Computing Across Curricula (CAC)
The Final Report of Fellow Action Research Project

Fellow Information

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Years Employed at NCSU: 4  Years of Teaching (Total): 3

Courses you teach (on average)
Number of Fall Sections:  
Undergraduate Level  1.5  Graduate Level  0
Number of Spring Sections:  
Undergraduate Level  3  Graduate Level  0

Project Information

Action Research Project Title: “Integration of Excel/VBA Tools into Engineering Thermodynamics”
Course Information
Course Title: Thermodynamics for Textile Engineers
Course Number: TE 303  Number of Students: 30-40

PURPOSE & OBJECTIVES

PURPOSE:
The TE Curriculum is integrating content taught in TE/ISE 110 into other courses. This introductory course is intended to teach students how to model problems relevant to their specific engineering discipline through software platforms commonly used in industry, such as Excel with VBA. A focus of the course is to encourage students to analyze the solutions through decision support systems (i.e., to become “power users”, not programmers). The goal of this CAC project is to contribute to this computing thread by integrating the computing skills introduced in TE/ISE 110 into the junior level TE 303 course.

RESEARCH QUESTIONS:
If Excel with VBA is utilized for homework assignments in TE 303, then the students will:
• Enhance their understanding of thermodynamics concepts and principles.
• Retain the computing skills learned in previous courses (TE/ISE 110) and gain experience in adapting these skills to a variety of new applications.
• Improve their confidence in utilizing computing for engineering problem solving.

COURSE BACKGROUND:
TE 303 is an engineering thermodynamics course that is taught from both the molecular and macroscopic perspectives. TE 303 is offered each fall to about 30-40 students, most of whom are textile engineering (TE) and polymer and color chemistry (PCC) majors. This course is required in TE and PCC curricula, but is not a prerequisite for any other course.
**METHOD**

**PLAN:** This project will be undertaken in phases over a three year period, so that the complexity of the thermodynamics problem solving utilizing Excel with VBA will be increased each year. This phased approach will enable the development of tutorials for the computing tools learned in TE/ISE 110 that are useful for thermodynamics problem solving, such as Solver and VBA. These tutorials are intended to help students who are not proficient in these skills, particularly those who have not taken the TE/ISE 110 or similar courses.

- **Fall 2008:** All homework assignments during the course semester require to be completed in Excel.
- **Fall 2009:** Select specific problems that require the use of the computer; any platform could be used but Excel/VBA was encouraged. Integrate more guidance on the computing aspects.

**FOCUS AREAS:**
The basics of using Excel/VBA to solve engineering thermodynamics problems, such as:
- Spreadsheet formatting, including name ranges and establishing "constants"
- Utilizing built-in functions such as mathematical operations
- Solving problems by breaking the problem into pieces and writing Excel formulas
- Creating a chart
- **Apply concepts to other solution strategies, such as numerical integration**
- Using optimization tools such as Solver
- Performing a sensitivity analysis
- Recording macros for automation, such as for looking up values in a plug-in for the thermodynamic data tables
- Writing simple code in VBA to calculate a relevant relationship

**CHALLENGES:**
- Since TE 303 has students in both engineering and science, it cannot be presumed that all students have a laptop through the College of Engineering laptop initiative, and thus computing cannot be used during class sessions.
- TE/ISE 110 is not a prerequisite for TE 303, so proficiency in these skills cannot be presumed for all students; however, the majority of the students have taken TE/ISE 110 in a previous semester.

**GATHERING DATA:**
- Perform a self-assessment on homework assignments throughout the semester, and to make changes to future assignments accordingly.
- Compare performance on test problems that are correlated with the use of specific computing skills (such as a sensitivity analysis of thermodynamic properties).
  - I did not have any exam problems for which I could easily quantify the difference between the learning from computing and from analytical solutions
- Survey students at the beginning and the end of the course on their confidence and competency on specific Excel/VBA skills.
  - We only administered the survey in Fall 2008

**RESULTS**
FALL 2008:
• Self-assessments indicated that:
  – Students’ computer skills were “weaker” than expected. More tutorials/guidance needed.
  – Completing the entire HW assignment with Excel was too tedious and time-consuming.
    • The use of the computer was not necessary for some problems.
    • Also seemed to be distracting from the learning of thermodynamics problem solving rather than improving it
    • Starting with Homework 3, only select problems are required to be done with a computer.
      – However, students would try to maximize their points without doing the computing aspects.

FALL 2009:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Points</th>
<th>Average</th>
<th>% students &gt;= 70%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hw 1 Problem 4: Temperature “Chilling” Effect</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Convert given equation into different unit system (Metric to Imperial)</td>
<td>10</td>
<td>9.0</td>
<td>83%</td>
</tr>
<tr>
<td>b) Use equation from a) to plot wind chill as a function of velocity of the wind for three temperatures</td>
<td>15</td>
<td>11.8</td>
<td>62%</td>
</tr>
<tr>
<td>c) Discuss results</td>
<td>5</td>
<td>3.9</td>
<td>76%</td>
</tr>
<tr>
<td><strong>Hw 5 Problem 6: Pressure/Volume data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Graph of the data</td>
<td>4</td>
<td>3.5</td>
<td>79%</td>
</tr>
<tr>
<td>b) Find n: PV^n = constant</td>
<td>5</td>
<td>3.9</td>
<td>79%</td>
</tr>
<tr>
<td>c) Analytical solution of work</td>
<td>5</td>
<td>3.8</td>
<td>69%</td>
</tr>
<tr>
<td>d) Computational estimate of work using numerical integration (Trapezoidal Rule)</td>
<td>5</td>
<td>3.4</td>
<td>62%</td>
</tr>
</tbody>
</table>

Analysis:
• Graphing abilities improved on later assignments
  o 62% on Hw 1 versus 79% on Hw 5
• Students who struggled with the computing aspects (qualitative evaluation):
  o BME majors; PCC majors seemed to do fine
  o TE students who had not yet taken TE/ISE 110 or whose grade in TE/ISE 110 was below a B
  o Students’ confidence in computing abilities improved in 2009 due to:
    o More directed focus on picking problems that could only be solved computationally
    o Giving more guidance/reminders on how to implement the computational solution
CONCLUSIONS

• In Fall 2008, I tried to do too much computing integration at once.
• Students do not feel confident of their skills from previous computing courses like ISE/TE 110
• Students need tutorials or other guides to assist them in remembering the content from ISE/TE 110.
• Students need assistance on applying computing skills outside courses where they originally learned them.

NEXT STEP/LESSONS LEARNED

PLAN FOR FALL 2010:
• Investigate the effects of Excel/VBA videos created by Jeff Joines, et al., in improving confidence in computing and problem solving.
  o Videos were created for specific tasks in TE 303, such as the numerical integration (videos were created after the assignments had been completed in 2009)
• Incorporate one or two more sophisticated computing problems into the assignments.
• Give “skeleton” spreadsheets as a starting point for some problems, especially early in the semester.
• Better quantification of results, including correlations to exam assessments.