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

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‘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.

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

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

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)
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
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

• Open the closed box.
• Discuss reasons for any discrepancies.

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”

• 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…”
  I: “Oh… sound needs a medium to go through and EM doesn’t. EM waves have perpendicular electrical and magnetic components…”
  B: “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 instruction 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/

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