JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

MICHAEL L. FALK, JOHNS HOPKINS
ALEJANDRA MAGANA, PURDUE

The Impact of Contextualized Computing for Materials Students

OVERVIEW

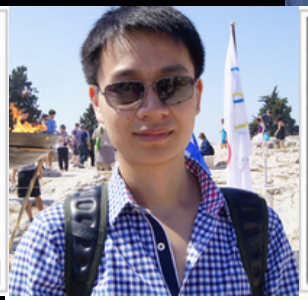
- Motivation for innovation and study
- Context of partnership
- Curricular innovation
- Evaluation
- Lessons learned

PARTNERSHIP AND TEAM

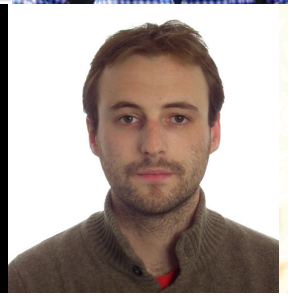
- Michael Falk, Johns Hopkins
  Materials Science and Engineering

- Alejandra Magana, Purdue
  Computer and Information Technology

- Mike Reese, Johns Hopkins
  JHU Center for Educational Resources
- Students at Purdue:
  - Camilo Vieira, Junchao Yan & Tosin Alabi

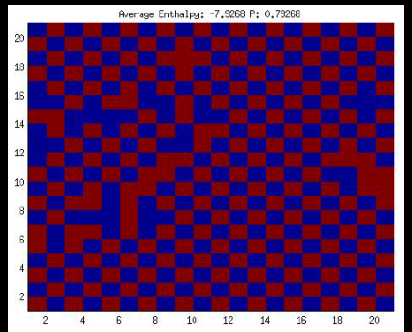


- Postdocs at JHU:
  - Sylvain Patinet & Anindya Roy



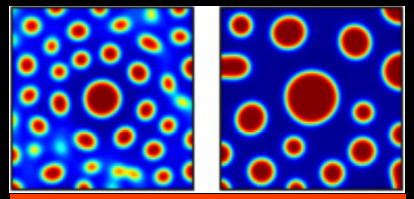
CURRICULAR INNOVATION: COMPUTATION IN MATERIALS SCI & ENG

MATLAB



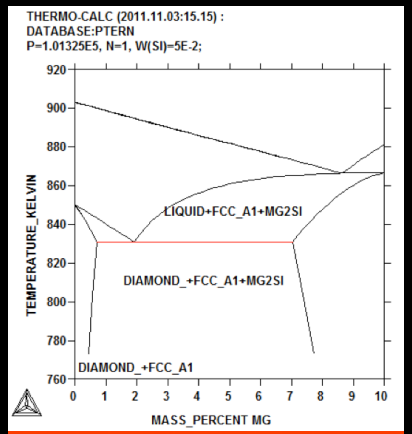
STRUCTURE OF MATERIALS

COMSOL

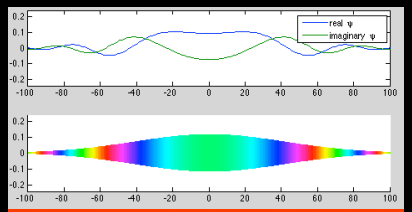


KINETICS & PHASE TRANS.

