

"Using optical analogies and computer simulation while teaching physics of CAT-scans"

Spartak Kalita, Dean Zollman

Kansas State University

Supported by National Science Foundation Grant 04-26745

1

'Modern Miracle Medical Machines' Motivation

- Pre-med students think physics lacks relevance to their future profession.
- Physics provides a lot of opportunities to show this relevance but we miss them in our curriculum.
- Modern physics is frequently missing from the pre-med physics course.



2

'Modern Miracle Medical Machines' Goals

- Conduct research on student reasoning and models related to application of physics to contemporary medicine
- Develop active engagement instructional materials on applications of physics to contemporary medical diagnosis and procedures
- Integrate physics and contemporary medical applications throughout the pre-med physics course



3

Context of Previous Research

1. Clinical interviews with students of various backgrounds
2. Clinical interviews with health-related majors
3. Clinical + Individual Teaching interview series with algebra-based physics students (primarily pre-meds)
4. **Group Teaching Interviews**



Computer-Aided Tomography



5

Teaching Interview Cyclic Framework

Students investigate the phenomena before a formal introduction of the concept

- **Learning cycle**
 - exploration, concept introduction, application¹
- **Modeling cycle**
 - model development, model deployment²

¹Karplus (1974)



²Wells, Hestenes & Swackhamer(1994)




6

Teaching Interview 'Clinical' Part

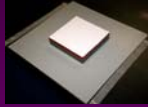
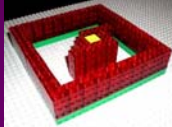


- Discussion Around Pictures:
 - Nature of X-rays, imaging properties
 - Personal experience
 - Comparison with other techniques
 - Focusing on X-rays vs. CAT scans
 - Limits of information
 - Frontal pictures versus slices
 - 2D versus 3D



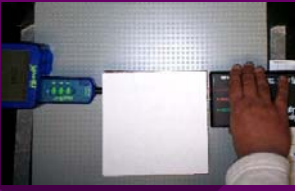

Teaching Interview Playing the Role of a Lego™ Physician

- Semitransparent setup
- What is inside?
- What kind of equipment do we need?

Teaching Interview

- What is the analog of X-rays in this situation?
- What can you get from measurements on one side?
- What can we do to get more information?

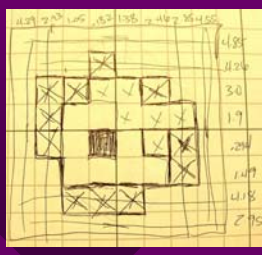

Teaching Interview Comparison between Boxes

How can the open box help us?




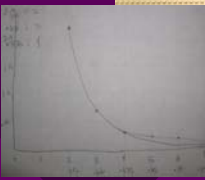


Teaching Interview Determining Shape and Location

- Go around the box and record light intensity along periphery.
- Make predictions about shape and location of an object inside the box.
- Explain how intensity depends on the number of Lego bricks.

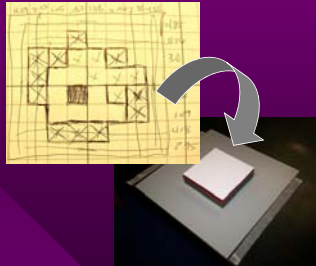
Teaching Interview Discussing Attenuation

- Predict intensity change as we add Lego™ bricks one-by-one.
- Measure intensity vs. number of bricks and modify prediction.
- Qualitatively explain intensity measurements.

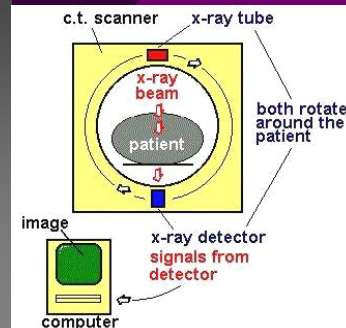




Teaching Interview Opening the Closed box

- Predict what's inside the closed box.
- Open the closed box.
- Discuss reasons for any discrepancies.



Teaching Interview Explaining CAT Scans



Teaching Interview Pre Activity Comparison Discussion

- Students concentrate more on **WHAT we see**, assuming that the nature of **CAT signal is somehow different** (like ultrasound, and probably MRI or PET)



Bone structure... cannot get any real decent tissue information... we cannot really see muscles, how ligaments are attached... obviously X-ray images involving skeletal structure of the body...



Here you see bone, you see organ tissue, skin tissue, kind of everything



Teaching Interview Post Activity Comparison Discussion

- Students concentrate more on **HOW we see**, being aware that **CAT signal is X-ray**



We can see how organs interact or are arranged according to each other... here we cannot tell for one of the fingers if it's pushed back or something... normally you really can't tell...



you get a different picture from that side... here you definitely get more information... different kind of information.



Group Interviews – Results (from transcripts – model building facilitation)

- A: "X-rays are of certain wavelength"
- B: "Yes, they are waves"
- I: "Are X-ray wavelengths shorter or longer than the wavelengths of visible light?"
- A: "Longer"
- B: "No, they are shorter... Frequency is higher"
- A: "Oh, yes"
- C: "I agree."
- I: "Can you draw how the type of the wave depends on the frequency?"
- C: "The spectrum?"
- I: "Yes"

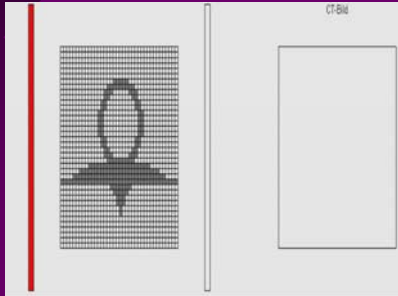


Group Interviews – Results (from transcripts – model building facilitation)

- I: "How these (sonograms) are different from these (X-rays and other EM waves)?"
- B: "I don't know."
- A: "Sonograms are longitudinal... vibrational, while EM are transverse and not vibrational..."
- B: "Oh... sound needs a medium to go through and EM doesn't. EM waves have perpendicular electrical and magnetic components..."
- I: "And what about sound waves? What do they have?"
- A: "I don't know... nothing like these... just waves"
- B: "They are moving back and forth."



Computer Animation



Overall Results (comparing individual and group interviews)

- Constructing the X-ray model for students required much less input, cueing and scaffolding from the interviewer
- Students trigger and reinforce each other's transfer process
- A peer instruction³ teaching module based on the interview protocol and the proposed lab activity looks like a promising idea
- Computer animation worth further studies and comparison

³Mazur (1997)



Thank you!

Modern Miracle Medical Machines website

<http://web.phys.ksu.edu/mmmm/>

My e-mail address: spartak@phys.ksu.edu

21

