CONCEPTUAL CHANGE & TRANSFER OF LEARNING:

CONSOLIDATING VARYING VIEWPOINTS

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What is Transfer?

Ability to use what you have learned in one situation in a different situation.

E.g. McKeough, Lupart & Marini (1995)

Some Early Views of Transfer

- Identical elements must exist between situations.
- Knowledge must be encoded in a coherent model.
- Students either transfer or they don't.
- Researchers/educators pre-decide what must transfer.
- Static one-shot assessment e.g. tests and exams.
- Focus mainly on students' internal knowledge.

Transfer is rare.

E.g. Gick & Holyoak (1980), Reed & Ernst (1974), Thorndike (1906)

Example: Interview on Optic Fibers

How does an optic fiber work?

From what I understand, it's a, it's almost a series of

In light of this example, do we need to rethink what transfer actually means?

Mateycik, Wagner, *et. al.* (2004)

Some Current Views of Transfer

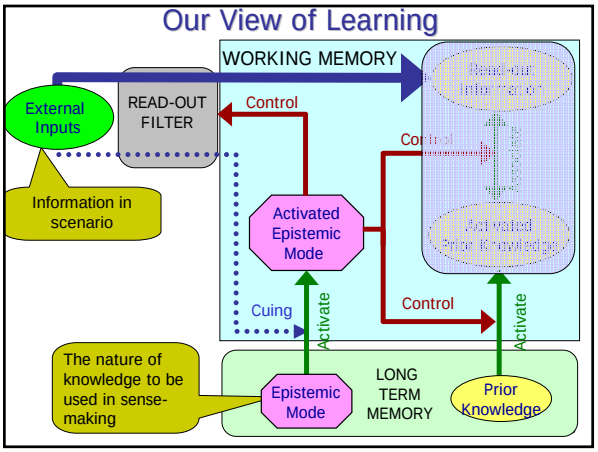
- (Re) construct knowledge in new context.
- Knowledge can transfer in pieces.
- Learners may transfer some pieces, but not others.
- We must examine anything that transfers.
- Dynamic, real-time assessment e.g. interviews.
- Focus also on mediating factors e.g. motivation.

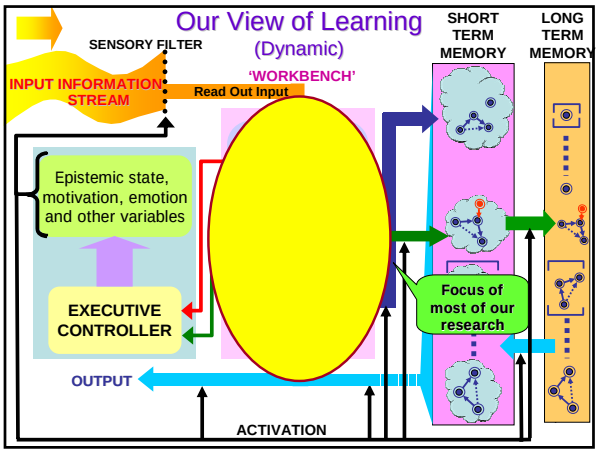
Transfer is ubiquitous.

Transfer, in this sense, involves **conceptual change**

Hammer *et al* (2005), diSessa & Wagner (2005);
Bransford *et al* (1999), Lobato (2003, 1996), Greeno *et al* (1993)

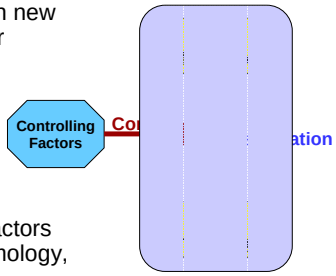
Our View of Learning





Our View of Learning

Learning is the creation of associations between new information and prior knowledge.



The association is controlled by other factors e.g. learners' epistemology, motivation etc.

Redish (2004)

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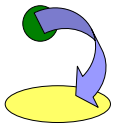
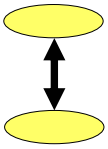
Two Kinds of Associations

- Assigning a new case to an existing knowledge element.
  - e.g. The electric field between two parallel plates is constant.