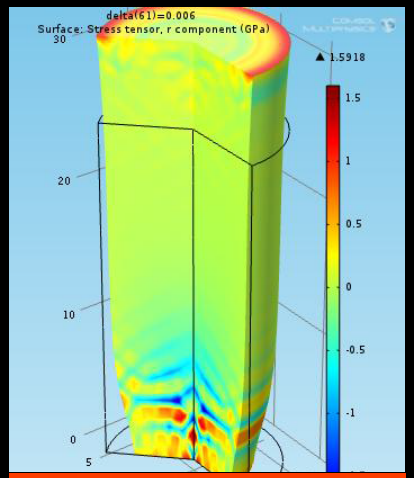
THERMOCALC



THERMO-DYNAMICS

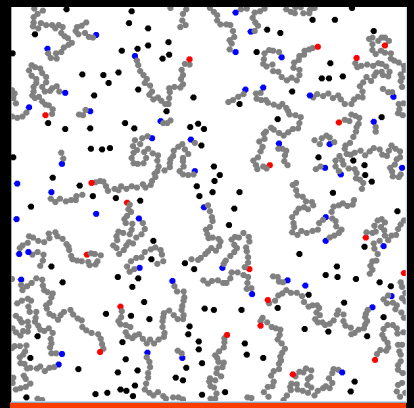


ELEC., MAG. & OPTICAL PROPERTIES



MECHANICAL PROPERTIES

ETOMICA



BIO-MATERIALS

COMPUTATION & PROGRAMMING FOR MATERIALS SCIENTISTS AND ENGINEERS

CPMSE

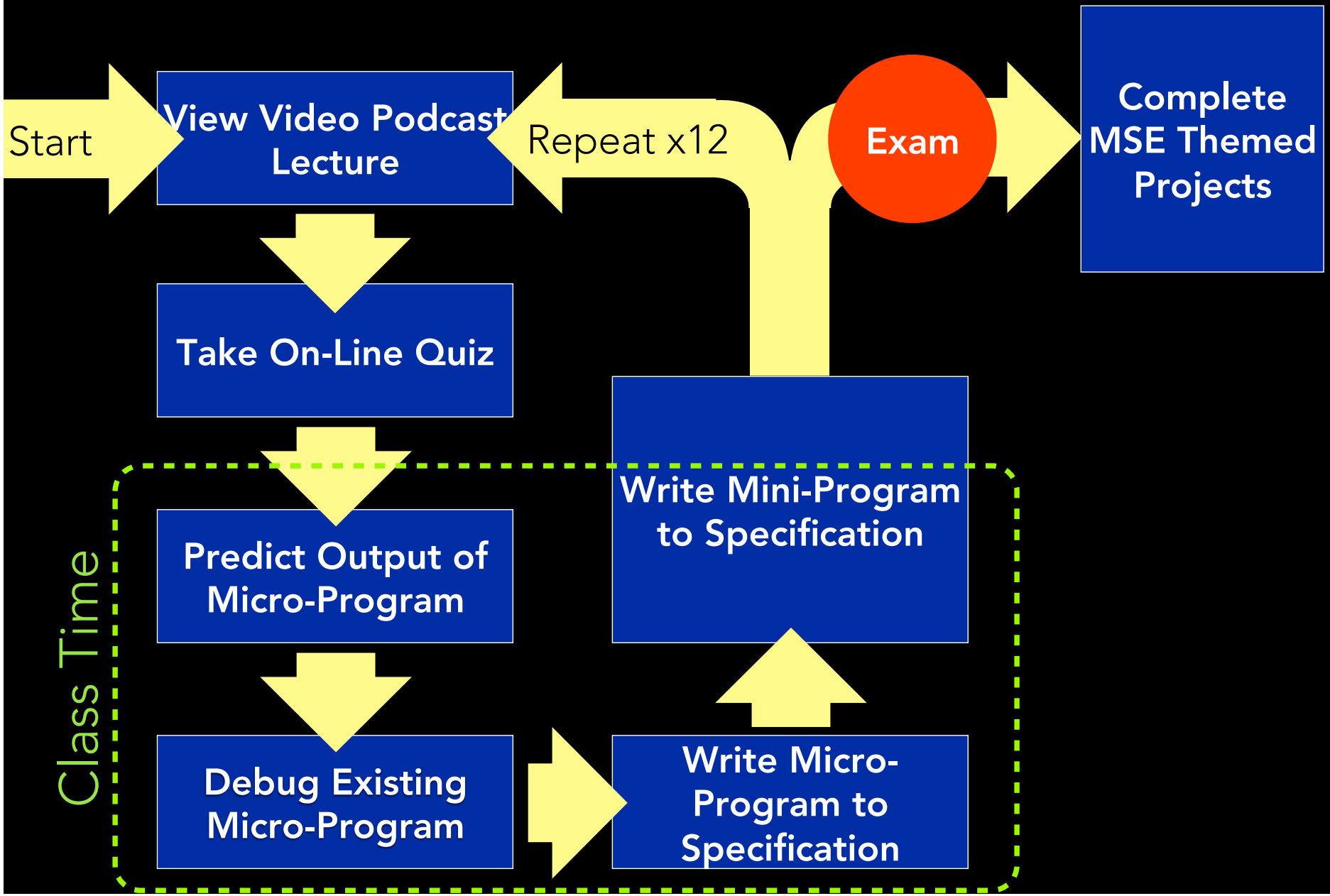
COMPUTATION AND PROGRAMMING FOR MATERIALS SCIENTISTS & ENGINEERS

Objective Teach algorithm development and programming in the context of MSE.

Strategy Students alternate between weeks honing basic skills in MATLAB and weeks engaged in week-long MSE themed projects.

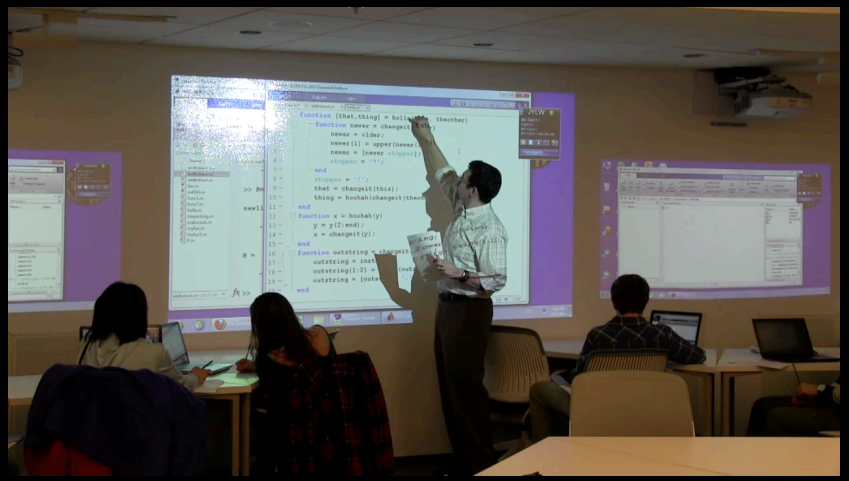
Class Enrollment
20(2012), 32(2013), instructor plus TA

