

# Advanced Learning Technologies and Advancing Learning in Higher Education

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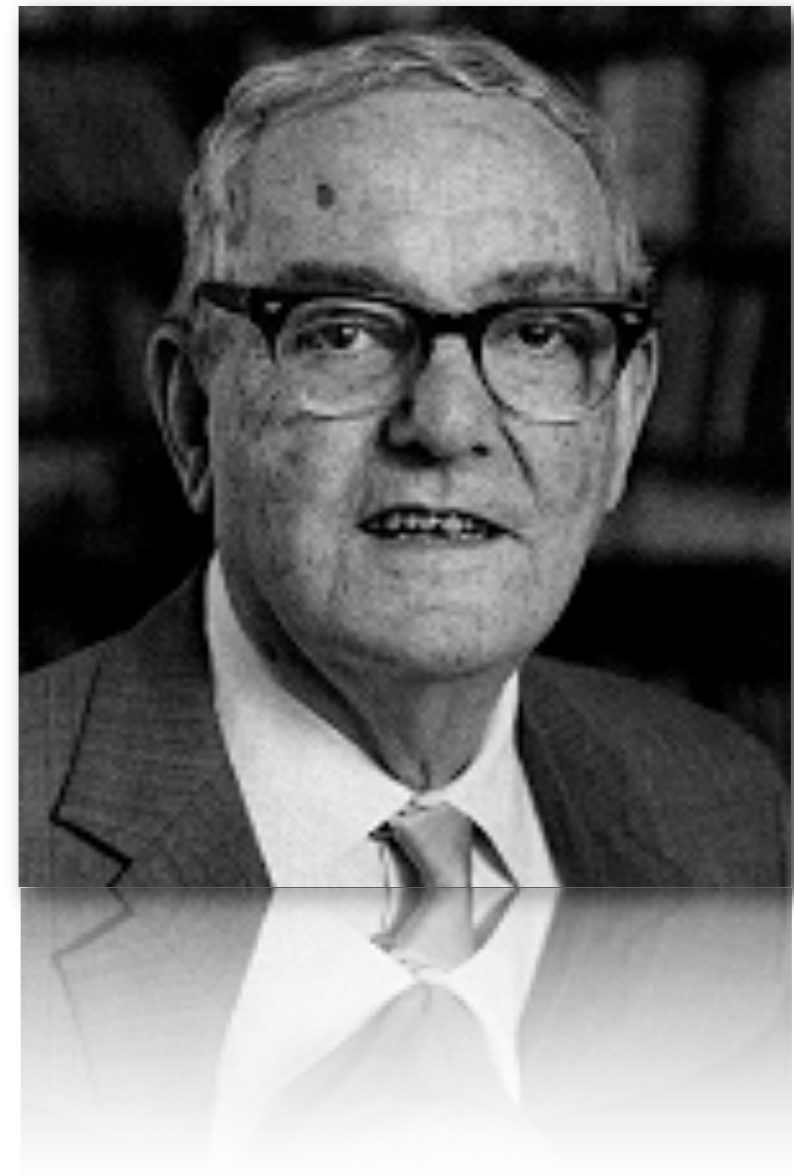


THE UNIVERSITY OF  
**SYDNEY**



*The meaning of knowing has shifted from being able to remember and repeat information to being able to find and use it.*

Nobel Laureate Herbert Simon  
(1917-2001)  
Cognitive Scientist and  
Economist



- › Innovations in advancing learning and advanced learning technologies
- › Time for talking
- › Fail first, then learn? Research into sequencing of pedagogical structure and “Productive Failure”
- › Discussion: Implications for advancing learning and teaching in higher education

# How to Teach “Hard Stuff?”

- Talk with neighbour next to you for 2-3 minutes:
  - Decide on something challenging or “hard” to learn
  - Think about how best to teach this over a 2-4 week period
  - Think of broad things you as a teacher do or activities you would have your students do
- We’ll share a few of these ideas

- You are teaching an important theory in your subject area that you wish your students will be able to make predictions about a new study.
- You are thinking about 3 different ways for your students to learn:
  - Way 1: Read and summarize a text on the theory and listen to a lecture designed to organize their understanding.
  - Way 2: Have the students actively compare data on experiments related to the theory and then hear the same lecture as Way 1.
  - Way 3: Have the students actively compare data on experiments related to the theory and give them twice the amount of time as Way 2 would be given.



