Computerizing Introductory (Calculus-based) Problem-solving Labs
Going to the Next Level?

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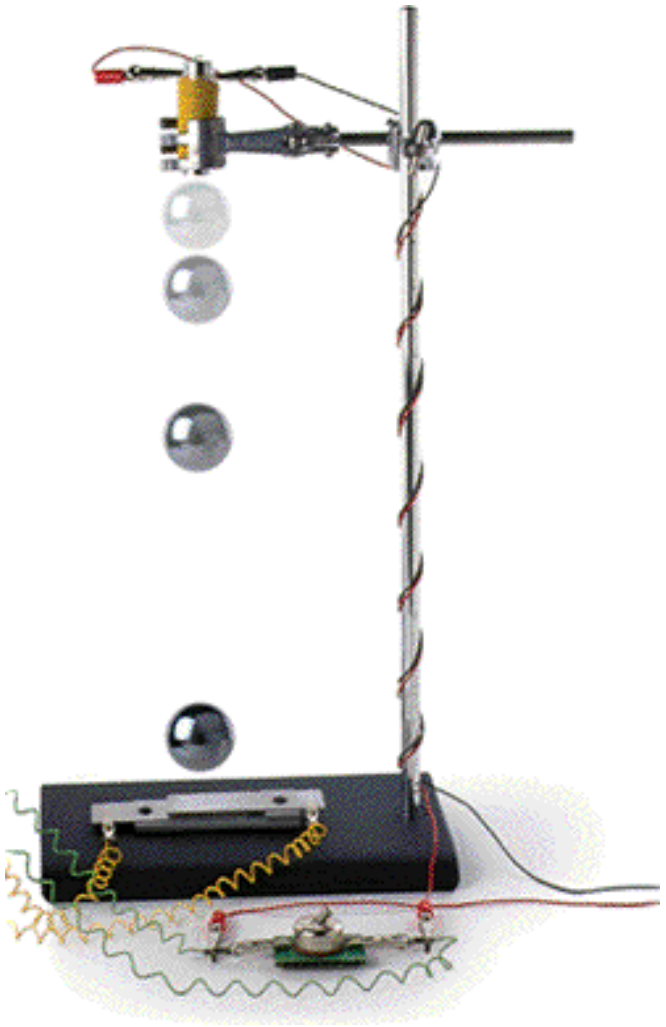

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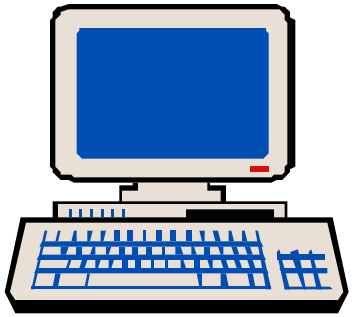
What do we Know about Computerizing Labs?