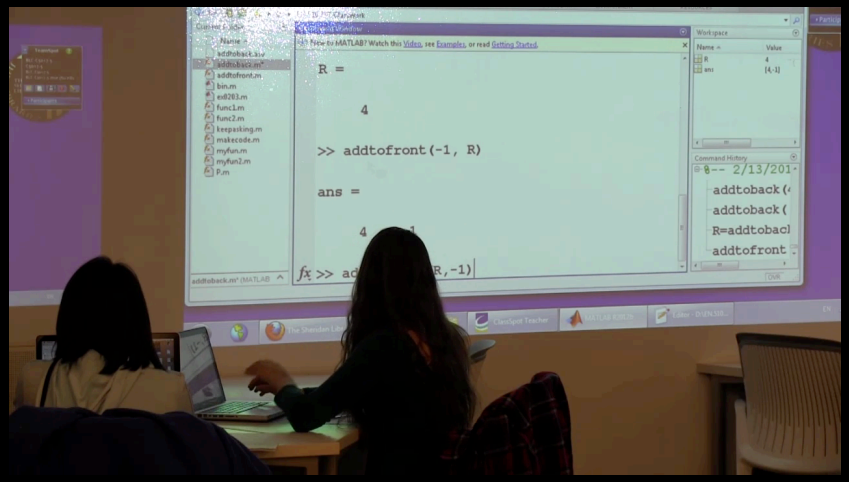
CPMSE WORK FLOW



COMPUTER MEDIATED COLLABORATIVE CLASSROOM

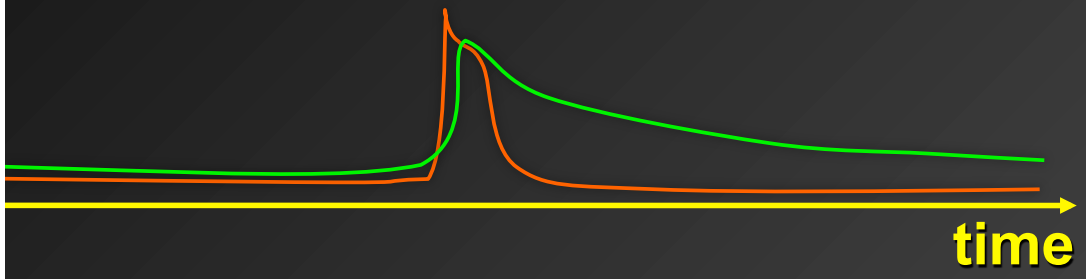
using ClassSpot by Tidebreak™

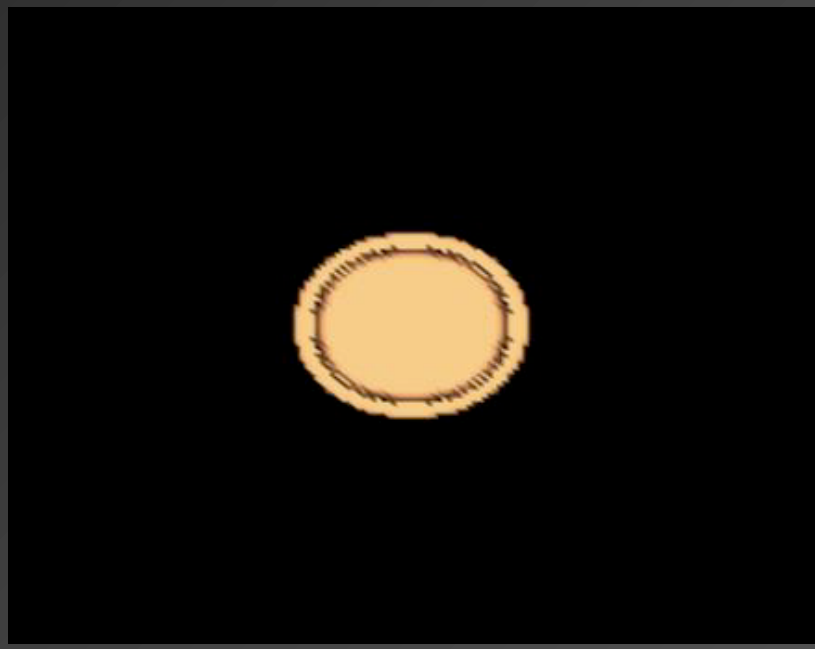




SIMULATING CARDIAC TISSUE

- Ventricullar Fibrillation (V Fib) is one of the major means of cardiac arrest
- During V Fib the heart loses its regular beat and flutters.
- In this state it can no longer pump blood.
  - U = the electrical potential of the region of tissue
  - V = the depletion of the tissue





CURRICULAR INNOVATION: COMPUTATION IN MATERIALS SCI & ENG

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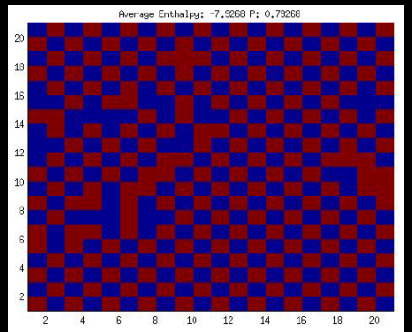

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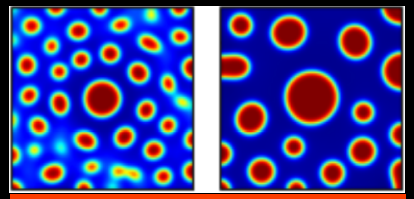

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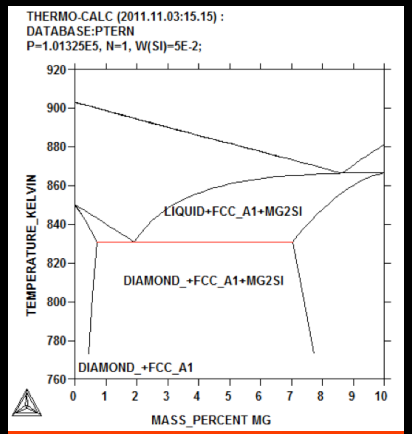
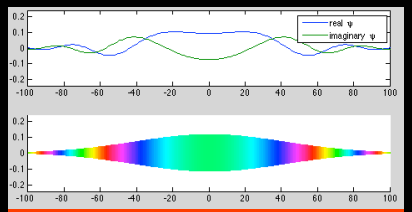


THERMO-DYNAMICS



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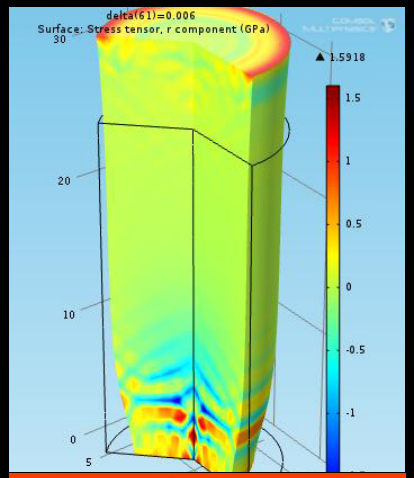