# Vanderbilt University Psychology Class Study: Transfer Problem Predictions



# Why these findings?

- Way 1:
  - Common teaching approach (i.e., read textbook, then lecture)
  - Students given tasks that may not have apparent meaning to them
- Way 3:
  - Just “discovery learning” not enough
  - Novices unlikely to discover difficult concepts on their own
- Way 2:
  - “Time for talking” provided “grappling time” to realize the limitations of what they know
  - Helped students see relevance of organizing principles in the lecture that followed
  - Created “time for telling” in which students both can learn and apply (transfer) knowledge in lectures

# Learning the Physics of Electricity with Agent-based Models: Fail First and Structure Later?



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- › Most “traditional” instruction and many used in activities with learning technologies start with structured experiences before introducing students to low structure activities
- › Start simple or “small” and build gradually in terms of conceptual complexity, knowledge, and skills
- › Current learning theories are similar: Expert models activity, learners are initially scaffolded doing activities, and gradually fade scaffolding
- › Good goal: minimize frustration if learners fail
- › But does this mean learning failures in low structure activities might not, under the right conditions, also lead to learning?

# Studies of Pedagogical Innovation: Sequencing Structure and “Productive Failure”

- › Study 1: secondary 4 students (grade 10) at all boys school in Singapore
- › Low-to-High sequence of structure (LtH) group: 16 dyads
- › High-to-Low sequence of structure (HtL): 16 dyads
- › Used four different NetLogo models of electricity developed at Northwestern University, one per day for one hour sessions

# Examples of High to Low Versus Low to High Activities

## High Structure Initial Learning Activity

Run the Model 3 NetLogo to know the effect of voltage on current in two wires joined in a particular pattern.

1. Move the sliders to the following values.
  - i. Total electrons= 300
  - ii. Collision rate with nuclei left =0.5
  - iii. Collision rate with nuclei right=0.5
2. Fill in the following table.

Voltage	Current in Left Wire	Current in Right Wire
0.5		
1.0		
1.5		

Answer the following question.

1. What is your observation about current in both the wires? Explain why it is so.

## Low Structure Initial Learning Activity

Run the NetLogo Model 3 to know the effect of voltage on current two wires joined in a particular pattern.

Answer the following question.

