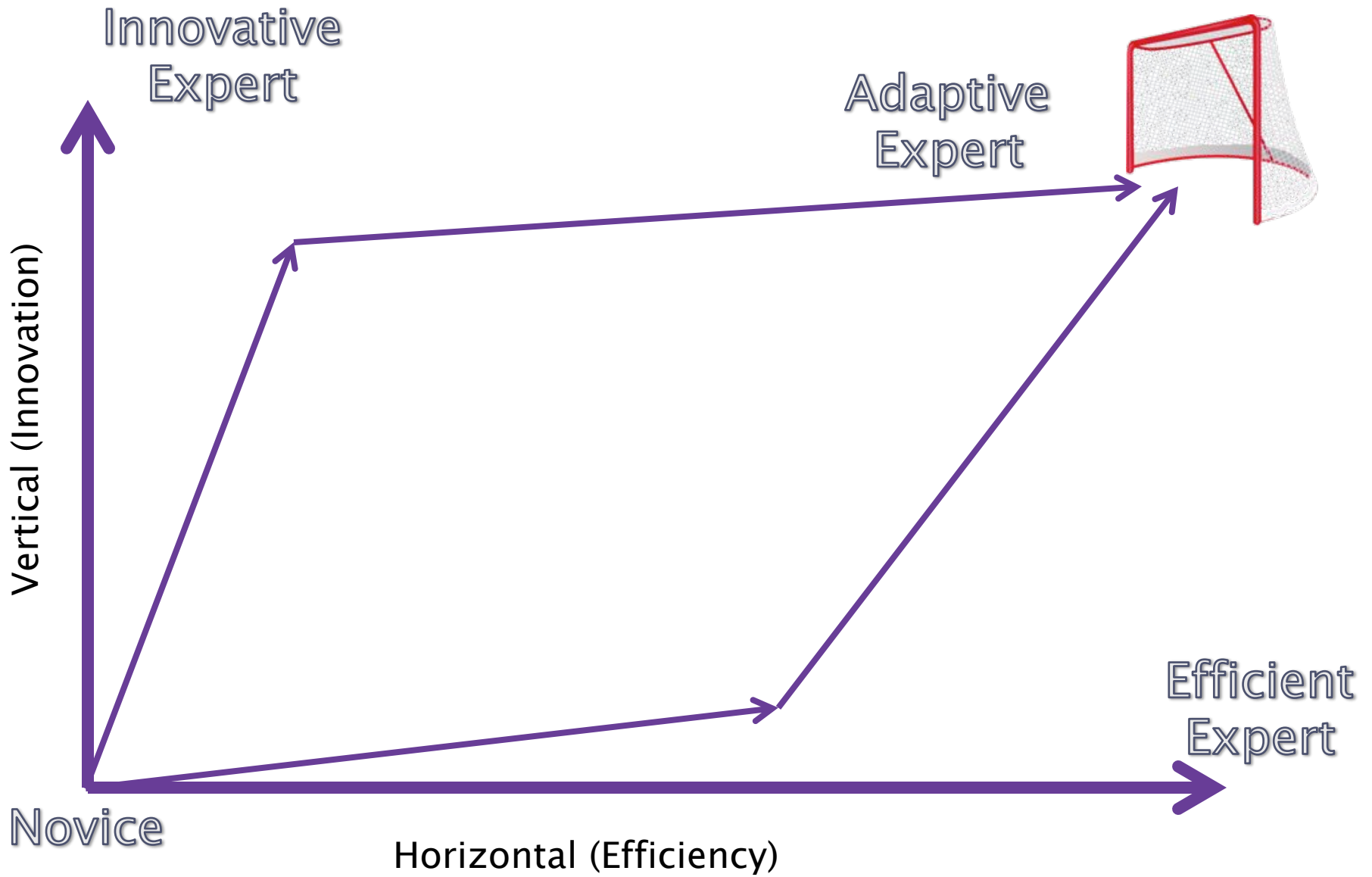


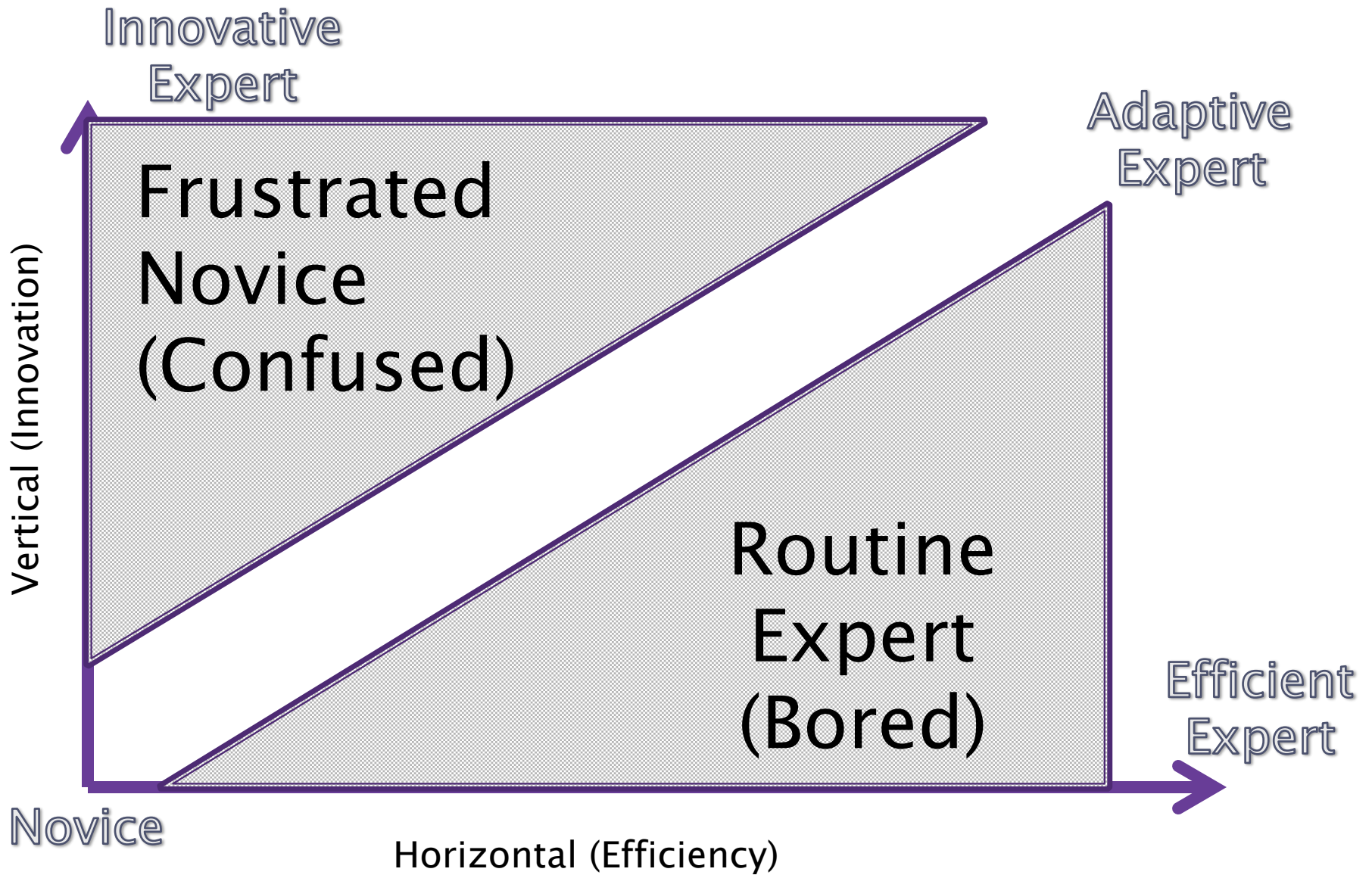
Creates the ability to innovate by modifying models



