Balancing the ECE Curriculum with the Kolb Learning Cycle*

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Overview

- Introduction
- Kolb/4MAT learning theory
- *Introduction to Robotics* pilot course
- NSF curriculum planning grant
  - Reordering of systems core with signal processing first
  - Kolb/4MAT introduced into these courses
  - Design of “curricular threads” including robotics, software-defined radio, and core electronics
- NSF curriculum implementation proposal
Introduction

- We are undergoing a curricular change in the ECE department to “reach, reinforce and challenge all students”
- Pedagogy updated to reflect modern research in how students learn
- Proposed curriculum change to add “threads” of content through a cross-section of the program to add coherence
- Re-structuring of systems core to introduce signal processing concepts early on
Pedagogy: Kolb Learning & 4MAT

- Learning styles: Perception (taking things in) and Processing (making it part of yourself)

Concrete Experience (Sensing/Feeling)

**Quadrant 1: Why?**
- Role playing/journal writing
- Field trips/simulations
- Motivational examples/stories
- Interactive discussion/lecture
- Class/group discussion

**Quadrant 2: What?**

**Quadrant 3: How?**
- Homework problems/guided laboratories
- Computer simulation/demonstrations
- Objective examinations
- Individual report
- Computer-aided Instruction

**Quadrant 4: What if?**
- Open-ended problems/laboratories
- Capstone design/undergraduate research
- Group problem solving/project reports
- Think tanks/student lectures
- Problems prepared by students

Reflective Observation (Watching)

Abstract Conceptualization (Thinking)
Pilot Course: Intro. to Robotics

- A team-based engineering design and competition course at the freshman level:
  - Excite students with engineering
  - Give them a feel for a real engineering project
  - Get them “hooked up” with other students
  - Aid retention and give non-engineers an engineering elective course
  - A new experience for us using Kolb/4MAT

- Use technology to learn technology, preparing to design technology
Technology Used

- Use LEGO Mindstorms *Robotic Invention System* as a basis for an engineering design course that includes hands-on labs and a final competition
  - 8-bit on-board microprocessor
  - 3 sensor inputs and 3 actuator outputs
    - Outputs: Motors up to 8 speeds, 2 directions
    - Inputs: 10 bit A2D—Rotation, light, touch
  - 4 on-board timers
  - IR link for bidirectional messaging
  - Sound generator, clock, multi-tasking

- Funded by ECE Department, UCCS Teaching and Learning Center, UCCS Instructional Fee
Syllabus

- **Course is 50% lecture; 50% hands on**

<table>
<thead>
<tr>
<th>Lecture Period</th>
<th>Hands-on Lab Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Getting started</td>
<td>1. Nobot</td>
</tr>
<tr>
<td>2. The RCX</td>
<td>2. Tankbot</td>
</tr>
<tr>
<td>[Labor day holiday]</td>
<td>3. Bumpbot</td>
</tr>
<tr>
<td>3. Introduction to NQC</td>
<td>4. Bugbot</td>
</tr>
<tr>
<td>4. Intro. to NQC (cont)</td>
<td>5. Linebot</td>
</tr>
<tr>
<td>5. Robot construction</td>
<td>6. Scanbot</td>
</tr>
<tr>
<td>6. Robot construction (cont)</td>
<td>7. Steerbot</td>
</tr>
<tr>
<td>7. Basic control</td>
<td>8. Diffbot</td>
</tr>
<tr>
<td>8. Basic control (cont)</td>
<td>9. Quiz on NQC. Work on project</td>
</tr>
<tr>
<td>9. Basic electronics</td>
<td>10. Quiz on construction. Project</td>
</tr>
<tr>
<td>10. Basic sensors</td>
<td>11. Quiz on control. Project</td>
</tr>
<tr>
<td>11. Basic sensors (cont)</td>
<td>12. Quiz on electronics. Project</td>
</tr>
<tr>
<td>12. Microprocessor designs</td>
<td>13. Quiz on sensors. Project</td>
</tr>
<tr>
<td>13. Microprocessors (cont)</td>
<td>[Thanksgiving holiday]</td>
</tr>
<tr>
<td>15. Robot qualification trials</td>
<td>15. Final competition (8:00am)</td>
</tr>
</tbody>
</table>

- **Evaluation:** “prelabs,” quizzes, lab reports, project
Nobot, Tankbot, Bumpbot, Bugbot, Linebot, Scanbot, Steerbot, Diffbot
Final Design Project

- Engineering design under severe constraints

![Diagram]

- Regions shown as gray will be painted flat black.
- Regions shown as white will be painted glossy white.
- Regions shown as yellow will be painted gray. That is, the region around each hole will be painted gray. There will be two gray stripes, 1 in. wide, as shown.
- Cups at hole locations are 3.5 in. tall, and 4 in. in diameter.
- All dimensions assumed to be accurate to within ± 0.5 inches.
- A sturdy wall, at least 3 inches but not more than 4.5 inches taller than the playing field, will surround the entire area.
- This is indicated by the dashed line in the lower drawing.
Kolb Compliance