1. What is your observation about current in both the wires? Explain why it is so.



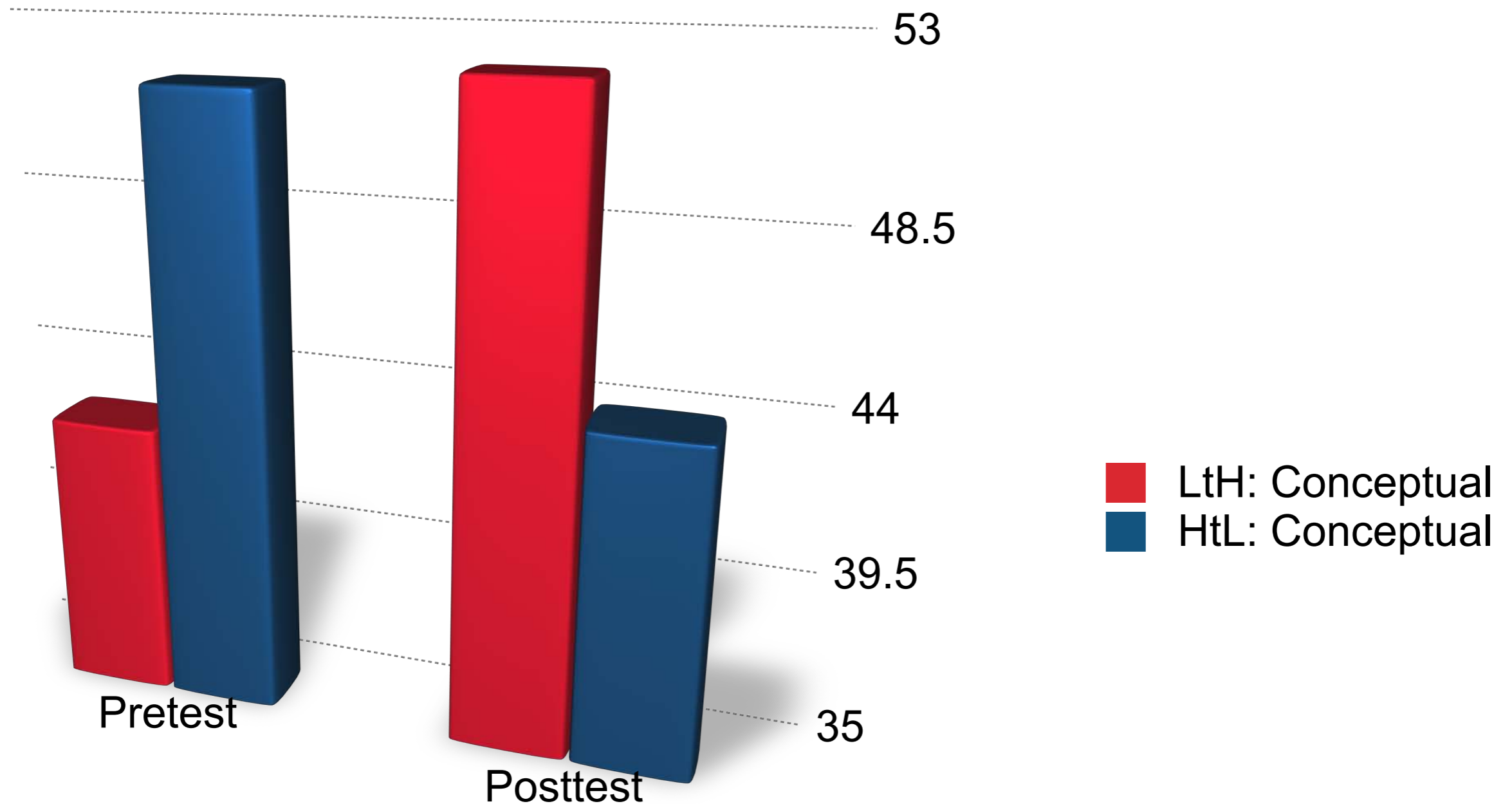
# Experimental Design: Four Models Each

Treatment Group	Question 1	Question 2	Question 3
High-to-Low Sequence (HtL)	High structure Dyads	High structure Dyads	Low structure Individuals
Low-to-High Sequence (LtH)	Low structure Dyads	High structure Dyads	Low structure Individuals



# Main Quantitative Findings

## Results: Conceptual Knowledge



- › Both groups liked using the NetLogo agent-based models
- › Appreciated the representational value of the visualizations in the NetLogo models over textbook pictures and PowerPoint lectures
- › **However, very different subjective impressions of their actual learning by treatment groups**

*Because some worksheets was not very specific-la. So we were discussing whether which of variable should be kept constant and which one is should be changing so that we can answer the question-la. So before we shift the sliders my partner and me will try to hypothesize, like oh this is directly related to that or in equal-proportion-to-that, so-we-try-to-slide. But in the end all our assumptions were wrong and then we couldn't find any relations so we keep shifting the sliders and then we were discussing, ah, why are the results are inconsistent with our assumptions and stuff.*