Vertical Transfer (Innovation)  
 Association between resources  
 to create new coordinated  
 resources

Horizontal Transfer (Efficiency)  
 Assignment of new  
 information into an existing  
 resource or set of resources





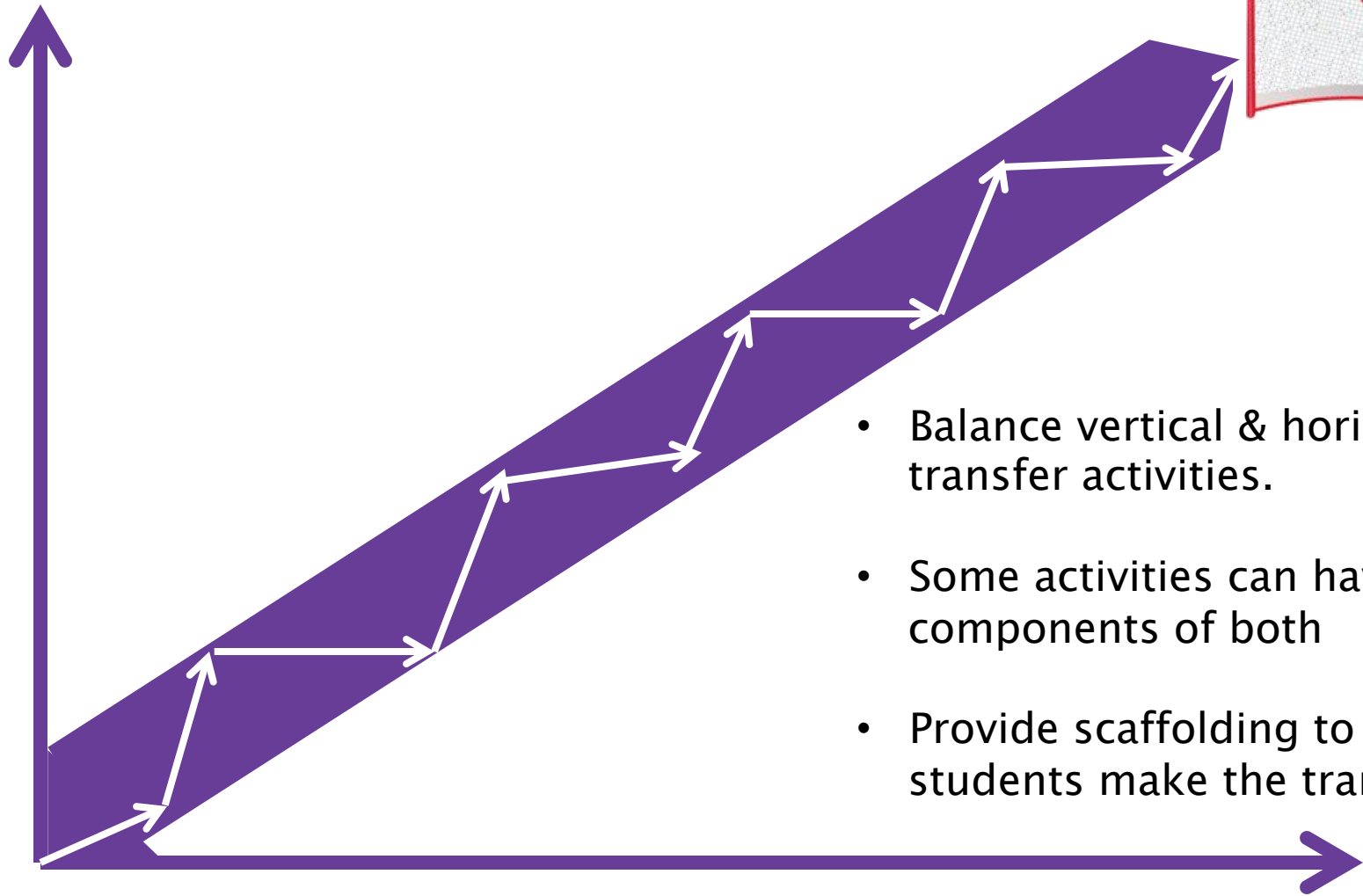
Vertical Transfer (Innovation)