- **Quadrant 1: The “Why?” question**
  - Motivating stories, news items, point to advanced courses

- **Quadrant 2: The “What?” question**
  - Formal lectures, reading assignments, demonstrations

- **Quadrant 3: The “How?” question**
  - Eight team-based guided laboratory exercises

- **Quadrant 4: The “What if?” question**
  - Team-based robot design project for final competition
Outcomes 1:

- Instructional goals accomplished!
- Students with backgrounds only in high-school Math and English are:
  - Writing their own computer programs
  - Building robotic structures and mechanisms
  - Designing feedback control systems
  - Learning about the theory of electronics, sensor design, and microcontroller-based systems
  - Cooperating in inter-disciplinary teams
  - Writing proper lab reports (with attention paid to correct grammar, spelling, word usage)
Outcomes 2:

- Surveys and quiz results showed a very high level of learning
  - Significant improvement in technical knowledge
  - Moderate improvement in non-technical components of the course
- Every student completed all labs successfully
- All design teams qualified for final contest
- Contest winner was able to beat professor-designed robots (!)
Ongoing Change...

- Received NSF planning grant proposal to “balance” ECE curriculum
  - New courses: *Introduction to Signals and Systems, Circuits and Systems I, Circuits and Systems II*
  - These courses will comply with Kolb/4MAT

- Submitted NSF implementation grant proposal to restructure entire systems area of curriculum (pending)
  - Will introduce Kolb/4MAT to remainder of systems core
  - Will allow improved hands-on exercises in “threads”
  - Will aid retention efforts
Signal Processing First

- Course re-ordering rotates sequence:
  - From: Circuits I, Circuits II, Linear Systems
  - To: Intro. to Signals & Systems, Circ. & Systems I,II

- We feel that present students better understand CD-players and iPODs than electric circuits

- Allows CpE/ Bio/ etc/ engineers to learn DSP concepts

- Courses will be taught with Kolb/4MAT compliance
Curricular Threads

- Improve coherence of BSEE (systems) by “weaving” specific concrete engineering applications or “threads” through the curriculum
  - We have identified: $\text{ROBO}^T$, $\text{SWIR}^T$, $\text{CEL}^T$

- Robotics thread ($\text{ROBO}^T$) example:
  - Early exposure at concept level in *Intro. to Robotics*
  - Build resistive sensors, op-amp motor drivers, A2D, D2A, PWM, and PID control in Circ. and Systems I, II
  - Build H-bridge motor drivers and active sensors in Electronics I, II
  - Introduce advanced concepts in new course “Embedded Mobile Robotics”
Proposed Curriculum Changes

- NSF Curriculum Implementation proposal
  - Kolb/4MAT and structure changes to systems core
  - Implementation of ROBOT, SWIR, CEL

Old Curriculum

<table>
<thead>
<tr>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
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<tbody>
<tr>
<td>Eng I (4)</td>
<td>Electr I (3+1)</td>
<td>Electr I (4)</td>
<td>Electr I (3+1)</td>
</tr>
<tr>
<td>Phys I (4)</td>
<td>Linear Sys. (3)</td>
<td>Circ. I (3)</td>
<td>Design Proj. I (3)</td>
</tr>
<tr>
<td>Math Elect. (3)</td>
<td>Robotics Intro. (3)</td>
<td>Math Elect. (3)</td>
<td>Math Elect. (3)</td>
</tr>
<tr>
<td>Senior Sam (1)</td>
<td>Senior (1)</td>
<td>Tech. Elect. (10)</td>
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New Curriculum with Revised Core

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Student takes total of three three-credit senior technical electives and three one-credit senior electives. Student also takes four three-credit technical electives.
Summary

- The UCCS ECE Department is revising its BSEE curriculum to “reach, reinforce, and challenge” all students
- The Kolb/4MAT system is central to the change
  - Our pilot course has been very successful
- NSF curriculum planning grant to continue work
  - Reordering of systems core with signal processing first
  - Kolb/4MAT introduced into the three new courses
  - Design of “curricular threads” ROBO\textsuperscript{T}, SWIR\textsuperscript{T}, CEL\textsuperscript{T}
- NSF curriculum implementation proposal to complete this phase of work
Acknowledgement

- ECE Dept. grant to purchase LEGO kits ($4,500)
- UCCS Teaching and Learning Center grant to develop *Introduction to Robotics* course ($4,000)
- UCCS *Instructional Fee* grant to purchase additional LEGO components to allow campus-wide elective ($9,000)
- NSF Curriculum Planning grant to design new curricular changes ($100,000)