- Constructing an association between two knowledge elements.
  - e.g. Integral of Electric field is the Electric potential.



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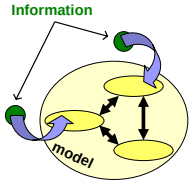
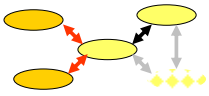
Two Kinds of Learning

- 'Horizontal'
  - A pre-constructed set of associated elements i.e. a 'model' exists.
  - Associate new information with elements of this model.
- 'Vertical'
  - New information incompatible with existing model.
  - Activate or suppress associations to create new model.





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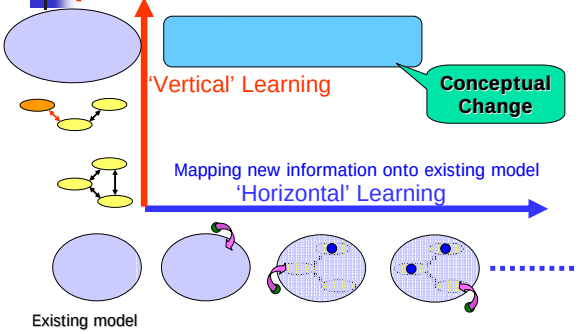
Our Framework for Learning



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Some Other Similar Views

- Assimilation vs. Accommodation[1]
- Model deployment vs. Model development[2]
- Efficiency vs. Innovation[3]

[1] Piaget (1952) [2] Hestenes (1987) [3] Schwartz, Bransford & Sears (2005) 12

Alignment with Others' Views

Horizontal	Vertical
Assimilation	Accommodation [1]
Efficiency	Innovation [2]
Model Development	Model Deployment [3]
Class C Transfer	Class A Transfer [4]
Low Road Transfer	High Road Transfer [5]
Applicative knowledge	Interpretive knowledge [6]
Sequestered Problem Solving	Preparation for Future Learning [7]
Used in structured, traditional contexts, which involves few internal representations activated repeatedly	Used in ill-structured, non-traditional contexts, which involves choosing, or constructing multiple internal representations [8]

[1] Piaget (1952) [2] Schwartz, Bransford & Sears (2005) [3] Hestenes (1987)
[4] diSessa & Wagner (2005) [5] Salomon & Perkins (1989) [6] Broudy (1977)
[7] Bransford & Schwartz (1999) [8] Jonassen (2003)

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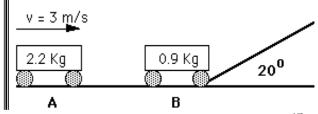
'Horizontal' or 'Vertical'?

- What type of learning do these problems entail?

You are helping your friend prepare for her next skate board exhibition. She takes a running start and jumps onto her skateboard. The skateb**Vertical**ng a level tr sloped wall. To win she must reach at least 10 feet above the ground. She knows you have taken physics, so she asks you if she can carry out her program as planned.

Cart A, moving at 3 m/s, has an inelastic collision with Cart B, initially at rest. After the collision, the carts move together up an inclined plane. Negle**Horizontal**nine the ve carts before they reverse direction.



Some Caveats

Horizontal & Vertical Learning…

- are not mutually exclusive.
  - A thinking process might involve elements of both horizontal and vertical learning.
- cannot be universally labeled.
  - Vertical learning for a novice may be horizontal learning for an expert.

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What We Know About Learning

- Is facilitated by…
  - Cognitive Conflict : Challenge existing ideas[1].
- Occurs within a…
  - Zone of Proximal Development[2].
- Can result in model building[3]
  - Models, if robust are usable in different contexts.