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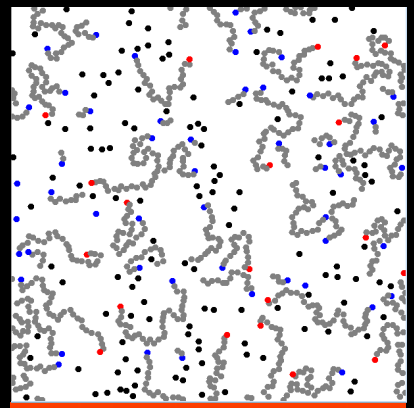


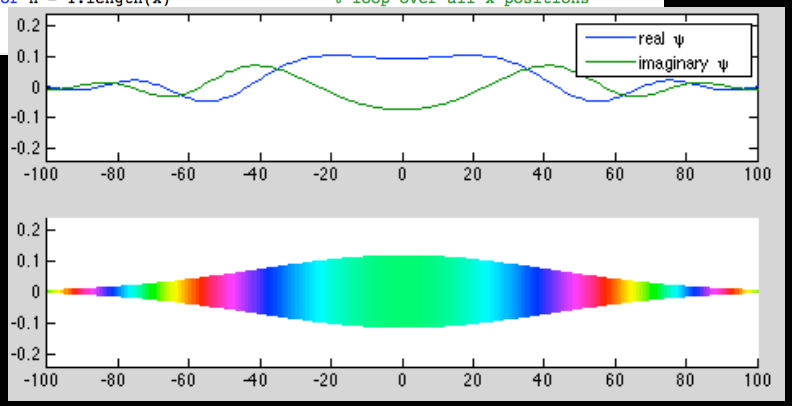
BIO-MATERIALS

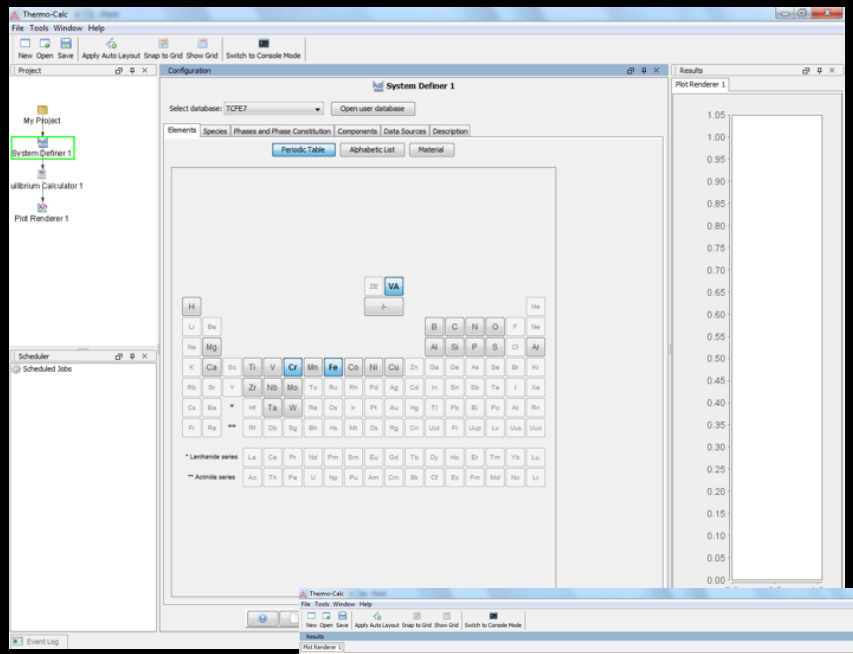
COMPUTATION & PROGRAMMING FOR MATERIALS SCIENTISTS AND ENGINEERS

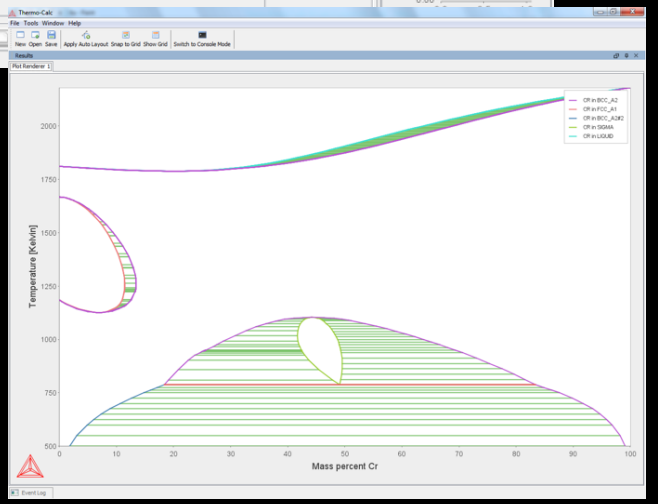
"PROGRAMMING" VS. "CONFIGURING"

