Week 7

Problem Solving

Problem Solving

- **Most important aspect University Science and Engineering education:**
- learn problem solving

  – Science educators and Employers ask

  What do we know about how to actually teach problem solving?

  How can we measure it to know if our students are learning?

  How might we teach them better?

Problem Solving:

"Problem solving is cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver." (Mayer, 1992)

- Definition based on the solver.
- Problem vs. Exercise

Problem:

"A problem arises when a living creature has a goal but does not know how this goal is to be reached. Whenever one cannot go from a given situation to the desired situation simply by action, then there has to be recourse to thinking. Such thinking has the task of devising some action, which may mediate between the existing and desired situations." (Duncker, 1945)

Problem Solving Component Skills, Processes and Beliefs

Anything that can affect the subject's ability to solve the problem.

'Addition'

'Connects steps and Pieces'

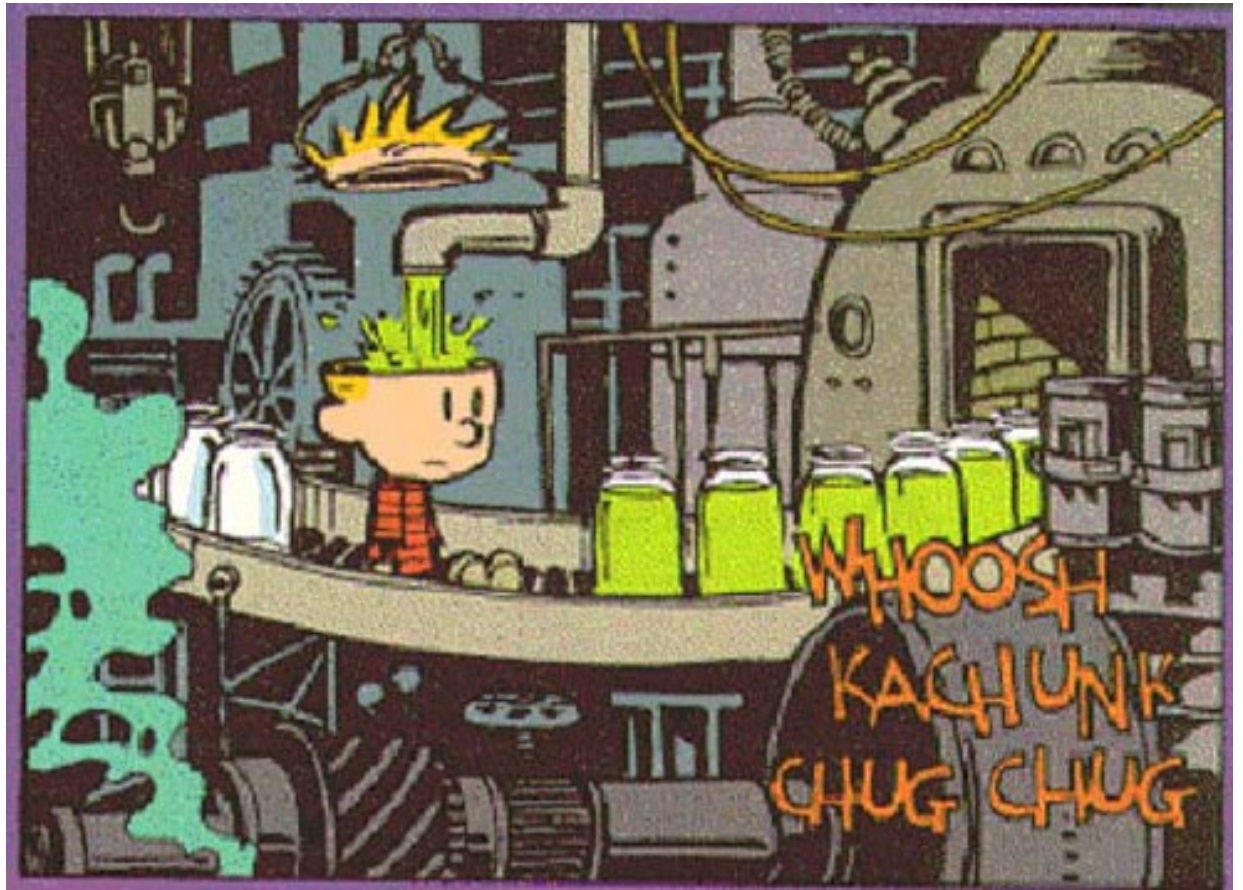
'Creativity'

'Wants to succeed on "test"'

Traditional Model of Education

transmissionist

Individual ← Instruction via transmission — Content (e.g. electronic circuits)



How learning happens

old/current model

knowledge

soaks in, varies with brain

Primary educational focus of universities:

- contents of knowledge “soup”
- admitting best brains
- blaming K-12 for deficiencies

new research-based view

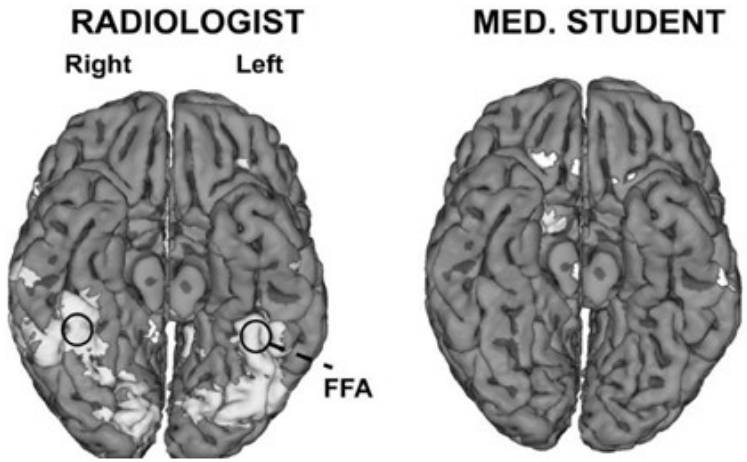
brain changeable

~ same

transformation

Changes in response to intense thinking.
Improved capabilities.
Very dependent on teaching methods, topics not so much.