## Interview with HtL Student

*We, ah, me and my partner asked [the teacher] to clarify some, clarify, some stuff about the model in question. I prefer that she teach. It's much more... It will clarify more things ... if she teaches.*

- › Pre-service teachers at research intensive university in Australia
- › Treatment groups:
  - Low-to-High Sequence (LtH) group: 7 (6F/1M)
  - High-to-Low Sequence (HtL): 6 (4F/2M)
- › Used 2 NetLogo models: Coulombs Law and Ohms Law



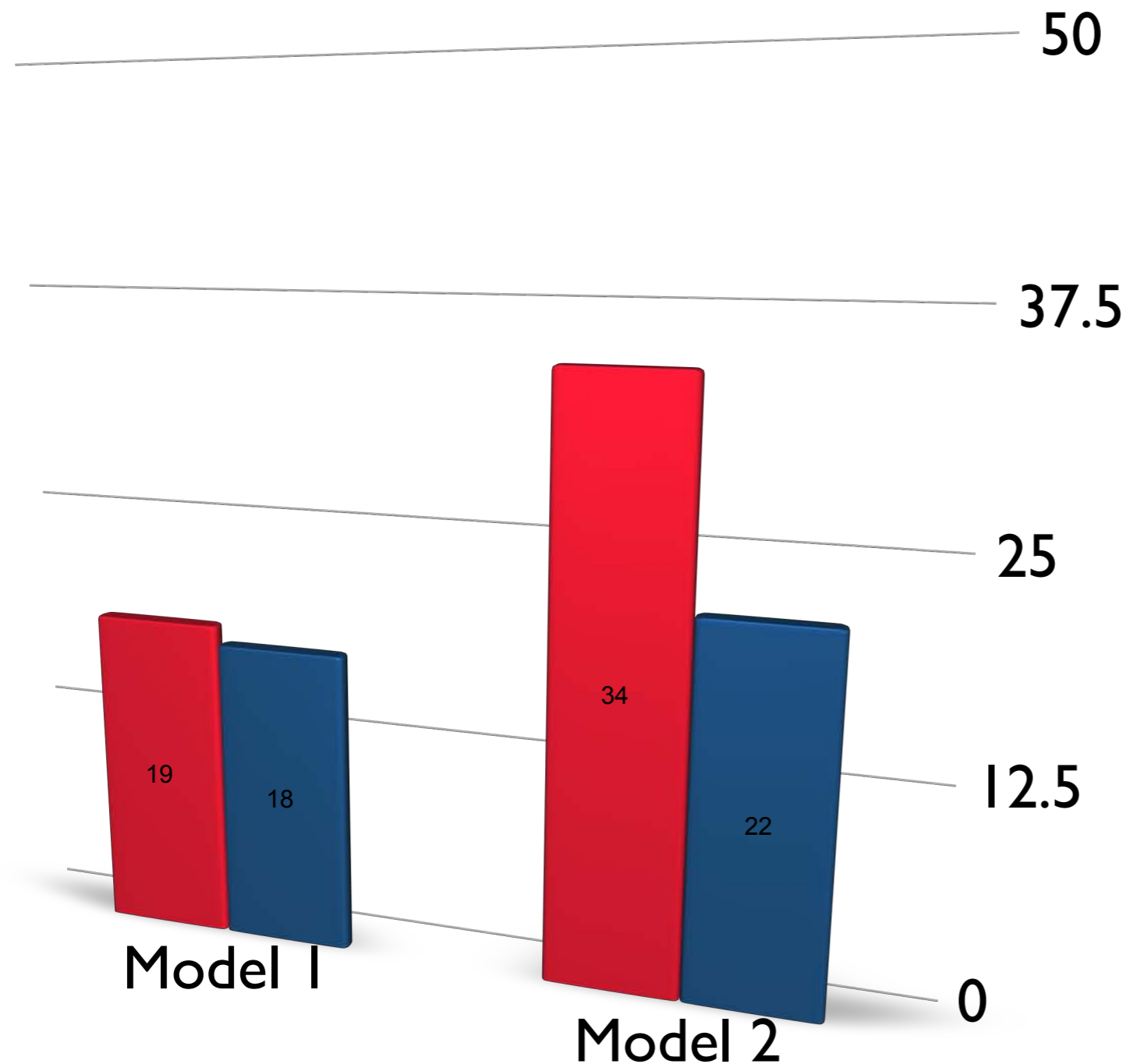


## Experimental Design 2: For Two Models Each

Treatment Group	Problem 1	Problem 2	Problem 3
High-to-Low Sequence (HtL)	High structure	High structure	Low structure
Low-to-High Sequence (LtH)	Low structure	High structure	Low structure