Quantum mechanics via MATLAB Thermodynamics via ThermoCalc

```
function packet(tmax, dt, xmax, dx, alpha, p0)
% This function plots the wavefunction of a wavepacket initally centered at
% x=0.  Right now it only can handle packets with no momentum (p0=0).  The
% input parameters are as follows:
% tmax = maximum time to show
% dt = time increment
% xmax = range of x will extend from -xmax to +xmax
% dx = space increment
% alpha = initial width of the wave packet
% p0 = momentum of wave packet (not currently used)

    x = -xmax:dx:xmax;                      % set up spatial grid
    for t = 0:dt:tmax;                      % loop over time
        temp1 = 1+2.*i.*t./(alpha.^2);      % calcuate the wavefunction
        temp2 = - x.^2./(2.*alpha.^2.*temp1);
        psi = exp(temp2)./sqrt(sqrt(pi).*alpha.*temp1);

        plotwavefunction(x, dx, psi);       % use function below to plot
    end
end

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
function plotwavefunction(x, dx, psi)
% This function plots the wave function two ways.  First as lines showing
% the real and imaginary parts, then as an envelope given by the magnitude
% of the complex value and a color giving the phase angle.

    persistent ylim;                        % find the limits for the graphs
    newylim = max(abs(psi));
    if (isempty(ylim) | newylim > ylim) ylim=newylim; end
    clf                                     % clear the figure

    subplot(3,1,1);                         % choose the upper plot
    plot(x, real(psi), x, imag(psi));
    % plot the real and imaginary data as well as the expectation value
    axis([x(1) x(end) -ylim ylim]);         % set the axis limits
    legend('real \psi','imaginary \psi');   % add a legend

    subplot(3,1,2);                         % choose the lower plot
    axis([x(1) x(end) -ylim ylim]);         % set the axis limits
    line([x(1) x(end)],[0 0],'Color','k');  % make a horizontal line
    for n = 1:length(x)                     % loop over all x positions
```







GUIDING RESEARCH QUESTION

How does the infusion of computation within engineering coursework affect student learning and their perception of learning?

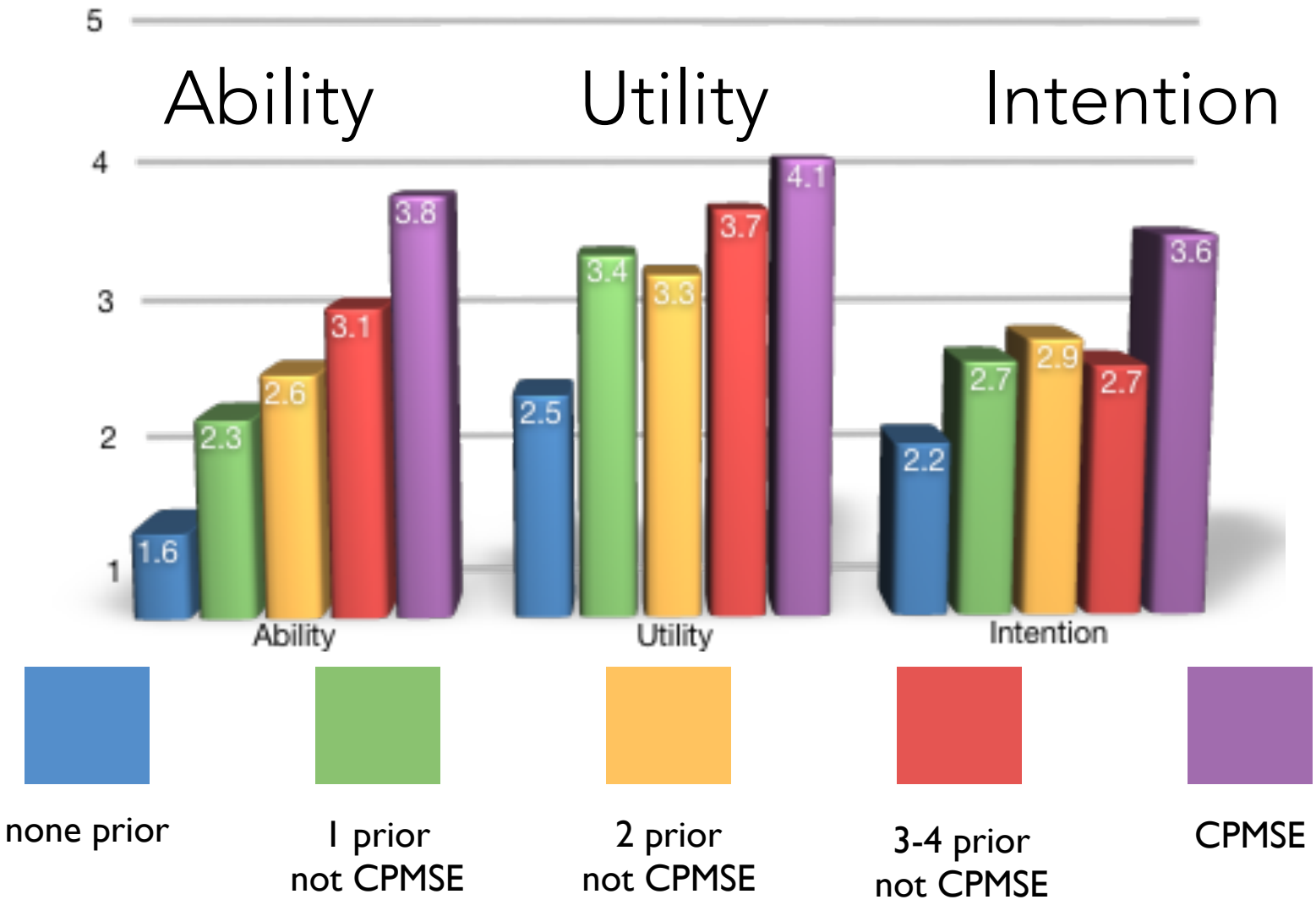
- Self-beliefs
- Disciplinary learning

FORMATIVE ASSESSMENT CPMSE COURSE
SPRING 2012

Technology Acceptance Model
(Self-Assessment Survey)
Ability
Utility
Intention

Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behavior.
Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts.

