The Impact of Contextualized Computing for Materials Students

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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

COMSOL

THERMOCALC

STRUCTURE OF MATERIALS

ETOMICA

THermo-Dynamics

Elec., Mag. & Optical Properties

MEchanical Properties

Bio-Materials

KINETICS & PHASE TRANS.
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
Start

View Video Podcast, Lecture

Take On-Line Quiz

Predict Output of Micro-Program

Debug Existing Micro-Program

Write Mini-Program to Specification

Write Micro-Program to Specification

Repeat x12

Exam

Complete MSE Themed Projects

Class Time
COMPUTER MEDIATED COLLABORATIVE CLASSROOM using ClassSpot by Tidebreak™
SIMULATING CARDIAC TISSUE

- Ventricular 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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STRUCTURE OF MATERIALS

ELEC., MAG. & OPTICAL PROPERTIES

MECHANICAL PROPERTIES

ETOMICA

THERMODYNAMICS

BIOMATERIALS
"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 initially 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 = x.'*x./((alpha.').^2); % calculate the wavefunction
        temp2 = -x.'*2./(2.*alpha.'.*temp1);
        psi = exp(temp1).*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;
    newylim = max(abs(psi));
    if (isempty(ylim)) ylim = newylim; ylim = ylim; end
    clf
    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
Technology Acceptance Model (Self-Assessment Survey)

- Ability
- Utility
- Intention

TECHNOLOGY ACCEPTANCE
FALL 2012

Ability
Utility
Intention

none prior
1 prior not CPMSE
2 prior not CPMSE
3-4 prior not CPMSE
CPMSE
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

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.
Participants:

- no prior: n=11
- 1 prior: n=38
- 2 prior: n=30
- 3-4 prior: n=14
- CPMSE 2012: n=12
- CPMSE 2013: n=24
### DISCIPLINARY LEARNING GAINS

**Programming Approaches**

<table>
<thead>
<tr>
<th>Construct</th>
<th>Programming (%)</th>
<th>Configuring (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Gain</td>
<td>8.8</td>
<td>14.1</td>
</tr>
<tr>
<td>SD</td>
<td>23.6</td>
<td>28.0</td>
</tr>
<tr>
<td>t</td>
<td>1.16</td>
<td></td>
</tr>
<tr>
<td>DF</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.246</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>0.48</td>
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</tr>
</tbody>
</table>

**Configuring Approaches**

- Biomaterials
- Structures
- Thermodynamics
- Thermodynamics
- Electronic Properties
- Electronic Properties
- Mechanical Properties
- Thermodynamics
- Mechanical Properties
- Kinetics
- Kinetics

* indicates a significant difference.
## EFFECT OF CPMSE 2012 ON LEARNING GAINS

### Mean Overall Learning Scores

<table>
<thead>
<tr>
<th>Construct</th>
<th>Previous CPMSE (%)</th>
<th>Non-CPMSE (%)</th>
<th>t</th>
<th>DF</th>
<th>p-value</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Scores</td>
<td>21.22</td>
<td>9.39</td>
<td>2.45</td>
<td>21.94</td>
<td>&lt; .05*</td>
<td>1.04</td>
</tr>
<tr>
<td>Programming</td>
<td>19.44</td>
<td>7.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Learning Scores for Programming Approaches
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

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