Optimal Adaptability Corridor

Horizontal Transfer (Efficiency)



Vertical Transfer (Innovation)



Horizontal Transfer (Efficiency)

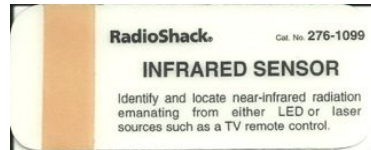
- Balance vertical & horizontal transfer activities.
- Some activities can have components of both
- Provide scaffolding to help students make the transfer.

# Example Vertical Transfer Problem from Visual Quantum Mechanics

## Infrared detector card

- ▶ Prior to cell phone cameras used by TV repair people to determine if IR was being emitted by remotes
- ▶ Point remote at the card
  - If remote is working, orange light is emitted by the card.
- ▶ Puzzle: How can low energy (IR) light cause higher energy (visible) light to be emitted from the card.

# Inputs

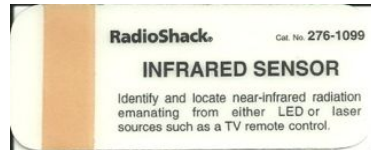


## Experiments with card

- ▶ Only works after sitting in light for a while
  - Color of light can matter
- ▶ Stops working after exposure to intense IR

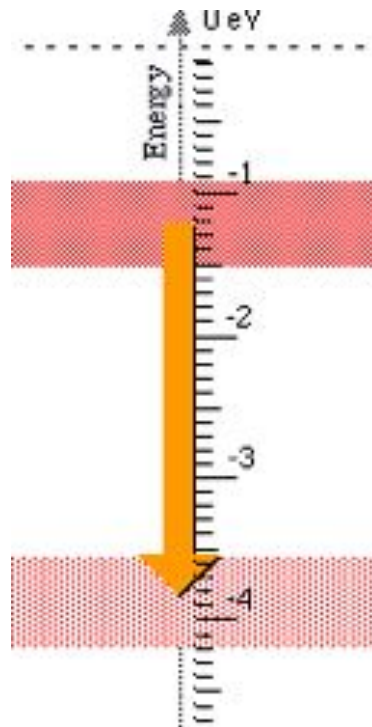


# Inputs



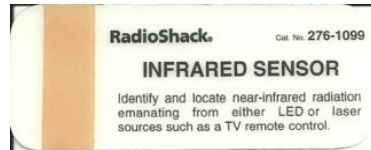
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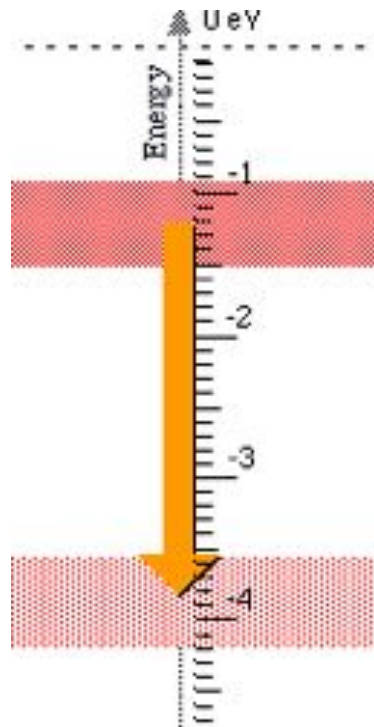
Band-gap model of solids