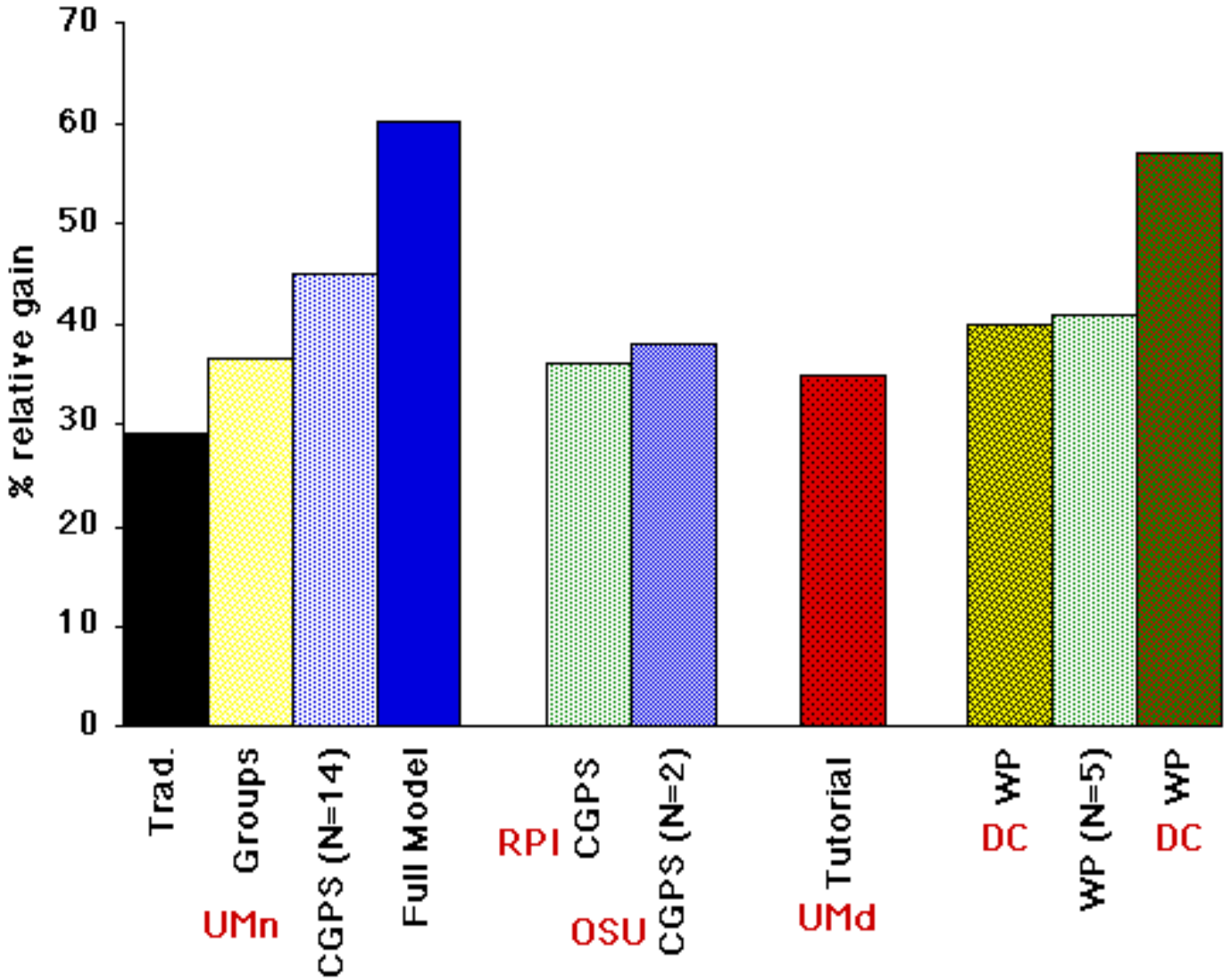
General Outcomes:

- Traditional labs have no effect on general achievement.
- TIMSS data: classrooms with technology have lower achievement scores
  - technology poorly integrated with content

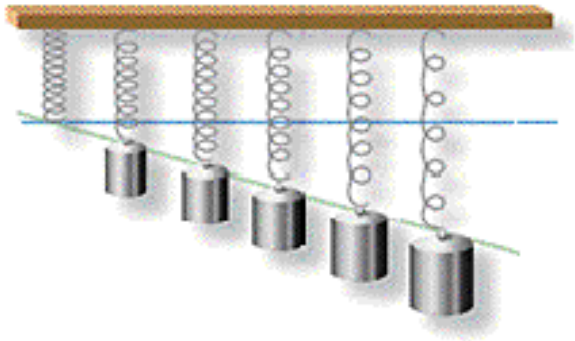
Physics Labs:

- Carefully designed, well implemented technology in labs can lead to higher achievement scores (e.g. Priscilla Laws, Ron Thornton, Bob Beichner)
- "Teachers must thoroughly integrate software into their instruction and not just tack it on." (Beichner, AJP, 1996)

Normalized Gains of FCI
Interactive Instructional Models

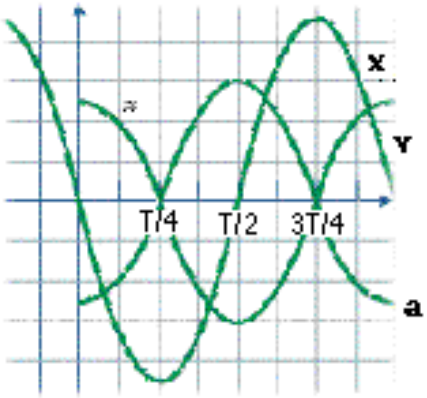


Our Problem-solving Labs



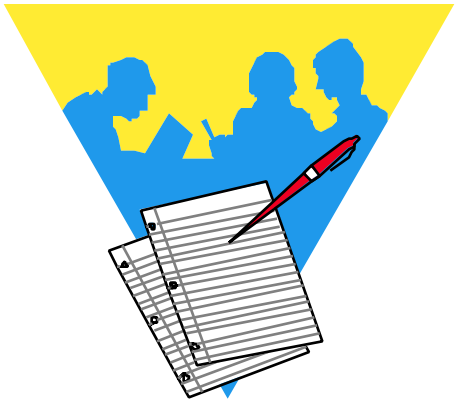
A "LAB" is a series of context-rich problem