# Mean Total Scores

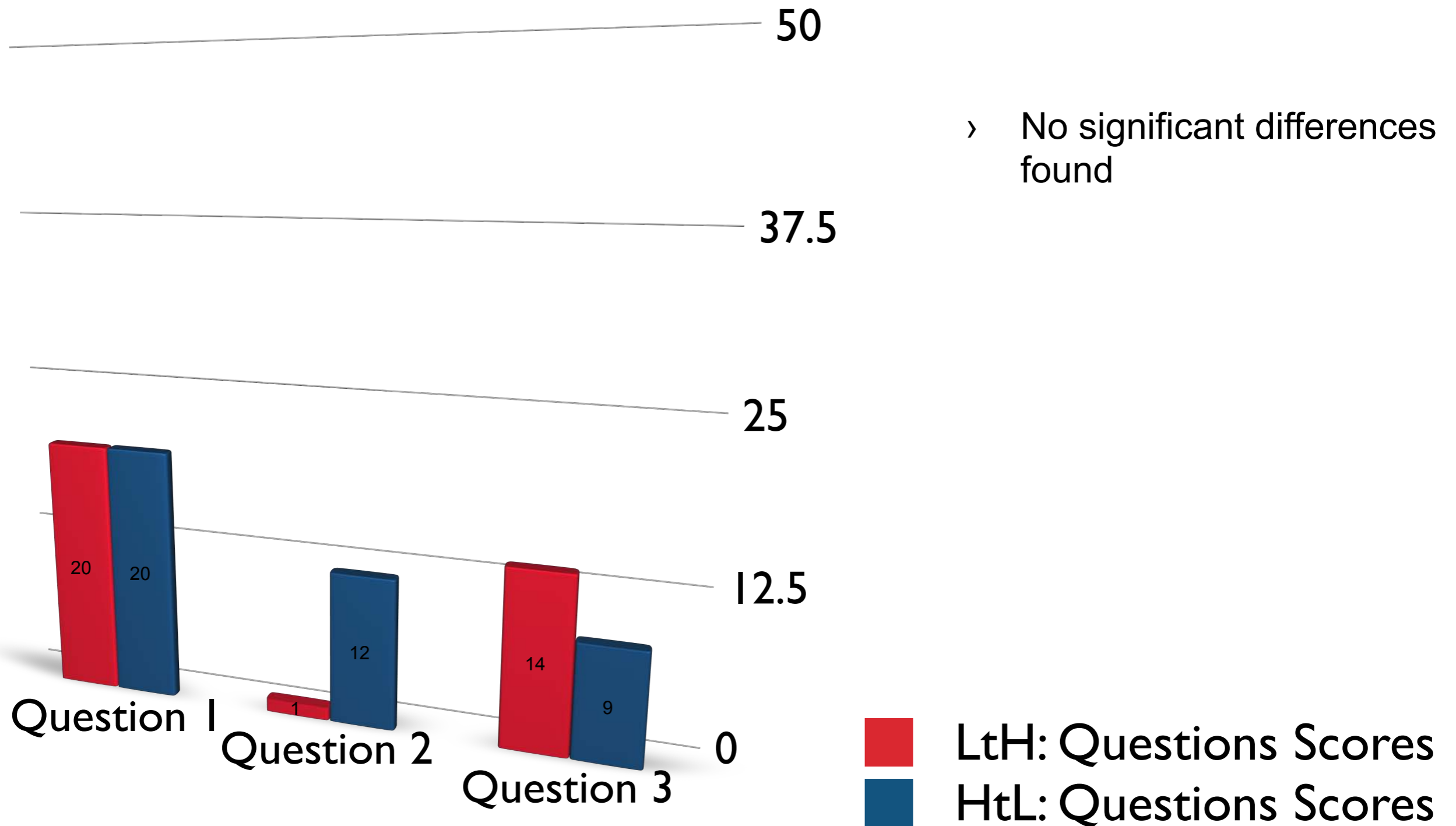


- › Model 1: LtH = HtL, NSD
- › Model 2: LtH > HtL ( $p < .05$ ,  $r = .51$ )
- › LtH Model 2 > Model 1 ( $p = .001$ ,  $r = .91$ )
- › HtL Model 2 and = Model 1 (NSD)

