LABORATORY DESIGN FOR ENHANCED LEARNING OUTCOMES

M S & T Conference 2017 – University Materials Council Meeting

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The University of Florida has approximately **38,000 employees** including regular and time-limited faculty, staff, student employees and other temporary employees.

UF has more than **400 endowed faculty chairs** and a goal to add 100 more via the UF Foundation's three-year Preeminence campaign. The Foundation's last capital campaign exceeded its goal and raised $1.7 billion.

85 percent of UF students graduate in six years, and 67 percent graduate in four years.

**About the Gators.**

Admitted students at the University of Florida have an average high school GPA of **4.4.**

84 percent of UF's undergraduates receive federal, state or private sources of financial aid, and nearly 60 percent graduate with no student-loan debt.

The Machen Florida Opportunity Scholars (FOS) program has brought more than **3,000 exceptional first-generation college students** to the University, and the FOS retention rates have been **97.9%.**
Undergraduate Laboratory Vision

Students perform a series of collaborative thematic activities integrating core content area knowledge with technical skills & methods, and engineering professional practices. Students apply knowledge to solve engineering problems using methods and practices of engineers.

Laboratory module outcomes are designed to build engineering professional identity, social and ethical engineering practices, teamwork, ABET, Systems Thinking, and content knowledge.
As students move through the curriculum, laboratory experiences provide the core application for their coursework knowledge. The complexity of the laboratory experiences changes with the knowledge that students acquire within the courses and laboratories.

* Laboratories receive writing credit for student work products in course (two grades for course)
<table>
<thead>
<tr>
<th>Laboratory Goals</th>
<th>ABET Goals (2006)</th>
<th>ABET Goals 2015</th>
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<tbody>
<tr>
<td>Conceptual understanding</td>
<td>Illustrate concepts and principles</td>
<td>(a) an ability to apply knowledge of mathematics, science, and engineering (e) an ability to identify, formulate, and solve engineering problems (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.</td>
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<tr>
<td>Design Skills</td>
<td>Ability to design and investigate Understand the nature of science (scientific mind)</td>
<td>(b) an ability to design and conduct experiments, as well as to analyze and interpret data (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability</td>
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<tr>
<td>Social Skills</td>
<td>Social skills and other productive team behaviors (communication, team interaction and problem solving, leadership)</td>
<td>(d) an ability to function on multidisciplinary teams (g) an ability to communicate effectively</td>
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<tr>
<td>Professional Skills</td>
<td>Technical/procedural skills Introduce students to the world of scientists and engineers in practice Application of knowledge to practice</td>
<td>(f) an understanding of professional and ethical responsibility (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (i) a recognition of the need for, and an ability to engage in life-long learning (j) a knowledge of contemporary issues</td>
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Laboratory goals aligned with ABET Criteria, based in work by Ma and Nickerson.

An ability to apply STEM knowledge

An ability to design and conduct experiments, analyze and interpret data

An ability to communicate effectively

An ability to function on multidisciplinary teams

Recognize generic structures and see recurring patterns and structures in curriculum areas

Engage in Design cycles

Track change over time to question how and why things change. Build models that include social and personal issues

Instructional Outcomes

Map the structure of systems and simulate varieties of how systems might operate. Use computer models to recognize patterns and analyze anomalies

An ability to use the techniques and modern engineering tools necessary for engineering practice

An ability to identify, formulate, and solve engineering problems

An ability to design a system or process to meet desired needs while considering the limitations imposed by social, economic, ethical, cultural, environmental, and natural constraints

Knowledge of contemporary issues

An ability to apply systems and systems thinking

An ability to analyze and graph data over time; study rates and accumulations. Build models of complex systems Use equations and functions

Describe systems concisely and accurately with words and diagrams Use a variety of graphic tools

Recognize the need for life-long learning

Understanding of professional and ethical responsibility

Understanding impact of engineering solutions in a global context

Investigate how elements change over time in order to focus on patterns and trends. Work in teams on problem solving

Based on http://www.clexchange.org/curriculum/standards/stem.asp
How are Laboratory Experiences Designed?

- **Backwards Design** – What outcomes?
  - **Skills Outcomes** – what do we want them to be able to take away and apply?

- **Content Outcomes** – what concepts are “big ideas” or difficult for students in the core curriculum?

- **Technique Outcomes** – what technology should students interface with as engineers?

- **ABET Outcomes** – what core ABET practices are aligned to the laboratories?
<table>
<thead>
<tr>
<th>Module #</th>
<th>Concepts</th>
<th>Laboratory Experiences</th>
<th>Skills</th>
<th>Student Products</th>
</tr>
</thead>
</table>

Laboratory Experiences are “Wrapped” in a current theme for professional development of students – Theme here is “Sustainable Solders”
Students have a simple interface for access to laboratory experience modules.

This forces students to work through material, rather than by assignment.
Within the Module, there is an overview of the experiments that will be conducted for the laboratory

Overview of what you have to do for the entire module

Heat Module – General Guidelines

In this module you have several experiments that lead to a larger experimental paper. The main parts of this experiment are:

1. Make a program in Arduino to measure temperature. Use this program to measure heat conductivity and diffusivity in different materials. Build a concept for heat flow in materials.
2. Use MATLAB to model heat impulses and visualize heat flow in materials.
3. Make a program in LabView, to do real time data logging of temperature using for a Thermocouple and a program in Arduino to read a heat Thermistor. Each person does this. Everyone should have their own LabView, and Arduino Program.
4. Calibrate a Thermocouple using ASTM Standards for the LabView program.