Strenuous extended mental effort.
New connections, new neurons.
Develops over time—very much like building muscle.
Expertise lies in rewired brain.



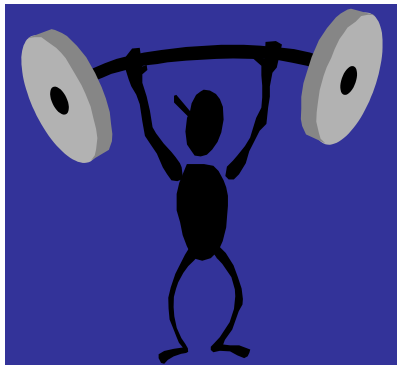
fMRI interpreting x-ray

Learning expert thinking*--

- Practicing desired thinking skills *(expertise)*

Decisions when solving science problem

brain "exercise"



- Decide: how to represent graphically
- Decide what concepts/models relevant
- Decide: *W*hat information relevant, irrelevant, needed.
- Decide: what approximations are appropriate.
- " : potential solution method(s) to pursue.
- ….
- " : if solution/conclusion make sense- how to test.

Learner must practice making decisions. Process & content.
Large difference between making decision (good or not) vs. being told outcome to use. (Holmes, Keep, Wieman, TBP)
Need scaffolded decision making. Decisions to make is too hard.

* Instructor talking.

Standard teaching practice— instructor spends 90+% talking while students listen passively, maybe take notes, ask occasional question.

Why bad? —
student brain is not practicing expert thinking–
essential for “brain exercise” & rewiring.

Learning from expert feedback-telling highly effective, but only if brain prepared first.

If students struggle with problem first, then told,
x10 learning compared to telling, then practice.
(Schwartz & Bransford)

- Student Making decisions:

Common teaching practice– “It is much more efficient if instructor, just tell them what answer/ decision should be, rather than having them spending time figuring out individually or by talking with peers.”

Why bad?

No, not exercising the decision making neurons. Like instructions when driving. Telling you to think about lifting heavy weight over and over to get strong.

Guiding principles for learning how to problem solve :

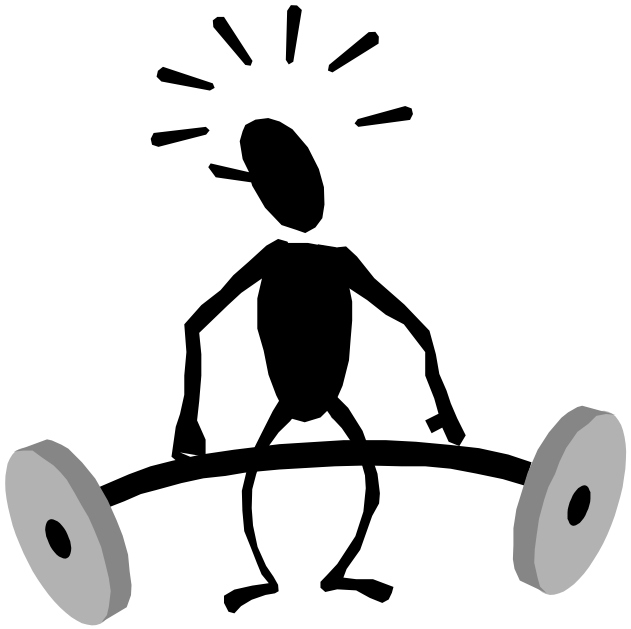
1. People understand concepts by seeing, discussing, and applying them, not by passively listening to explanations.
2. Understanding physics and engineering (& solving problems that develop understanding) is a learned skill, like golf or playing basketball or violin.
   Takes time, effort, and practice. Research says better retention if sustained effort rather than cramming.
3. People learn best by sharing and getting feedback on their thinking
   -- **Student-student more often than student-faculty**.
4. Students learn most when they take the responsibility for what is learned.

Physics and Engineering are <u>not</u> a collection of facts

<u>It is way of thinking.</u> *Only you can teach yourself to think!*
Analyzing, applying concepts, solving problems.

We provide you with opportunities to help you learn.
Content, problems, simulations, guidance, organization.

Learning only comes as a result of your effort!



Model for learning in physics and engineering at Gavilan

1. Read class notes or book – introduce ideas and terms.
2. Analysis and discussion in class – explore, develop basic ideas and understanding.
3. Master and retain ideas through use in extensive HW (6-7 hrs/wk)

(collaboration good, but submit own work)

Collective Work vs. Independent Work

Group Work Encouraged
(in fact, hopefully, necessary)

What is authorized:
- working with others to make sense of questions
- collectively sorting out the answer (explaining reasoning)
- writing up your own solution in your own words

What is NOT authorized:
- telling students the answer
- representing someone else's work as your own