Problem Based Learning

Definition and goals

Problem-based learning (PBL) [...] is a student-centered pedagogy in which students learn about a subject in the context of complex, multifaceted, and realistic problems [Wiki]. The goals of PBL are to help the students develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation [Hmelo-Silver2004].

Role of the instructor

The role of the instructor [...] is that of facilitator of learning who provides appropriate scaffolding and support of the process, modeling of the process, and monitoring the learning. The tutor must build students confidence to take on the problem, encourage the student, while also stretching their understanding [Wiki, Barrett2010].

Problems

The problems form the backbone of the course and provide the focus. They initiate curiosity and intrinsic motivation. A PBL problem should [Schmidt1983, Schmidt1993]:

- contain a set of phenomena that can be perceived in reality
- be about a professionally relevant problem
- consist of a neutral description of an event or a set of phenomena that are in need of explanation in terms of underlying processes, principles or mechanisms
- sufficiently concrete
- activate prior knowledge
- arouse epistemic curiosity
- lead to problem-solving activity
- be open: it can never be completely solved
- should have a degree of complexity adapted to students' prior knowledge

Schmidt HG (1993). "Foundations of problem-based learning: some explanatory notes". *Medical Education* 27 (5): 422–432

Schmidt, H.G. (1983). Problem-based learning rationale and description. *Medical Education*. 17, 11-16

Barrett, T. (2010). The problem-based learning process as finding and being in flow. I*nnovations in Education & Teaching International*, 47(2), 165-174.

Hmelo-Silver, C.E. (2004). Problem-based learning: What and How Do Students Learn? *Educational Psychology Review*, 16(3)

Wiki, http://en.wikipedia.org/wiki/Problem-based_learning

Solutra suspension

Learning aims: To get acquainted with problem based learning. Rehearse mass-spring system.
Material: EK2 Introduction; Vibrations

Imagine yourself in 2003. The University of Twente is, for the first time, going to participate in the Solar Challenge. You are part of the team who is building the first ever solar energy driven car. The first prototype is a disaster. When the car passes a cattle grid (Figure 1) it rocks like mad. This is very inconvenient and quite unsafe because the car bounces out of control and might flip over. When you slow down, the bounces becomes less. But of course this does not help to win.

Clearly, the car has to be redesigned. This is unacceptable. Someone suggests, the car might need better suspension.

Figure 1. Cattle grid.

Grandpa's damping

Learning aims: Traveling wave, superposition of modes.
Material: Falstad, F1-47/49 Solutions of wave equations

“So you heard Feynmans lectures!” Grandma's friend comes in, and wiggles his cane at grandma. “No way, you were already in your fifties than.

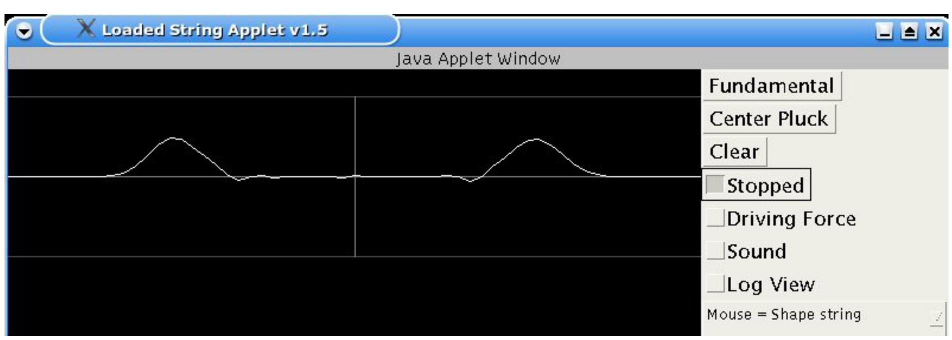
“42, *grandpa*”, grandma replies indignantly, “and I didn't actually attend his lectures, I saw them on video. Quite an interesting guy, this Feynman. Pity he passed away, I might have married him”

Grandpa, defeated again, looks at the washing line in the garden. For years he has been asking her to marry him. Feeling uncomfortable with the situation, he walks up to the washing line, pulls down the end and let go. “Look” he said, “the wave travels to the other end, but also decreases in amplitude and changes in shape. I suppose there is damping in the line. Hey, didn't you talk some time ago about adding damping to a guitar string ...” He looks at me from below his hat, and I have the impression he knows I didn't quite grasp that.