Determine the error in measurement for the thermocouple and thermistor. (qualitative and quantitative)

3. Use the calibrated thermocouple to measure heat concepts in how materials respond to heat by measuring and constructing a phase diagram for a Sn-Bi Alloy.
4. Use ThermoCalc to model the Sn-Bi Alloy and compare to your experimental phase diagram.

This lab involves hazards. Electrical, hot surfaces, boiling liquids, ice, potential for slips and falls. You need to be aware and prepared for all hazards. Wear pants, shirts (no tanks) and non-slip full shoes.

This experiment will require you to keep an extensive notebook to record all of your data, observations and procedures.
Within the overview is a list of activities students will engage in and be assessed on for the laboratory experience.

1. Arduino Lab for heat conductivity
2. Arduino Programming of TMPs and measurement of heat flow
3. Post lab Analysis for heat flow
4. Survey Questions for heat flow
5. Lab notebook grade on Heat flow
6. Skills Criteria for Arduino Lab and Heat flow
7. Labview Programming and Thermocouple Calibration
8. LabView Programming of Thermocouple
9. ASTM calibration of Thermocouple
10. Error Analysis for Thermocouples
11. Survey Questions for Labview Programming and Calibration
12. Lab notebook grade for Labview programming and thermocouple calibration.
13. Skills Criteria for Labview programming and thermocouple calibration
14. IEEE paper section draft for Labview programming and thermocouple calibration
15. Heat Transformation in binary Alloys
16. Measuring Phase Transformations in Sn-Bi Alloy
17. Data Analysis of Phase transformations
18. Error Analysis of Phase Transformations
19. Lab notebook on Heat Transformations
20. Survey questions for heat transformations
21. Skills criteria for heat transformations
22. Draft version of IEEE paper for heat transformations
23. Final draft of IEEE paper for heat transformations
Clicking on one of the links takes students to the page for that experience with all required activities for that experience.
Students have rubrics for Notebook and Skills Criteria Assessment for each part of the laboratory.

<table>
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<tr>
<th>Criteria</th>
<th>Ratings</th>
<th>Pts</th>
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<tbody>
<tr>
<td>Student can write a Labview program for two Thermocouples and is able to explain what the program is taking in and how it outputs data. Student has evidence of program and data in notebook</td>
<td>Full Marks 5.0 pts</td>
<td>5.0 pts</td>
</tr>
<tr>
<td>Student can correctly wire TC leads into the daq. Student can articulate how a TC works and what the Daq inputs from the TC. Student can correctly wire the DAQ for TC in combination for ASTM Calibration. Student can wire DAQ for two calibrated TCs</td>
<td>Full Marks 5.0 pts</td>
<td>5.0 pts</td>
</tr>
<tr>
<td>Student can correctly prepare an ASTM ice bath, and can explain the ASTM standards that govern TC calibration</td>
<td>Full Marks 2.0 pts</td>
<td>2.0 pts</td>
</tr>
<tr>
<td>Student can correctly set up the calibrated TCs and can articulate the hazards related to this experiment</td>
<td>Full Marks 2.0 pts</td>
<td>2.0 pts</td>
</tr>
<tr>
<td>Student can conduct the ASTM calibration for cold and hot TC measurements, evidence of this is in the notebook</td>
<td>Full Marks 5.0 pts</td>
<td>5.0 pts</td>
</tr>
<tr>
<td>Student can find the time response for each of the calibrated TC</td>
<td>Full Marks 2.0 pts</td>
<td>2.0 pts</td>
</tr>
<tr>
<td>Student has conducted a data analysis for the TCs and can determine error and offset in the TC and compare to manufacturer datasheet</td>
<td>Full Marks 4.0 pts</td>
<td>4.0 pts</td>
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Labview Programming and ASTM TC Calibration

view longer description threshold: 3.0 pts

<table>
<thead>
<tr>
<th>Does Not Meet Expectations</th>
<th>Exceeds Expectations 0.0 pts</th>
<th>Meets Expectations 0.0 pts</th>
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<tbody>
<tr>
<td>0.0 pts</td>
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Total Points: 25.0
ABET & Professional Outcomes from Laboratory Experience

• Students work together as teams to solve complex engineering problems with a global and social “Wrapper”
• Students learn to communicate effectively as part of a team, and also to communicate in the ways of engineers (written and oral)
• Students interface with common standards, methods and tools used by engineers in practice.
• Students bring together core content knowledge from other core courses in MSE and engineering to apply to laboratory experience.
• Students grapple with data, analysis and interpretation of experimental results.
• Students learn to simulate and model material behavior.
Summary

• Laboratory experiences for students can provide students with a “unique” experience to synthesize core content knowledge.

• Laboratories are a way to develop ABET, Systems Thinking and Professional Practices in students.

• Laboratories can be designed to help students develop “big ideas” for core content, and deliver skills and techniques to build engineering competencies.

• Laboratories can scaffold students through deliberately staged activities towards learning and skills outcomes.

• Successful practices are not an accident – time must be devoted to designing effective laboratories.
Questions?

Thank you for your time

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