

C₃PO – Customizable Computer Coaches for Physics Online

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- 1. University of Minnesota–Twin Cities**
- 2. University of Minnesota–Rochester**
- 3. University of Colorado–Boulder**
- 4. Central Michigan University**
- 5. Central Arkansas University**

**25 year continuing project to improve undergraduate education by:
Many faculty and graduate students of U of M Physics Department
In collaboration with U of M Physics Education Group**

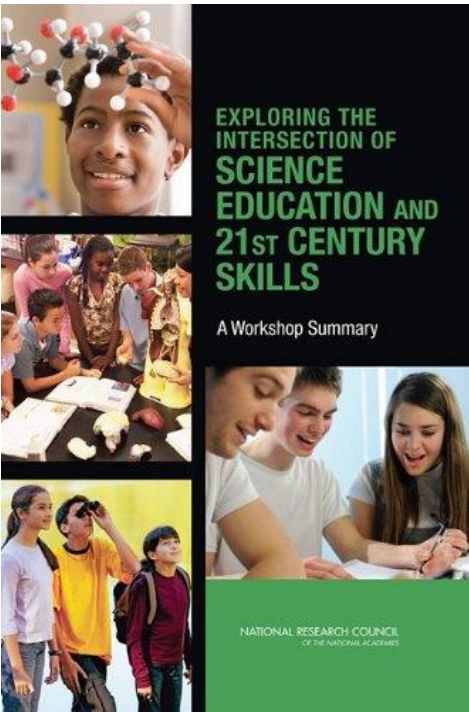
For more details google: per minnesota

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Why Problem Solving

21st Century Skills



**NATIONAL
RESEARCH
COUNCIL OF
THE NATIONAL
ACADEMIES
(2010)**

- **Adaptability:**
- **Complex communication/social skills:**
- **Self-management/self-development:**
- **Systems thinking:**
- **Problem solving:**
 - **Diagnose the problem.**
 - **Link information.**
 - **Reflect on solution strategy.**
 - **Switch strategy if necessary.**
 - **Generate new solutions.**
 - **Integrate seemingly unrelated information.**

What is Problem Solving – Cognitive Science

A problem is a situation that you do not know the path to a resolution.

If you know **how** to do it, it is **not** a problem.



Solving a problem requires making **decisions** to connect what you know in new ways.



Problem-solving Requires a Framework

Used by experts in all fields



STEP 1

Recognize the Problem

What's going on and what do I want?

STEP 2

Describe the problem in terms of the field

What does this have to do with ?

STEP 3

Plan a solution

How do I get what I want?

STEP 4

Execute the plan

Let's get the answer.

STEP 5

Evaluate the solution

Can this be true?

Not a linear sequence.
Requires continuous reflection and iteration.

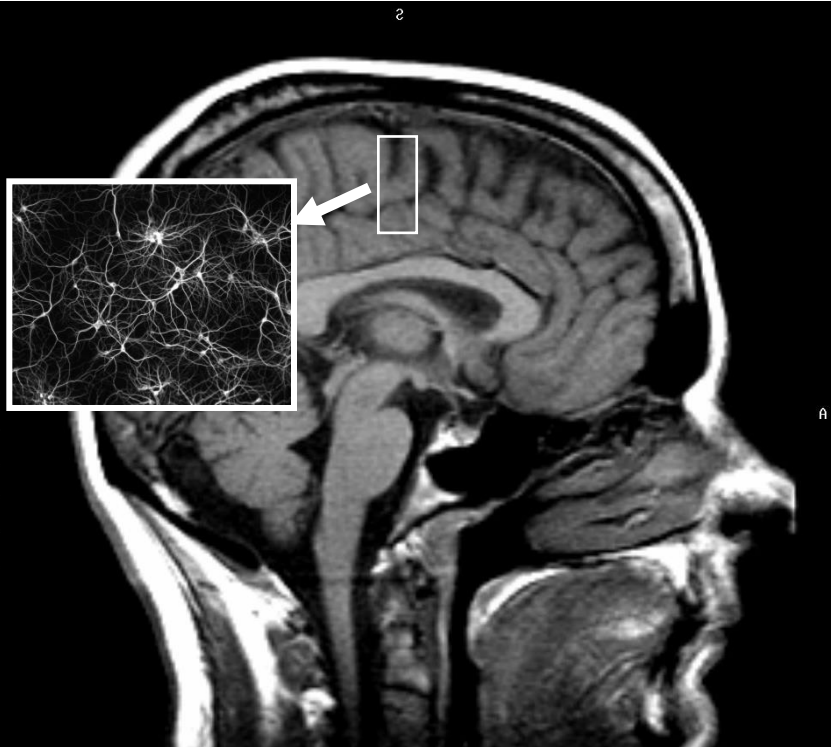
Each step contains a large number of decisions

Real problem solving is an effective way to learn physics concepts

Cummings et al, AJP 1999

From G. Polya, 1945

Learning is Complex



Apprenticeship Works



Cognitive Apprenticeship

3 Actions Necessary for Learning



model



coach



fade

Neurons that fire together, wire together

Simplification of Hebbian theory:
Hebb, D (1949). *The organization of behavior*. New York: Wiley.