[1]Piaget (1964) [2]Vygotsky (1978) [3]Hestenes (1987)

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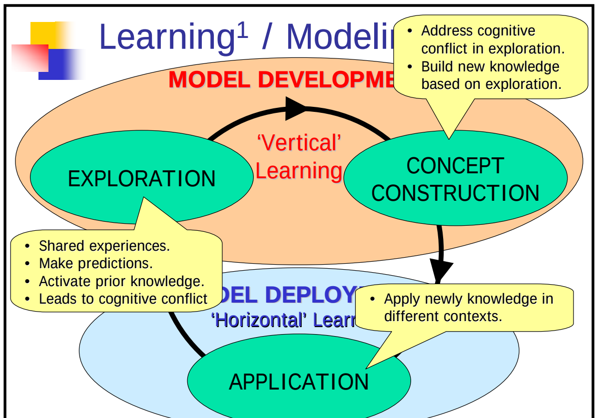
Learning[1] / Modeli



[1] Karplus & Renner (1974) [2] Hestenes (1987)

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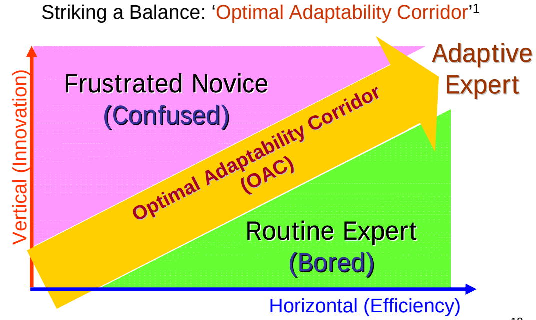
What Kind of Learning?

Horizontal (Efficiency) vs. Vertical (Innovation)

Striking a Balance: 'Optimal Adaptability Corridor'[1]



[1] Schwartz, Bransford & Sears (2005) [2] Murray & Arroyo (2002)

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Implications for Instruction

- Balance horizontal and vertical learning
  - Follow an 'Optimal Adaptability Corridor'
- Adapt the Modeling Cycle
  - First Model Development
  - Then Model Deployment
- Employ strategies for conceptual change
  - Use cognitive conflict to promote model development
  - Facilitate learning within Zone of Proximal Development

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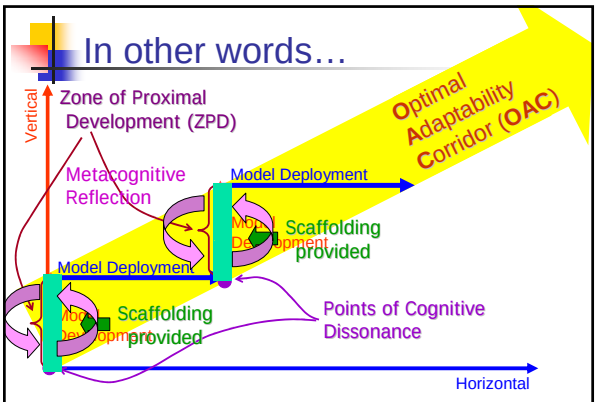
In other words…



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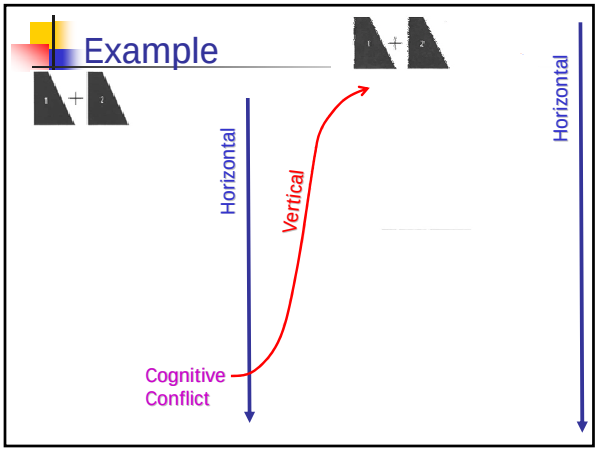
Example



BUT…

HOW DO WE DESIGN INSRUCTION THAT ACHIEVES THESE GOALS?

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In other words…

- How do we probe the dynamics of learning?
  - How do learners interact with situations causing cognitive dissonance?
  - How and what can we learn about their Zone of Proximal Development?
  - What are their various trajectories of learning along the horizontal-vertical continuum?
- Based on these insights…

How do we design appropriate experiences to scaffold students' learning?