TECHNOLOGY ACCEPTANCE
FALL 2012



SUMMATIVE ASSESSMENT OF THE 2-YEAR LONG CURRICULAR INNOVATION (MODULES)

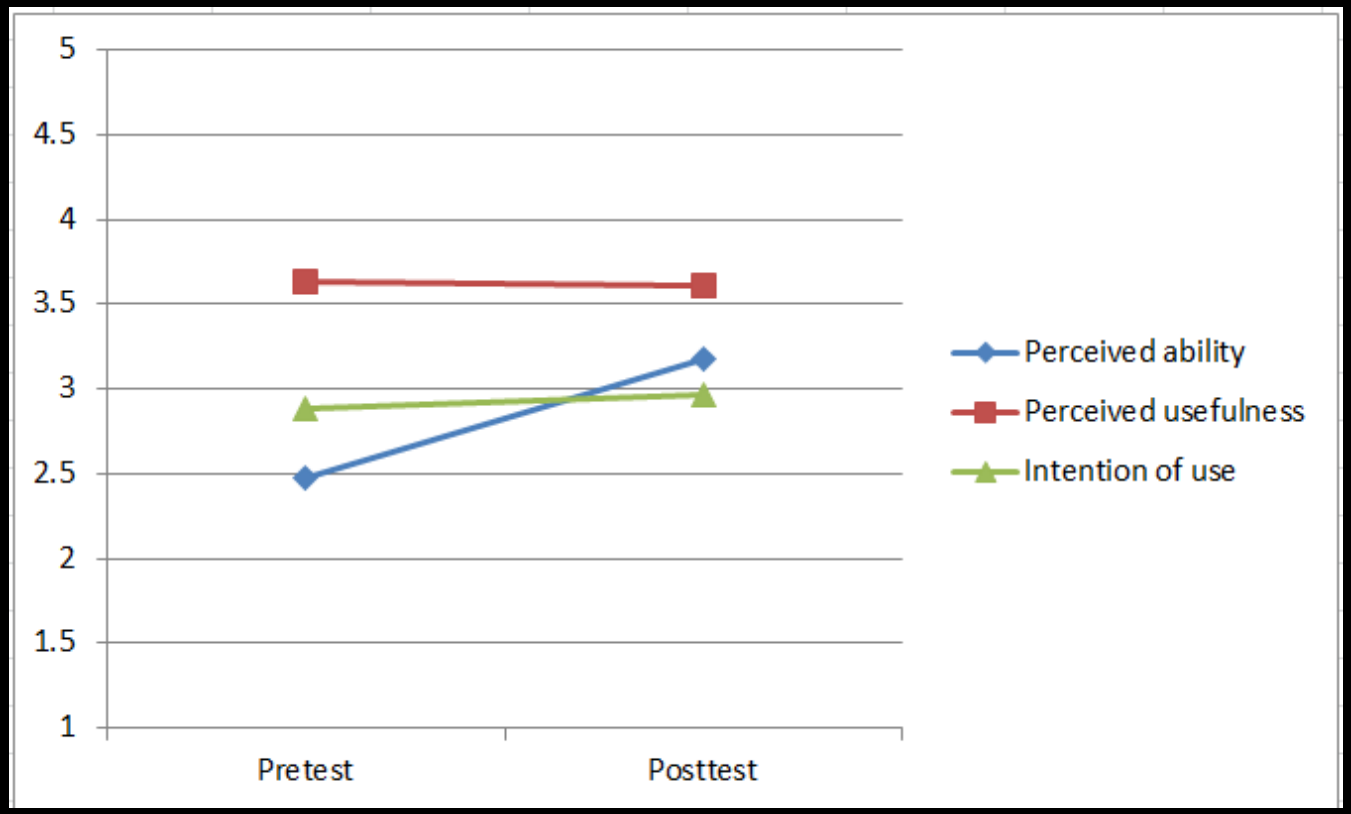
Survey on Student Self-Beliefs
Ability, Utility, Intention

Pre-/Post- Ad Hoc Assessment of Module Learning Gains

"Think Aloud" exercises to gather qualitative data on learning modalities

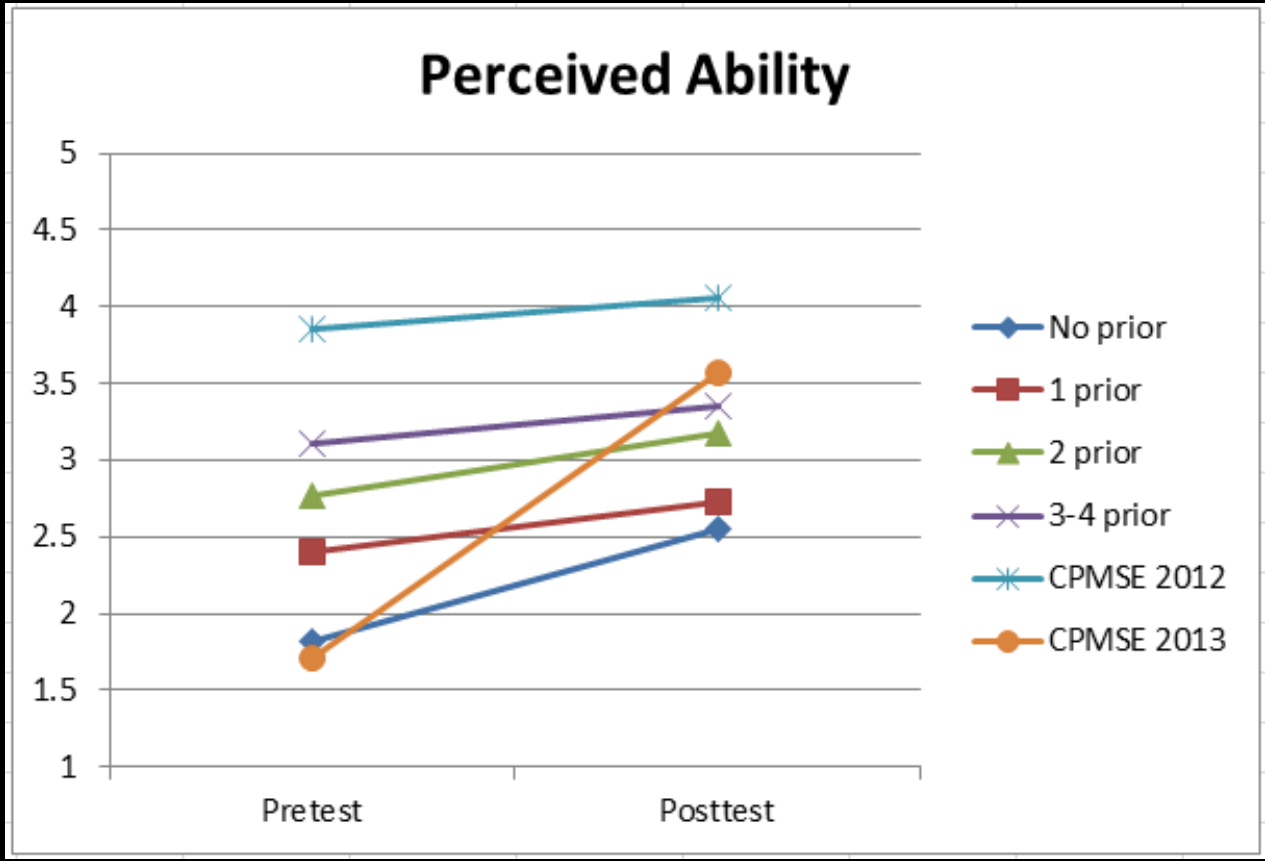
Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behavior.
Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts.