- Students come to a lab session prepared with their solution to the assigned lab problem(s).
- Whole-class discussion of predicted solutions.
- Students, in groups of three, use equipment to check their solutions:
  - Exploration
  - Measurement
  - Analysis
  - Conclusion



- Closing whole-class discussion on results, troubles, errors, conclusions

What we Wanted to Find Out



- **When computer tools are added to the Minnesota problem solving labs, what happens to students' progress toward the course goals?**
- conceptual understanding
  - **problem solving**
- **How do computers affect student behaviors and attitudes?**

First-year Implementation 1997

- For 3 of the 5 lecture sections, randomly assigned half of students to computerized labs (N ~ 200 each)
- Extensive TA training with minimal focus on computer use -- computer use training as needed
- Continual improvements of software
- Lab problems kept as close as possible to traditional lab problems

Force Concept Inventory (FCI)
First-year Implementation (1997)

	NO COMPUTERS		COMPUTERS	
	Men (N=130)	Women (N=53)	Men (N=152)	Women (N=53)
% Pretest	47 ± 2	35 ± 2	52 ± 2	32 ± 2
% Posttest	72 ± 2	61 ± 2	74 ± 2	54 ± 2
Norm. Gain	49 ± 2	42 ± 3	50 ± 3	34 ± 3

Test of Understanding Graphs - Kinematics (TUG-K) and Problem-solving Grades (1997)

	NO COMPUTERS		COMPUTERS	
	Men (N=122)	Women (N=46)	Men (N=121)	Women (N=49)
TUG-K				
% Pretest	55 ± 2	43 ± 3	62 ± 2	45 ± 3
% Posttest	74 ± 2	65 ± 3	79 ± 2	64 ± 3
% Final Probs	53 ± 1	51 ± 2	55 ± 2	51 ± 3

Survey Results
1st-Year Implementation (1997)

Survey Statement	NO COMPUTERS (N=168) % Agree	Neutral	COMPUTERS (N=172) Agree	Neutral
helped me understand concepts	50	26	49	28
time well-spent learning	38	33	51	30
TA gave useful help when stuck	79	12	65	16
look forward to using . . .	16	27	47	33

	% Often/A. Always	Often/A. Always
discuss equipment difficulties	53	32
discuss physics	39	48
communicated well	64	67

Second-year Implementation

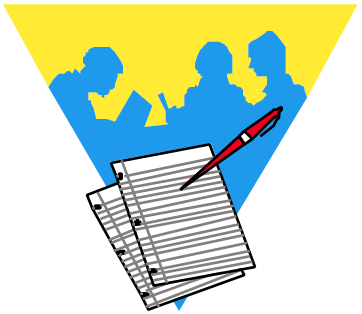
Planned Changes:

- ALL lecture sections -- 724 students, 31 TAs, 6 lecturers
- More focused TA training on computer use in labs
- Additional information in TA handbook
  - **different grouping guidelines for lab, discussion section**
  - **different seating arrangements**
  - **what to watch for when monitoring groups**
- Mentor TAs knowledgeable about labs

Problems:

- Large scale implementation
- Late delivery of essential equipment
- Increased sizes of lab sections (N~18 students each section)

TUG-K Results for Computerized Labs



	1997		1998	
	Men (N=121)	Women (N=49)	Men (N=92)	Women (N=25)
% Pretest	62 ± 2	45 ± 3	61 ± 2	50 ± 4
% Posttest	79 ± 2	64 ± 2	74 ± 2	69 ± 4

FCI Results for Computerized labs

	1997		1998	
	Men (N=152)	Women (N=53)	Men (N=468)	Women (N=137)
% Pretest	52 ± 2	32 ± 2	50 ± 1	34 ± 1
% Posttest	74 ± 2	54 ± 2	72 ± 1	60 ± 1
Norm. Gain	50 ± 3	34 ± 3	46 ± 1	39 ± 2