■ LtH: Total Score  
■ HtL: Total Score

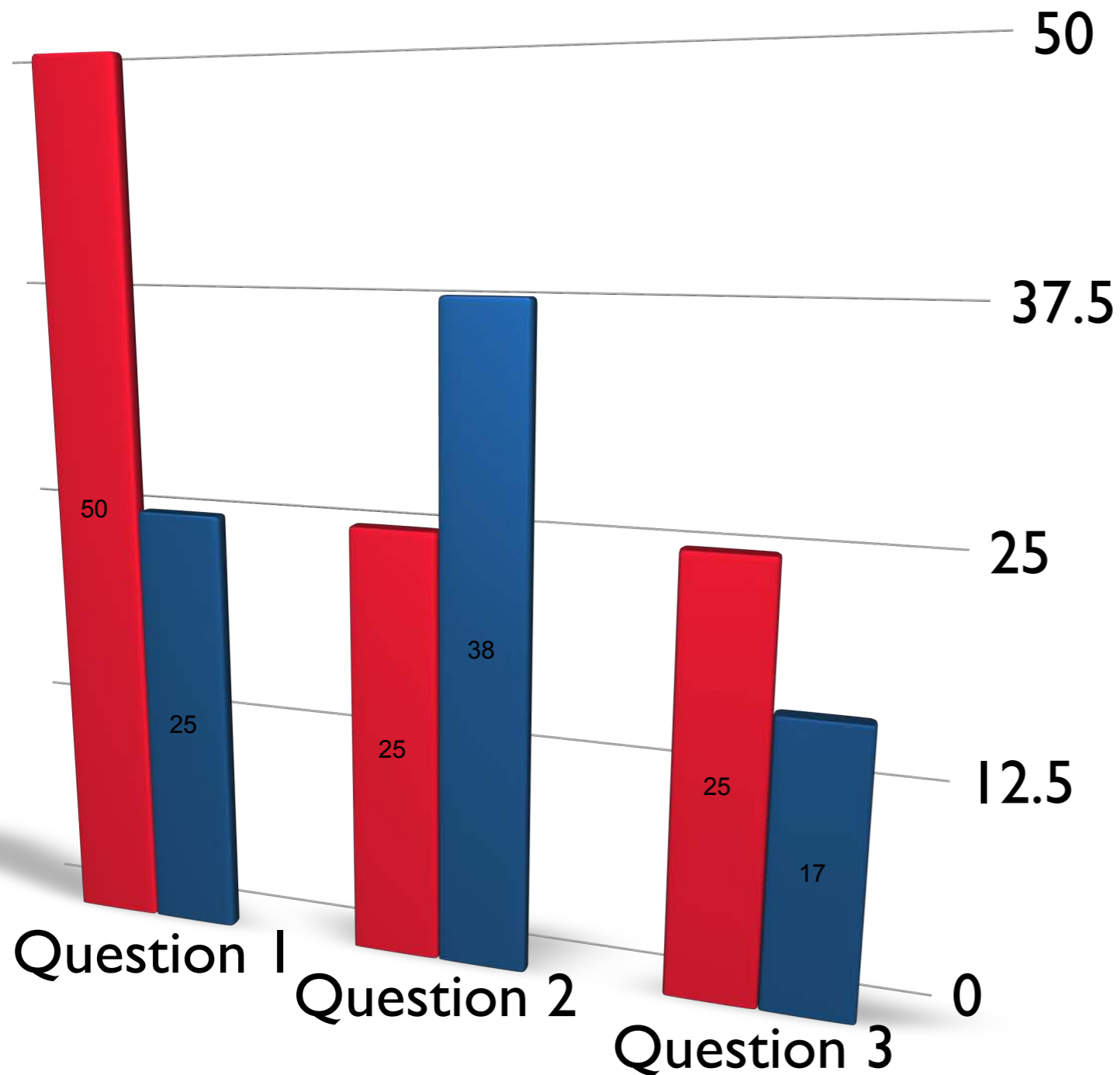


# Model 1 Activity Questions





# Model 2 Activity Questions



- › Question 1: LtH > HtL: LtH > HtL ( $p < .05$ ,  $r = -.69$ )
- › Question 2: LtH = HtL, NSD
- › Question 3: LtH > HtL: ( $p = .05$ ,  $r = -.47$ )

■ LtH: Questions Scores  
■ HtL: Questions Scores

- › Five students were individually interviewed about their experience in the study
  - LtH: 3
  - HtL: 2
- › None described their participation as a negative experience

## Did you write more on posttest?

- LtH: I wrote more in the post-test ... and especially about the question about whether the wire was thicker, would the resistance reduce or increase, because I could relate it to the real world it helped me get the answer to the question. Because I remember in year 10, my teacher asked me the exact same question and because I couldn't relate it to the real world, I found it very hard to answer that question, but since I could relate it to the real world now because of the simulation, I found it easier to answer the question.
- HtL: I wrote very little. I didn't really know how to elaborate them without the scientific knowledge to do it.

# Potential Pedagogical Effectiveness of Low to High Sequences of Structure

It might depend on the student... If they do that [interrogate the model as best they can to answer the questions], yes, but I think some kids would just be like, without the structure they might be like not be able to take that initiative. **But I think the idea of being able to have that freedom first makes a lot of sense**, and I think ... yeah, you can start to form some conclusions that are malleable, **and then when you go to do this bit here [table]**, I guess the idea is that you **make your own sort of scaffolding**, as rigid as it is, or rickety, and then you can

