Investigating students' ideas about X-rays and the development of CAT teaching materials

Spartak Kalita, Dean Zollman
Kansas State University

supported by the NSF grant DUE0427645

Modern Miracle Medical Machines reasons and goals

Reasons:

- 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 curriculums

Goals:

- Conduct research on the models that students use in the medicine-related physics topics
- Develop active engagement teaching materials to help students learn about the application of modern physics to contemporary medicine

Motivation to study students' models of X-rays

- Students have a lot of preconceptions about X-rays that come from
  - Their own experience
  - Various non-organized sources (mass media etc.)
  - Physics (or other Science) classes
- These preconceptions
  - Shouldn't be ignored
  - Can be studied

Investigating students' models - I previous series of interviews

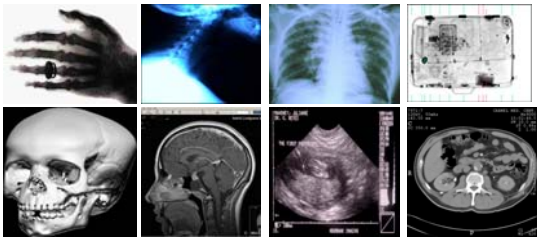
- Pilot testing – Fall 2004
  - 18 students (2-3 year college)
    - 7 - Engineering (Calculus-based Physics)
      - took Physics in high school
    - 5 - Elementary Education (Concepts of Physics)
      - took Physics in high school
    - 6- Various non-science majors (Concepts of Physics)
      - didn't take Physics in high school
- Fall 2005
  - 10 pre-med students (2-5th years)
    - all are required to take 1-year General Physics in their 2d or 3d year

Investigating students' models series of interviews – Spring 2006

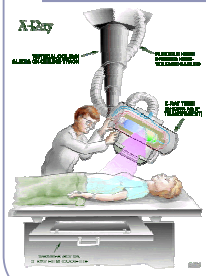
- Around 20 GP students (mainly premeds)
  - regular semi-structured clinical interview
  - developing and testing CAT materials (focusing on image processing)

Starting the interview identifying familiarity with X-rays

- Have you seen such pictures? Can you group them?



Exploring students' experience with X-ray equipment





Focusing on X-rays

- Why can X-rays see the hidden things that we cannot see with our eyes?
- Why we can see the bones and almost cannot seen any other tissues including the skin?
- What are the properties of X-rays?
- [Like basically… to look inside… to actually see when they look at the bones… there are dense sections… and there are sections that not dense… they have to distinguish between the two… basically.]
- [I think that X-rays are able to just penetrate epidermis, but then it hits the bone.. and perhaps bounces off]
- [And this area shows up differently then this area where it didn't penetrate… and I think it has to do with the density of the object]

Physics of X-rays

- How X-rays interact with our body parts?
- What other thing are similar to X-rays?
  - [Waves, EM waves, light, other parts of the spectrum]
    - Elaboration
- What makes some things more transparent to X-rays?
  - [Density]
    - Elaboration – comparison with visible light (more dense substances are often more transparent then less dense ones)
- How would you explain X-rays to a 12-year old (if differently)?

Comparison of X-rays to Ultrasound

- In what cases ultrasound is used? Why we need all of them – ultrasound and X-rays (and probably other imaging techniques)?
- How they are similar and how they are different?
- [I think this one is more related to light, particles interact - and this one is more like soundwaves]
- [Sound is transverse, I believe and light is longitudinal… or the other way… I may have confused them… but one is longitudinal and one is transverse…]
- [I don't think that soundwaves have any polarity and I know that light waves do]
- [This one is used more for like skeleton system… this one is more to see the organs]
- [X-rays may hurt the baby, ultrasound don't]

"Solidness" vs "Density"?

- [May be heart and diaphragm are like more solid mass and the lungs have some cavities in them… you have bronchioles and that perhaps… the space shows up better then the solid, the diaphragm. It may something to do with the fact that lungs are smooth muscle…]

- **If they <particles> are fixed in solids and they aren't fixed in liquids – how exactly it affects how they interact with X-rays?**
- [Obviously in solids it's not moving anywhere… but in liquid… particles are able to move anywhere they want and X-ray comes in… and it interacts probably with the particles but… I think it's just the ability that they can move… so perhaps if an X-ray comes in and hits a particle then the particle can move somewhere else. It gets the energy… and it can move.]

Increasing the frequency of X-rays

- If we increase the frequency of X-rays closer to the gamma part of the spectrum – the hand on the picture will be more visible in this case or it will be less visible?
- [Probably less – because it's going to be able to pass through it – the higher the energy – the capable it to pass through it… that's why… I don't know what's with X-rays today but gamma-rays can do a horrible damage – I think they will be able to pass right through… the cells, the bones, the tissues without really any effect]
- - Without any effect or doing a damage?
- [They are obviously interacting with the particles… any be we would get a better picture but we cannot use gamma-rays because they are <dangerous> to tissues… it's just going to overexpose the film]

Some general questions

- How would you explain X-rays and ultrasound to a 12-year old?
- Do you know (can you recall) how X-ray or ultrasound machine works?
- How would you prefer this subject to be taught?
- How would you teach this subject?

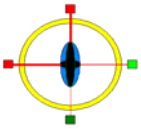
Teaching Experiment - I (absorption of X-rays)

How much radiation will pass through the four absorbing bars (in comparison with one)?

Does it depend on the distances between them?

How much radiation will pass through the long bar (of arbitrary length)?

Teaching Experiment – II (CAT modeling setup)



How can we determine the shape of the hidden (radiation absorbing) object inside the apparatus?

If we rotate the pair of the source and the sensor and measure the results what we can say about the object?

What we will not be able to say about the object no matter how many careful observations we make around the circle?

How can we overcome this drawback?

Implementation of Learning Circle to the Teaching Experiment part

- Exploration phase
  - Playing with the CAT model
- Concept Introduction
  - Absorption coefficient?
- Concept Application
  - Determining the shape

Variations of the Activities

- Using visible light
  - Easier to see (realistic pictures)
- Using infrared light
  - Easier to model (realistic scenario)
- Extension to non-symmetric configurations

Problems

- Multiple connections between the clinical interview and the teaching experiment phases (lack of)
- May turn somewhat advantageous:
  - Students are encouraged to figure out for themselves which parts of our previous discussion are relevant for the CAT model experiment

Thank you!