“Uhmm, it had something to do with an extra term in the differential equation”, I replied. “Perhaps I should look it up again. Do you think it is the same problem?”

“Of course!”, grandma cheered. “A string is a string, the atoms do not know whether they are part of a standing or traveling wave. It's all in the boundary conditions!” She walks up to grandpa, who is still playing with the washing line, and takes him by the arm. “Come, *grandpa.* Getting married is also just a change in boundary conditions...”

I sneaked out, better go and look up damping. I wonder why grandpa said the shape changes. Did it?



Falstads loaded string java applet

Nanolab

Learning aims: Calculate B fields with Stokes and Biot-Savart
Material: F2-14 The magnetic field in various circumstances, vector potential, Biot-Savart

The University of Twente is realizing a new laboratory for nanotechnology. Inside the lab there will be an electron microscope with an energy dispersive filter (Energy Filtered TEM, or EFTEM), so that we can look at materials and determine their composition with nm resolution. Cool...

The EFTEM however has very stringent demands on disturbances by external magnetic fields. One source of varying magnetic fields are the wires running to heavy equipment. Sometimes these wires carry 100 A and run over lengths of 10 meter. How far should we keep them away from the EFTEM, if we want the field to be less than 10 nT? And how far away do we need to be for 1 nT?

Things to consider in your calculation are whether you can simply assume the wires to be of infinite length, perhaps you will be too far away? What is the difference between the fields you get when you assume infinite or finite length? Also note that the current is carried by two wires with opposite current direction.

It would be great if you can come up with a simple analytical approximation of the field, so that engineers can use them as design rules. What measures would you suggest do to reduce the field?

Figure 1: The new NanoLab building

FM receiver

Learning aims: Impedance matching
Material: Cheng chapter 9, Gustrau & Mantueffel chapter 3.3.5 (All on blackboard)

Front:

Back:

Sound

Learning aims: Sound waves and their similarity to EM waves
Material: F1-47, F2-20.4 Sound waves

It was time to visit my grandma again. I took a day when I was sure her friend was out, because I did not quite get the problem with the washing line yet and didn't want to get embarrassed again.
It was a really nice visit, and grandma talked a lot about the old days. Then we reached the point of my study again. She informed.
“So, I hear you are nearing the end of the year. Did you enjoy your study?”
“Well, some things were good, and some were bad. But overall, I think I learned something. Most importantly that you only learn by mistakes. And of those I made a lot!”
“Well, well, so you are becoming wise now. Good for you. What did you learn?”
“Uhm, we have this course of waves and fields, and it really struck me that there is so much similarity between fields. Electric fields and heat diffusion. Waves in strings and electromagnetic waves.”
“Different physics, same formula's”
“Exactly! It's just like boys, if you know one, you know them all...”
“Ha! But here's another one. What about sound waves, they are waves as well.”
“Sound waves? I wonder what a sound source looks like. It's a moving object, isn't it?”
“Yes, the simplest thing you can imagine is a balloon which expands and contracts very rapidly. It will give spherical wave...
“Yes, I remember reading about that in Feynman, never did the calculation though..”
“How far does the analogy go, would also the frequency dependence and the dependence of the pressure, intensity and so on be similar to electromagnetic waves? What in sound waves would correspond to the Pointing vector and what to the field strength?"
“Hmm, I would have to sit down and find out. You know what, if we charge the balloon, there are moving charges and it emits an electromagnetic wave!”
“You know as much about electrodynamics as you know about boys. Here, have another cup of tea”

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