Collins, Brown, & Newman (1990)

Brain MRI from Yale Medical School
Neuron image from Ecole Polytechnique Lausanne

Why Computer Coaches

Coaching is an essential part of learning – Cognitive Apprenticeship

- Instructor office hours
- Tutorial rooms
- Study groups
- Collaborative groups

Human Coaching is
Not always available



Need on-demand coaching available 24/7

Web based computer coaches

Added bonus

Computer coaches are infinitely patient and non- threatening

Necessary features of coaches (GC09)

- Emphasize student decision making
- Explicitly connect decisions to previous decisions
- Use a consistent organized problem solving framework
- Repetition of same procedures for all problems
- Can be modified by each instructor

Version 1 – Coaches for Intro Mechanics

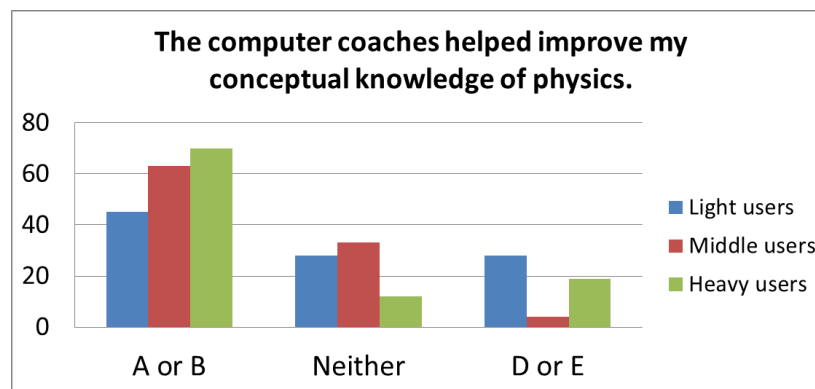
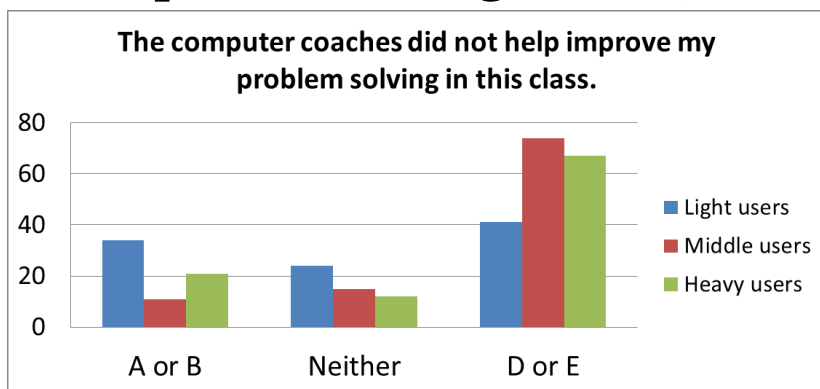
- Popular with students BB01, PST2C14 –

Between Coach & WebAssign most chose Coaches

Average attempts 80% -- Average completion 66%

Even with no credit, half of class used Coaches

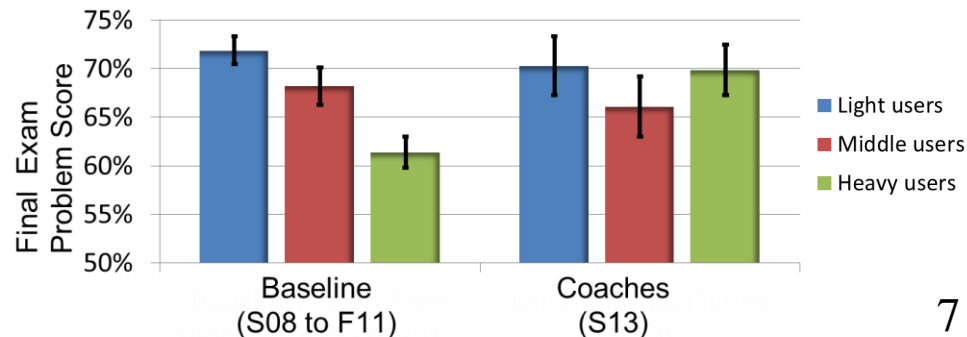
- Students think Coaches helped both their problem solving & conceptual knowledge BB01, PST2C14



- Large gains in problem solving for the 1/3 of the class that has lower confidence and less well prepared

One full grade over predicted

BB02, PST2C14



Coaches Version 1 Version 2

Version 1 Drawbacks

- Not easily modified by instructors.
- Not flexible enough for confident students

Drawbacks addressed in Version 2 Coaches –software (GC10) being tested

- Instructors can modify wording, symbols, strategy, decision grain size, and logic using a graphical interface (no coding required). PST2C15
- Students can skip decisions, navigate backwards, adjust their decision grain size.

The End

**Please visit our website
for more information:**



<http://groups.physics.umn.edu/physed/>

More information in next talk

The best is the enemy of the good.

"le mieux est l'ennemi du bien"

Voltaire