# Inputs

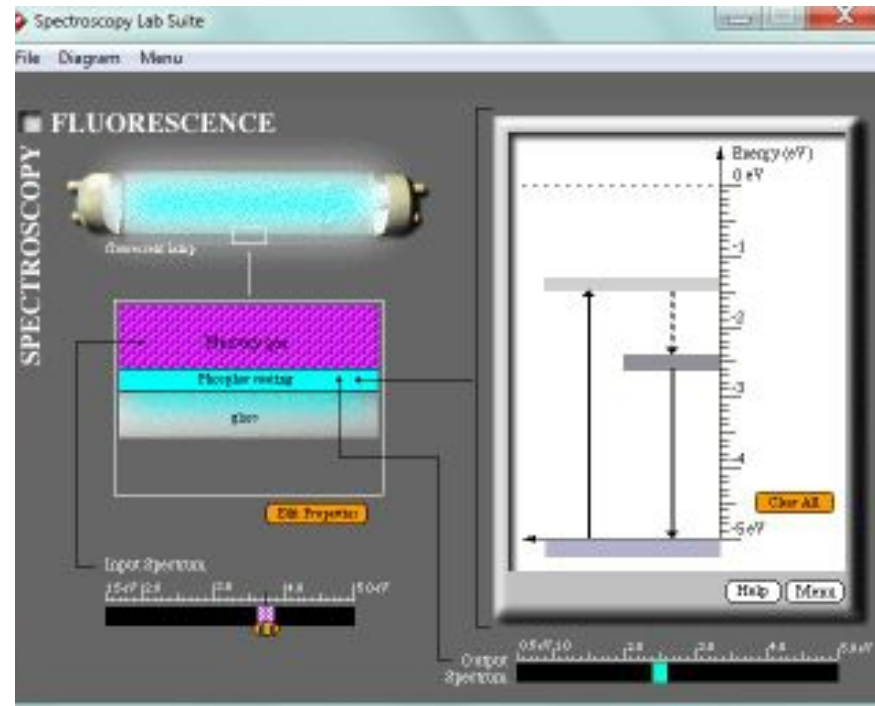


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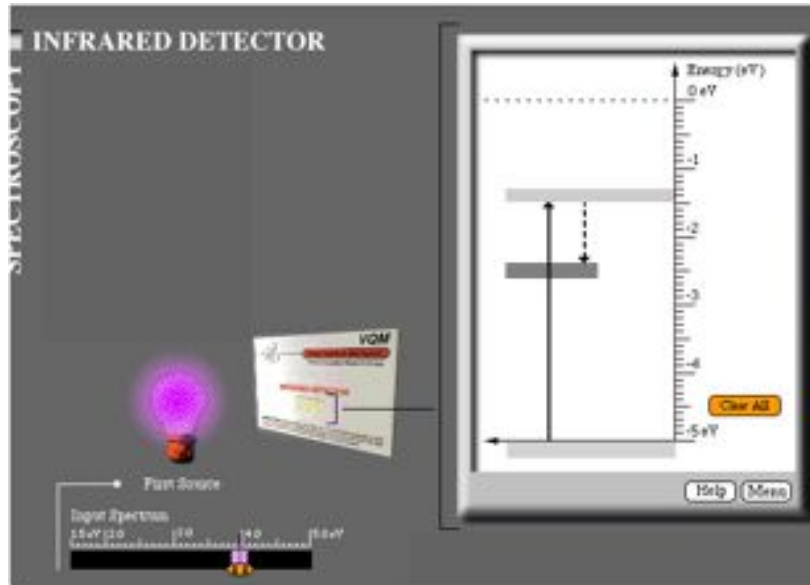