SUMMARY OF STUDENT SELF-BELIEFS



- Participants:130 students from 6 disciplinary courses.
- Procedures:
  - Exposure from one to three learning modules.
  - Surveyed at the beginning and at the end of the semester.

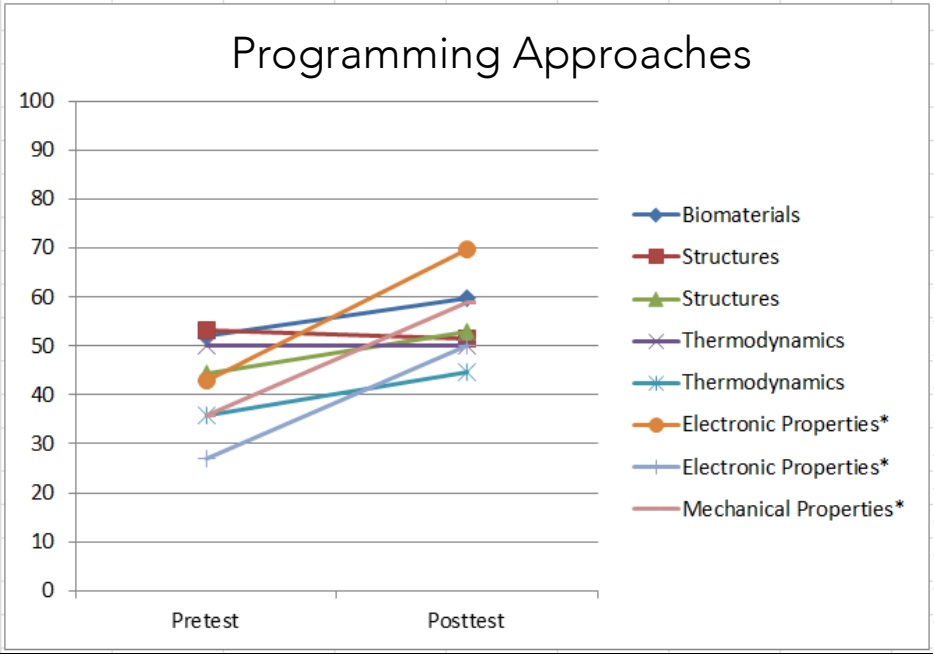
EFFECT OF PRIOR COMPUTING COURSES

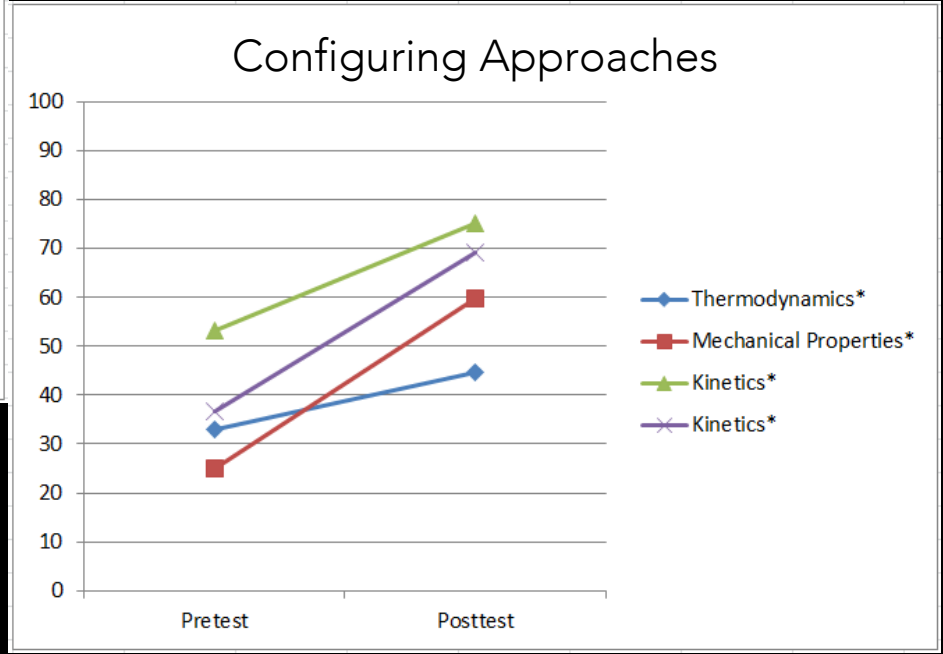


- Participants:

no prior	n=11	3-4 prior	n=14
1 prior	n=38	CPMSE 2012	n=12
2 prior	n=30	CPMSE 2013	n=24