Survey Results for Computerized labs

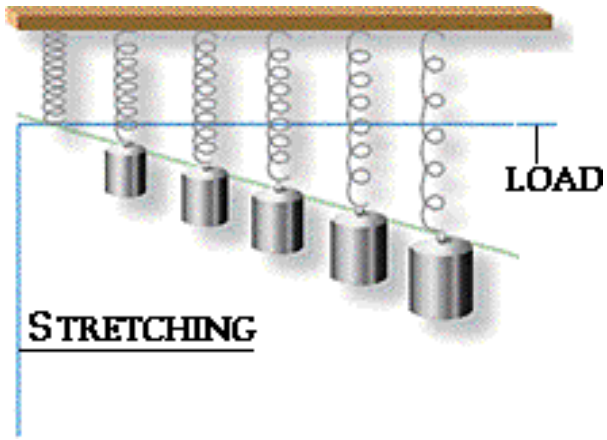
	1997 (N=172)		1998 (N=590)	
	% Agree	Neutral	Agree	Neutral
helped me understand concepts	49	28	55	22
time well-spent learning	51	30	47	29
TA gave useful help when stuck	65	16	73	13
look forward to using . . .	47	33	25	40
	% Often/A. Always		Often/A. Always	
discuss equipment difficulties	32		33	
discuss physics	48		48	
communicated well	67		70	

Conclusion

Given a cooperative-group problem solving pedagogy that yields stable, high gains on standardized conceptual tests, the careful implementation of computer measurement and analysis tools in the laboratory did not change student achievement.

NEXT PHASE:

Is it possible to use the new computer tools to target explicit student difficulties, resulting in a higher level of student achievement?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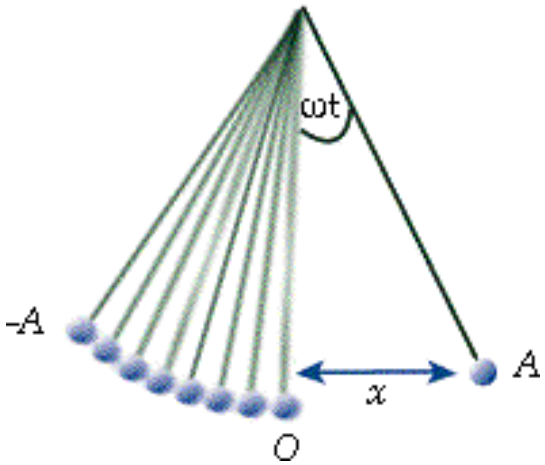
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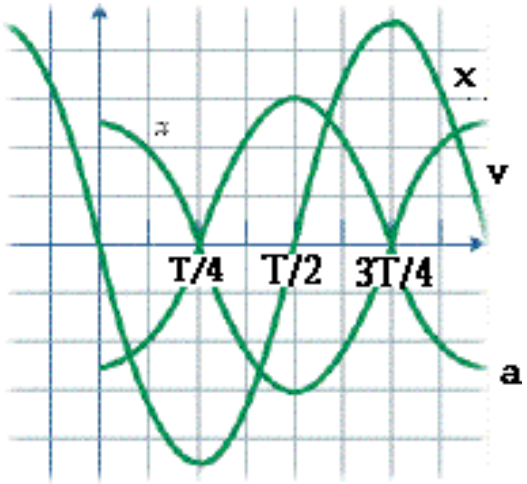
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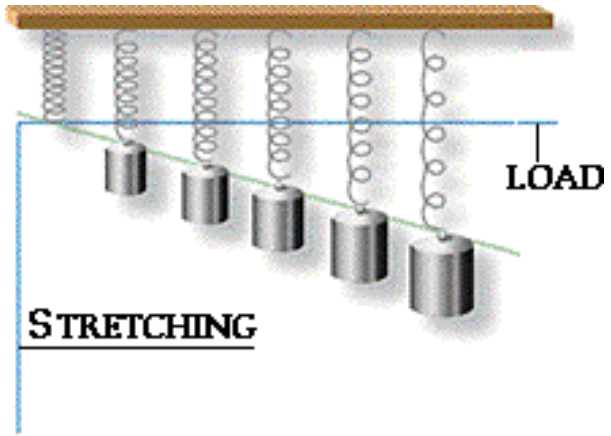
Problem-solving on Final 1st-year Implementation



	NO COMPUTERS	COMPUTERS
% Final (6 problems)	52 ± 1	54 ±1

Rationale

- Use National Instruments software to program measurement and analysis tools
  - **Can program to match pedagogy for problem solving labs**
  - **Can make revisions and extensions as lab problems change**
  - **Can use same software for all computer tools - Video analysis, Hall Probe, Faraday Probe, etc.**
  - **Software available over large time frame**

Description of Problem-solving Labs

- labs are a series of context-rich problems
- students make predictions before lab
- students solve lab problems in groups of 3
- all data analysis is done in lab
- lab problem reports written individually
- sessions, conducted by graduate student TAs, last two hours (once a week).

Video-tool

What is different in the computer labs:

- computers used to acquire data via video-cameras
- computer aided data analysis by students
- graph- and function-oriented analysis process