Band-gap model of solids

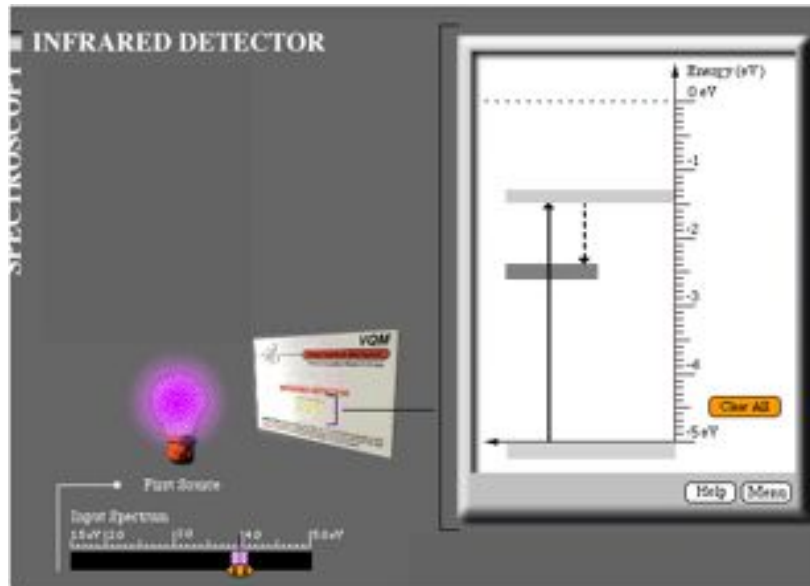


Energy level model of fluorescence

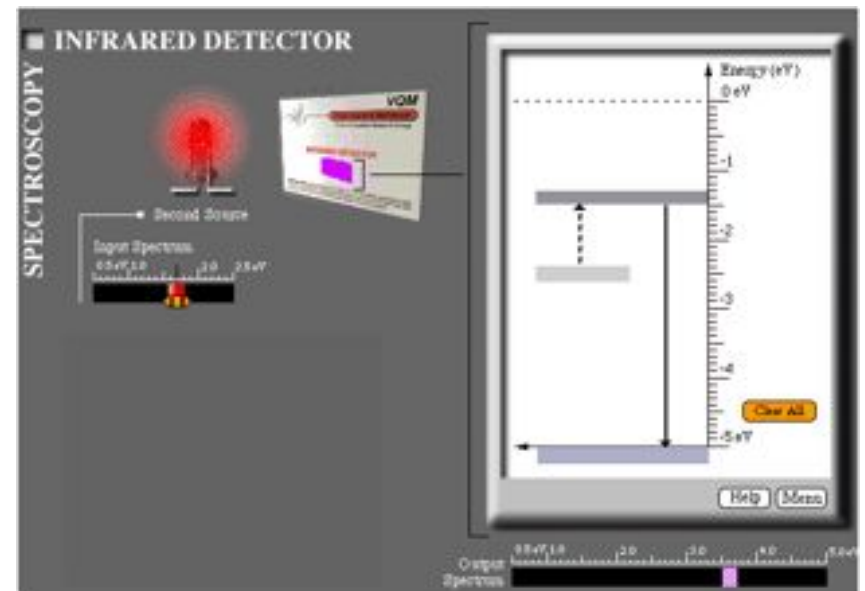
# Output: Energy Level Model of IR Detector Card



# Output: Energy Level Model of IR Detector Card



With appropriate help (scaffolding) students can build this two-step model.

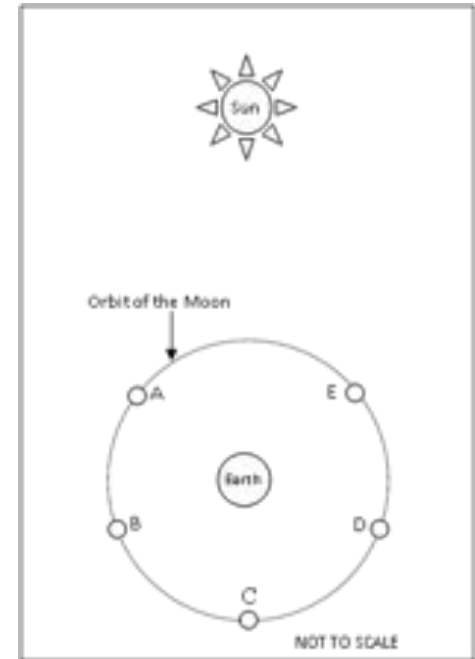
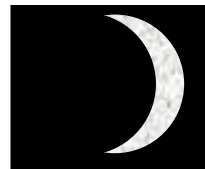


