Multimedia Learning and Quantum Tunneling

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Research Question

- How can you best create an audio-visual resource to promote learning of quantum mechanics?
- My expectations:
  - Established research based principles
  - Active research in the area
- Reality:
  - Excitement about e-learning
  - Textbooks on instructional design, best practices, etc.
  - Older research, the 'media debate,' the ET cycle

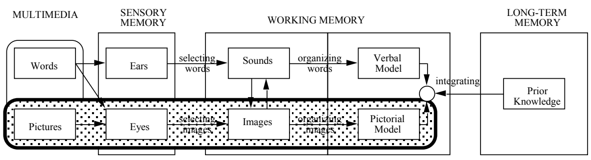
Rationale

- "With few exceptions there is NOT a body of research on the design, use, and value of multimedia systems," (Moore, Burton, and Myers, 2004) Multiple-channel Communication: The theoretical and Research Foundations of Multimedia. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (pp. 979-1005).
- Mayer, 15 years of research

Scientific Approach

Mayer's "Take home message"

People learn better when multimedia messages are designed in ways that are consistent with how the human mind works and with research-based principles.



Preliminary Studies

1. Student perceptions of a popular science video (Falling Cats)
2. Quantum mechanics teaching in the school of physics at Usyd
3. Research based survey on quantum tunneling

1. Falling Cats

- 3 Focus groups, varying backgrounds and interests in physics
- Student preferences align with Mayer's principles for the most part
- Lower prior knowledge/interest were more skeptical
- All groups brought up physics issues without prompting in discussions

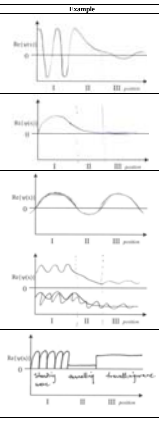
2. Current Teaching

- Lecture audit of 6 courses from first year to honours
- Structured observation, time spent on topics, with particular instructional methods
- Use of visual aids is high ~50%, simulations, desktop experiments, movies, pictures
- Interactivity (discussions and predictions) limited
- Math approached in a variety of different ways

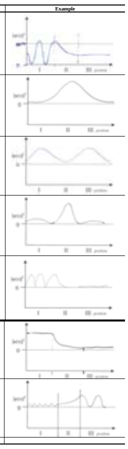
3. Tunneling Survey

- 64 students surveyed after lecture and comp. Lab instruction on "conceptual touchstone"
- 60% Classical energy loss conception
- 72% Fail to give qualitatively correct wave function
- 91% Fail to give qualitatively correct probability density

Category	Frequency (%)	Example
1. Standard (Most features consistent with a ÒcorrectÓ wave function)	28	
2. Single maximum (One large maximum, centred over Region I or II)	9	
3. Large sinusoid (Typically 1.5 wavelengths, negative values in Region II)	13	
4. Conflated wave function and probability density (Some features of a ÒcorrectÓ wave function plus features of probability density)	28	
5. Other	11	
6. Blank	11	



Category	Frequency (%)	Example
1. Standard (Most features consistent with a ÒcorrectÓ probability density plot)	9	
2. Single maximum (One large maximum, centred over Region I or II)	23	
3. Double maxima (Two maxima, centred over Regions I and III)	19	
4. Triple maxima (Three maxima centred over the three regions)	6	
5. Rectified sinusoids in Regions I and III	13	
6. Standard without interference in Region I	9	
7. Other	14	
8. Blank	6	

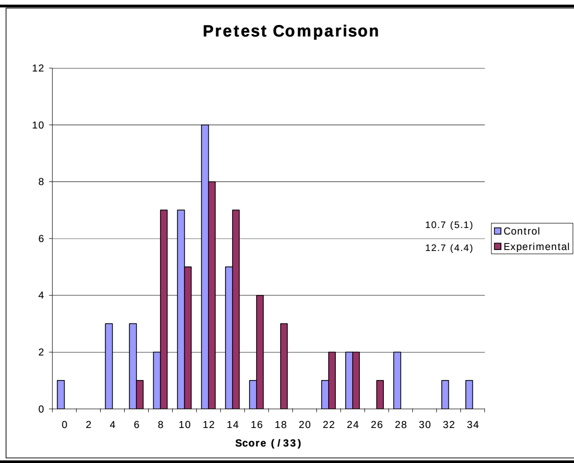


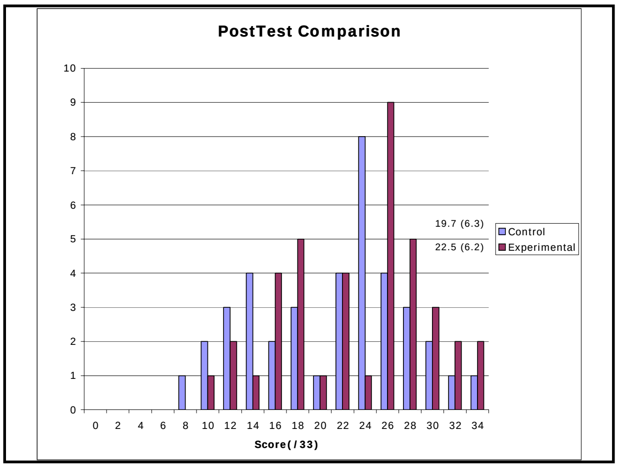
Resource Development

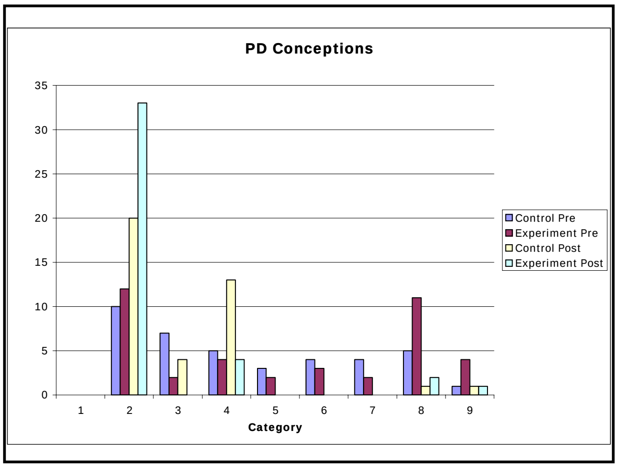
- Substantial fractions of the class show persistent misconceptions
- Discussion is limited in most lecture classes
  - Prior knowledge
  - Interest
  - Culture of physics
- Can the discussion be simulated / stimulated?

Experiment

Dialogue	Control
Dialogue	Monologue
Same physics Same multiple representations	
Misconceptions	Only correct conceptions
Longer	Shorter




PostTest Comparison
10
9
8
7
6
5
4
3
2
1
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
Score(/ 33)
19.7 (6.3)
22.5 (6.2)
Control
Experimental


PD Conceptions
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9
Category
Control Pre
Experiment Pre
Control Post
Experiment Post