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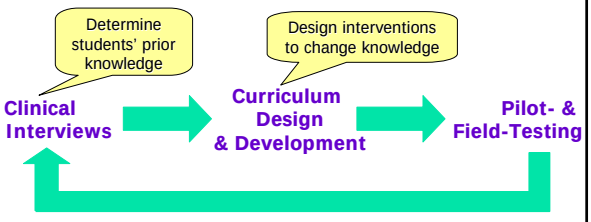
Designing Learning Experiences

Typical Methodology



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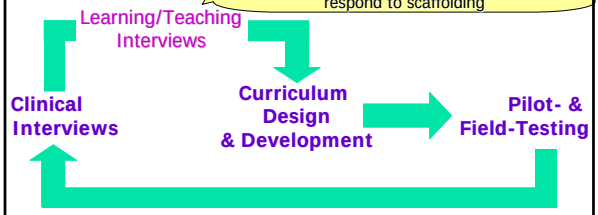
Designing Learning Experiences

Alternative Methodology

Carefully examine the process by which students construct knowledge, and how they respond to scaffolding



Steffe (1983) Steffe & Thompson (2000)

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What is a Learning/Teaching Interview?

- 'Mock' instruction:
  - Attempts to change student knowledge.
  - Rich setting for students to express themselves.
  - Variety of instructional strategies.
  - May involve groups of up to three students.
- Researcher's Role:
  - Observer.
  - Instructor.

Engelhardt *et . al.* (2004)

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Learning/Teaching Interviews...

Can provide insights about ...

- Dynamics of horizontal and vertical transfer.
- Effectiveness of instructional strategies.
- Student interactions with...
  - instructional materials,
  - peers, and
  - instructor.

Learning/Teaching Interviews can be a useful tool for research & design of learning experiences.

BUT...

WHERE IS THE EVIDENCE THAT SUCH STRATEGIES MIGHT WORK?

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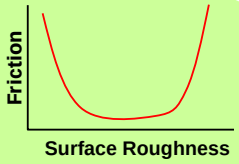
'Microscopic Friction' Study

GOAL

Design instructional experiences to help students construct a desired model of microscopic friction?

What model?

- Friction is due to electrical interactions.
- Friction varies with roughness as shown:



Corpuz (2006)

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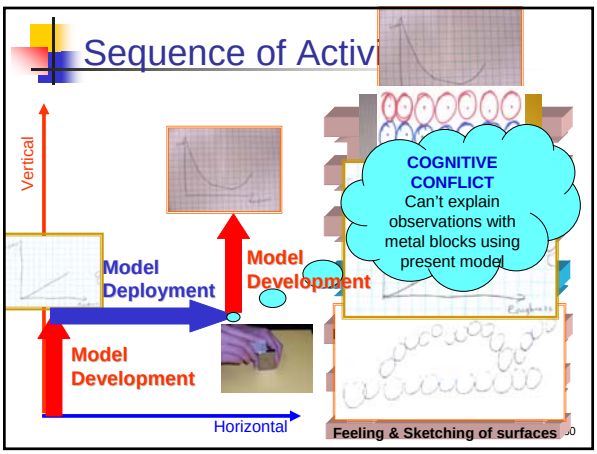
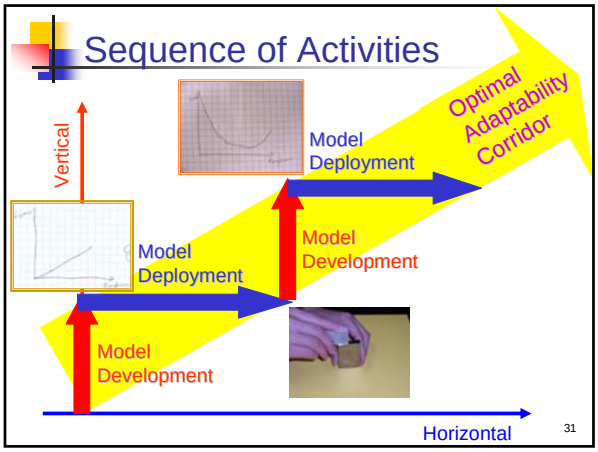
Sequence of Activi