# Comparison – Phases of the moon

You look outside and see a first quarter moon. Suppose that an astronaut were on the moon looking at Earth. Make a sketch of the Earth as seen by the astronaut. How will the illuminated portion of the Earth appear different three days later?

UW PER Group: *Physics by Inquiry*

Which Moon position (A–E), shown in the diagram at right, best corresponds with the moon phase shown below?



Mostly Vertical

Horizontal

# Identical Problems to

Horizontal

- ▶ Faculty

- ▶ First & Second Year Graduate Students

- ▶ Undergraduate Students

Vertical

Truyol, Gangoso, & López

# Some Additional Issues

## Horizontal & Vertical Transfer...

- ▶ are not mutually exclusive.
  - A given thinking process might involve elements of both horizontal and vertical transfer.
- ▶ cannot be universally labeled.
  - What is perceived as vertical transfer by a novice may be perceived as horizontal transfer by an expert.
  - Experts may disagree about the type of transfer that has occurred in a given situation.



# Difficulties transferring knowledge of integration from math to physics

## ▶ Students

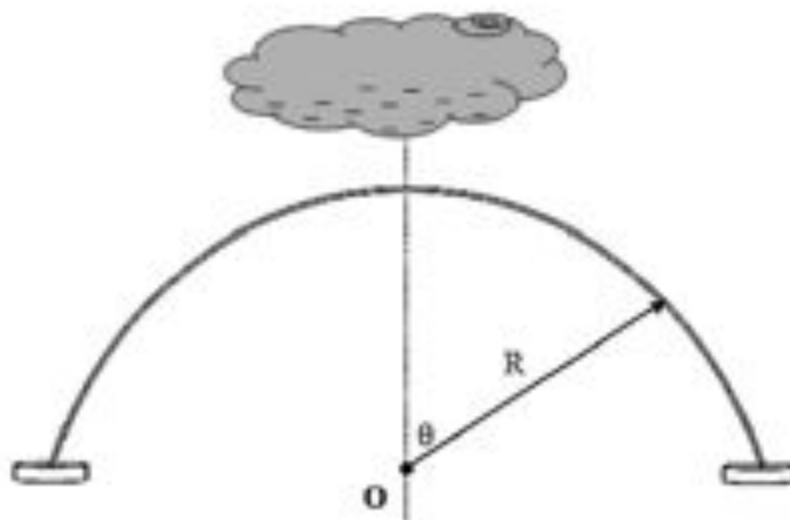
- Enrolled in second semester calculus-based physics
  - Studio style course
- Completed or concurrently enrolled in Calculus 2
- Physics or Engineering majors

## ▶ Methodology

- Students solve problems
- 15 students
- Teaching-Learning Interview
  - Provide help as needed
- 4 interviews
  - Each within 2 weeks of exam on the topic



# Example Problem



You are standing at the center of a non-conducting circular arc on a stormy day. The charge distribution on the arch varies as.