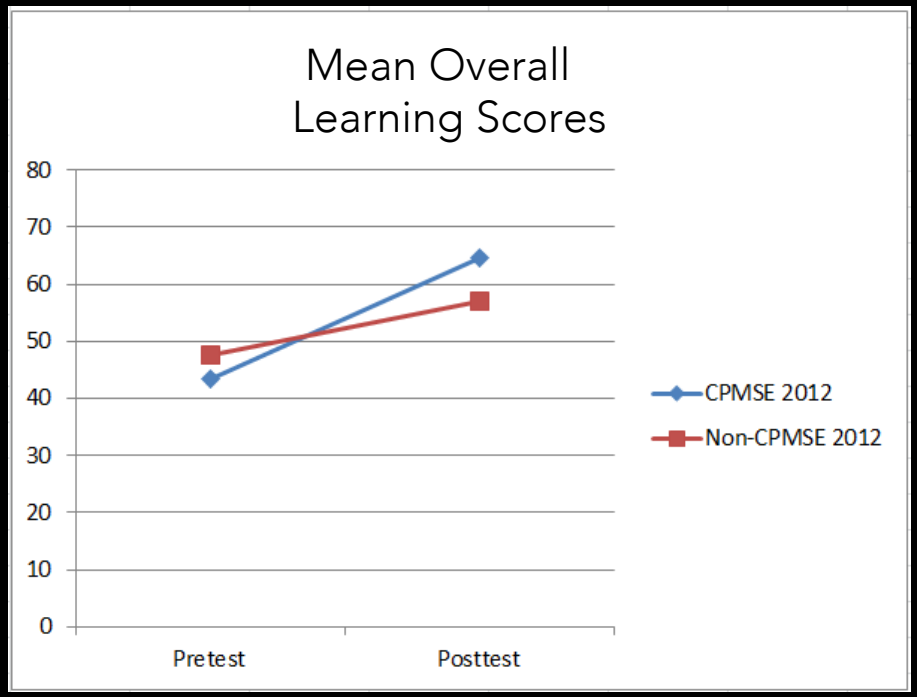
DISCIPLINARY LEARNING GAINS

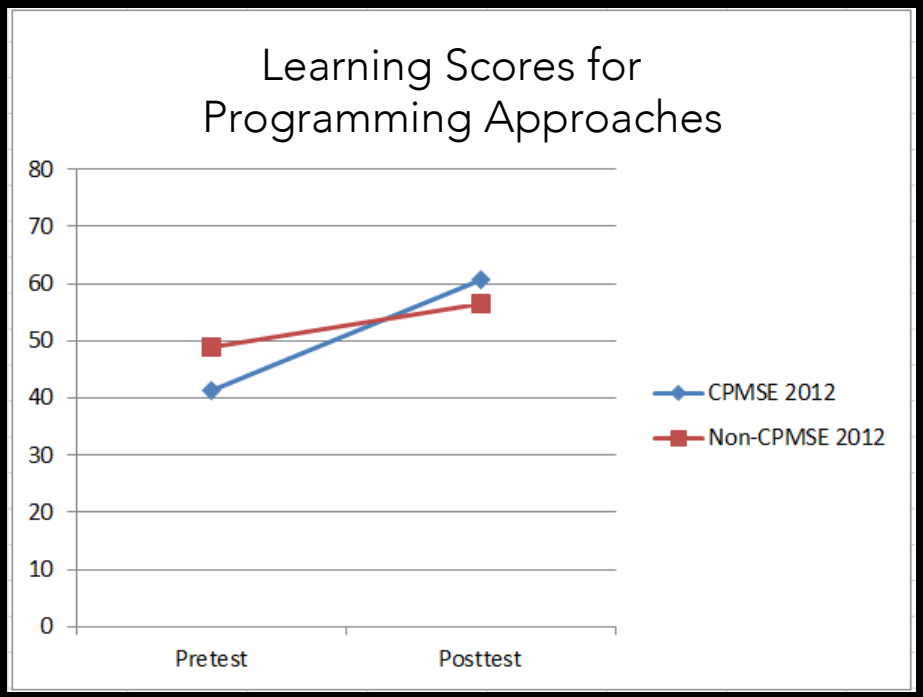




	Programming (%)		Configuring (%)					
Construct	Mean Gain	SD	Mean Gain	SD	t	DF	p-value	d
Learning Gains	8.8	23.6	14.1	28.0	1.16	240	0.246	0.48

EFFECT OF CPMSE 2012 ON LEARNING GAINS





	Previous CPMSE (%)		Non-CPMSE (%)					
Construct	Mean Gain	SD	Mean Gain	SD	t	DF	p-value	d
Overall Scores	21.22	14	9.39	25.24	2.45	21.94	< .05*	1.04
Programming	19.44	12.85	7.38	26.38				

SUMMARY OF FINDINGS

- At the curricular level:
  - Previous experience in programming courses has a larger impact on students' self-beliefs than individual modules integrated into core disciplinary courses.
  - The CPMSE course had the larger impact on student-self beliefs as well as gains in disciplinary learning.
- At the course level:
  - Students acquired higher disciplinary learning when using "configuring" modules than "programming" modules.
  - Students may acquire better understanding of the mathematical model by implementing the solutions through a "programming" approach.

Acknowledgements

Professors and students who have participated in these studies

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Thermo-Calc for sponsoring the webinar
http://www.tms.org/pd/webinars/impact-of-Contextualized-Computing-for-Materials-Students.aspx