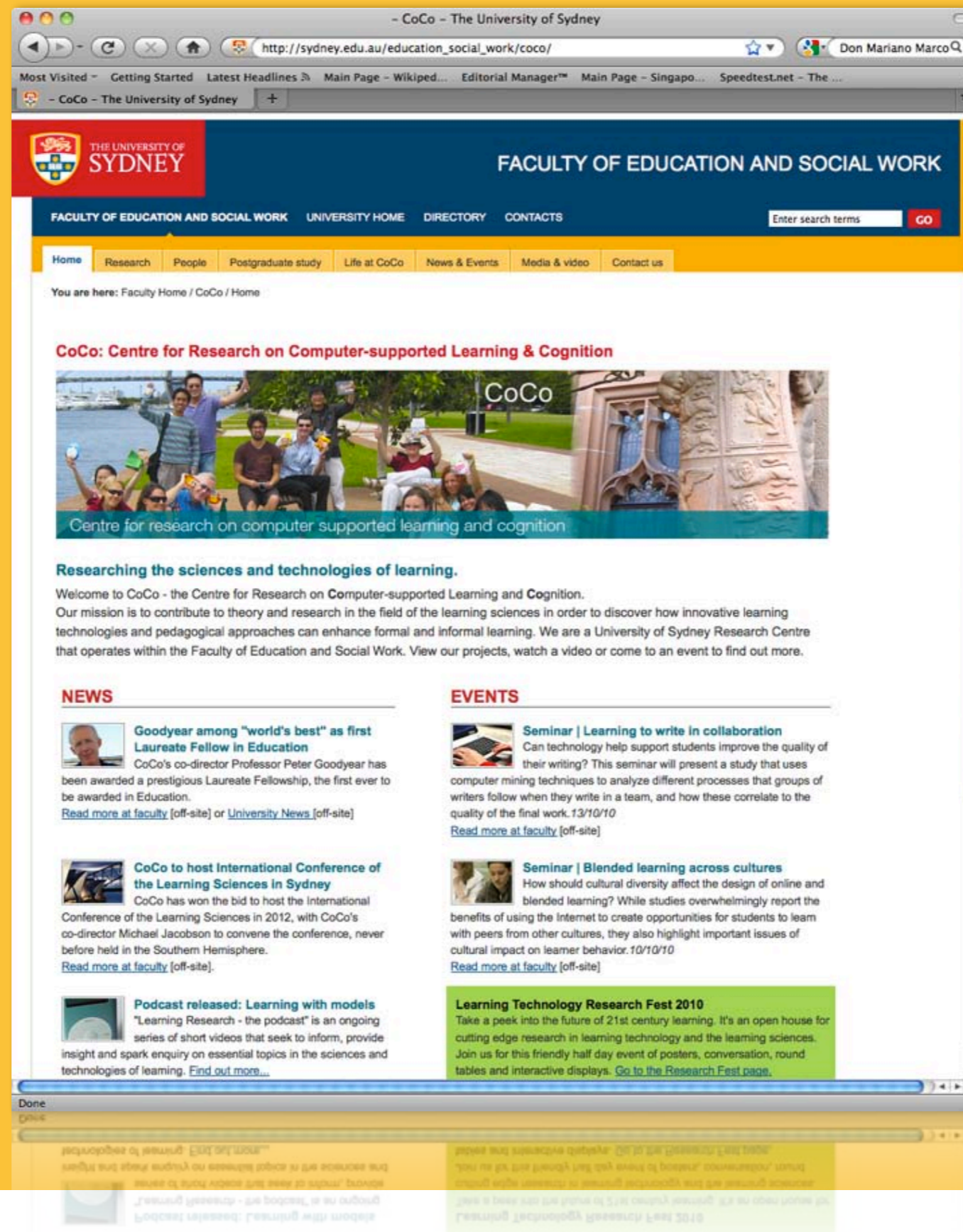
## Discussion: Low to High Pedagogical Structure

- › Why the significant learning gains for LtH?
- › Initial failure in LtH group resulted in relatively large **activation of prior knowledge** (including misconceptions)
- › Subsequent structured problem solving with agent-based models provided feedback (cognitive focus) that helped students link to relevant prior knowledge and to construct enhanced

## Discussion: High to Low Pedagogical Structure

- › High to low structure sequence students failed to activate broad range of prior knowledge
- › Worked rather “mechanically”
- › Observed “learned helplessness”
- › Small scale studies, but consistent with other research by Manu Kapur (Productive Failure) and earlier work by Schwartz & Bransford (Time for Talking) and VanLehn (Impasse Driven Learning)

- › Note that representational affordances of an advanced learning technology perhaps **necessary** but **not sufficient** for learning
- › Argue pedagogical trajectories of **high-to-low structure** followed by assessment are ubiquitous in education at all levels
- › *Missing opportunities to enhance learning by not providing low then high structure experiences?*
- › *Questions:*
  - *Do we even need initially high structure experiences?*
  - *Do we instead need an initial “**zone of proximal failure**?”*
- › Implications: potential for **significant** impact on curricula, assessment, and school practices generally



Thanks!

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