$$\lambda = \lambda_0 \cos \theta$$

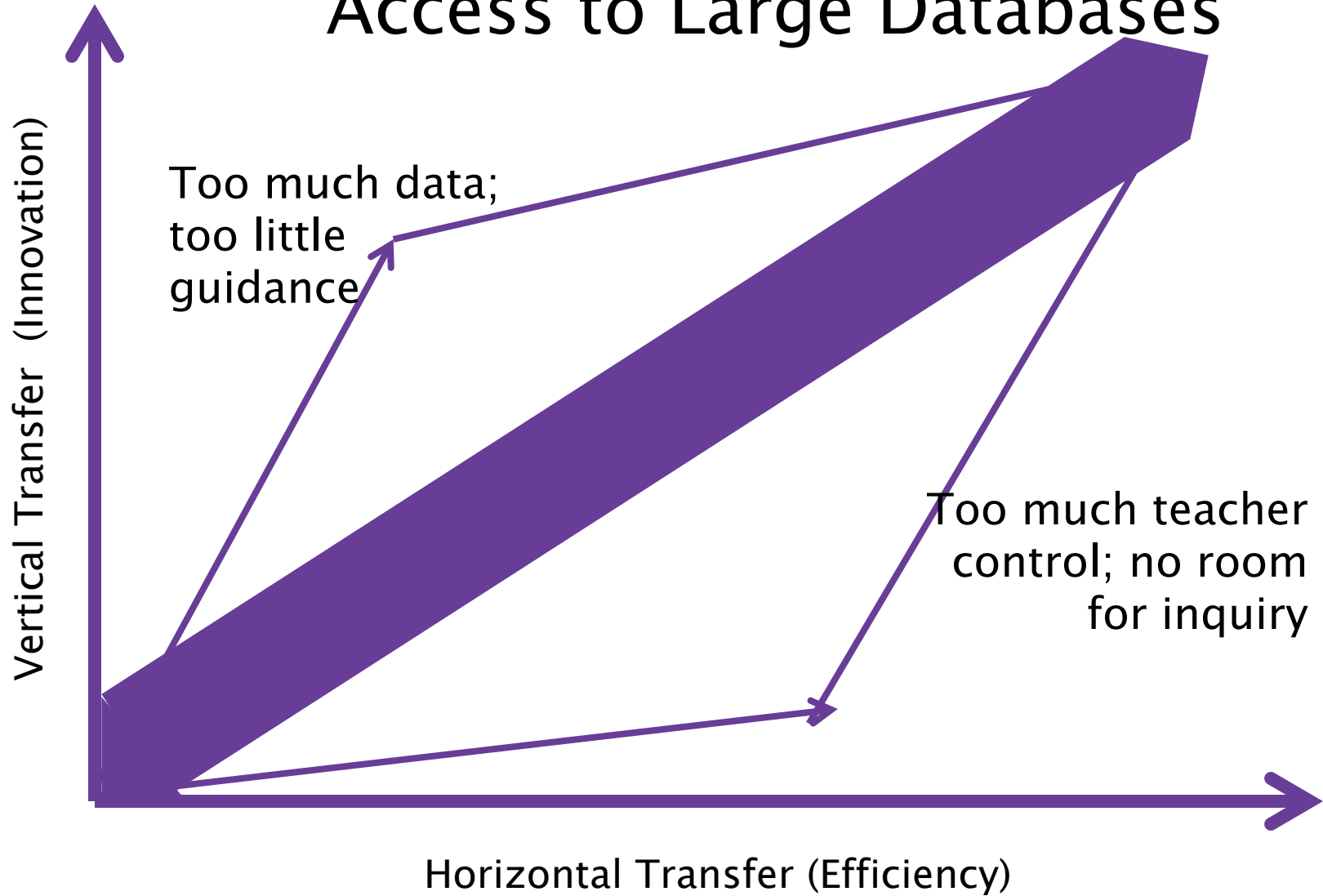
Find the direction and magnitude of the electric field at your feet.

# Some conclusions of this study

## Students

- ▶ recognize that they need to use integration
- ▶ have difficulty setting it up
- ▶ Have trouble connecting variable with physical quantities
- ▶ did not apply summation of infinitesimals properly
- ▶ were able to complete the problems with guidance
  - Including helping transfer ideas learned in Calculus

# Access to Large Databases



# Transfer

- ▶ Does happen
- ▶ But students need help (scaffolding)
- ▶ Small steps work better than large ones
- ▶ Both vertical & horizontal transfer are desirable
- ▶ And students need practice with both

Thank You  
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