Sequence of Activities



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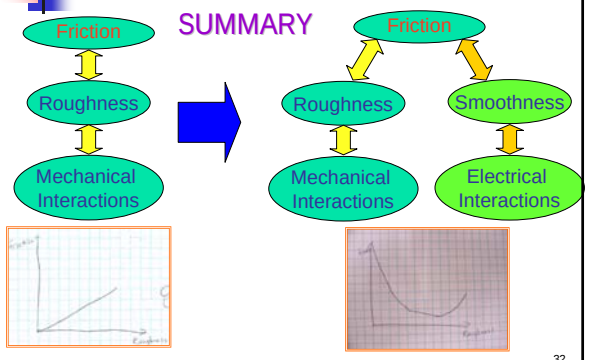
'Microscopic Friction' Study



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PILOT TESTING

Qualitative Evaluation (N=14)

Physics Course	No. of Students
1st Semester Algebra-Based Physics	8
2nd Semester Algebra-Based Physics	4
Conceptual-Based Physics	2

Quantitative Evaluation (N=173)

Physics Course	No. of Students
Conceptual-Based Physics*	173

* Elementary Educ. Majors: <40% have HS Physics

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Qualitative Evaluation

- Small Group Activity
  - Recorded students' model progression
    - open-ended questions
    - student discussion
  - Post-Activity Interviews with students
    - Feedback about activity

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Qualitative Results

Individual Ideas Before Activities

Your Ideas of friction

Friction is a factor of weight and texture as I understand it. The smoother the object the less friction it will have. Water, oil, or other liquids can reduce friction by filling in small spaces to make a surface smoother. Friction is a force.

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Qualitative Results

Individual Ideas After Activities

Write your individual thoughts now about friction?

I'm surprised that smooth objects are so hard to move. But thinking about it on the atomic level, it makes sense that the more surface and close proximity of the atoms creates some friction too.

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Qualitative Results

Group Consensus After Activities

Please write your consensus idea/s on the box below.

Factors Affecting Friction:
Texture, surface area, contact-bonding.

How each factor affect friction:
Textures that are rough physically grab, textures that are smooth may bond and will have greater surface area to interact.

Cause of friction at the atomic level:
Electrical Charges/ bonding of close atoms

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Quantitative Evaluation

Multiple-Choice Test

- Pretest-Posttest Control Group
  - Control Group 1 (N = 24)
    - Videotaped lecture (1 hour)
  - Control Group 2 (N = 83)
    - Classroom lecture (1 hour)
  - Experimental Group (N = 66)
    - Activity-based instructional material (1 hour)

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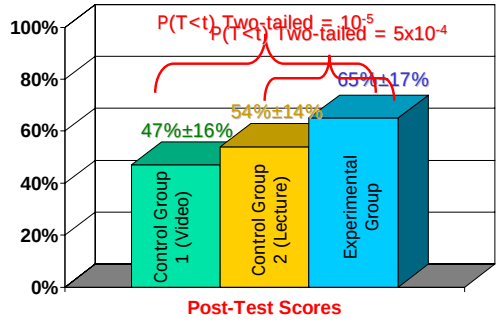
Quantitative Results

Pre-Test scores: ~30%±15% : ALL Groups



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We can also apply this to…

- Learning how to Learn:
  - Students deploy strategies to succeed in physics, based on their model of what it takes to succeed in this course.
  - If they fail, they reach a point of dissonance – model does not work.
  - We can then facilitate a process by which they reflect and develop a revised model of how to learn physics.

Vertical

Horizontal

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We can also apply this to…

- Learning how to Teach:
  - As teachers we deploy our model of how students learn and how we should teach.
  - If students fail our assessments, we reach a point of dissonance – our model of learning and teaching does not work.
  - We then develop a revised model of how they learn, and think about how we can teach more effectively.

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SUMMARY

- Transfer, as per some current perspectives may be indistinguishable from learning.
- Learning can loosely be described as vertical learning (or conceptual change) and horizontal learning.
- To create adaptive learners, we must balance both horizontal and vertical learning.
- This can be done through sequences of small steps of both vertical and horizontal learning.
- Learning/Teaching interviews highlight the dynamics of learning and facilitate design of experience to promote learners' development of adaptive expertise.
- This framework may also be applied in other domains -- learning how to learn and how to teach.

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THANK YOU
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