Experiences in Updating the ECE Curriculum with Signal Processing First and Kolb/4MAT Pedagogy*

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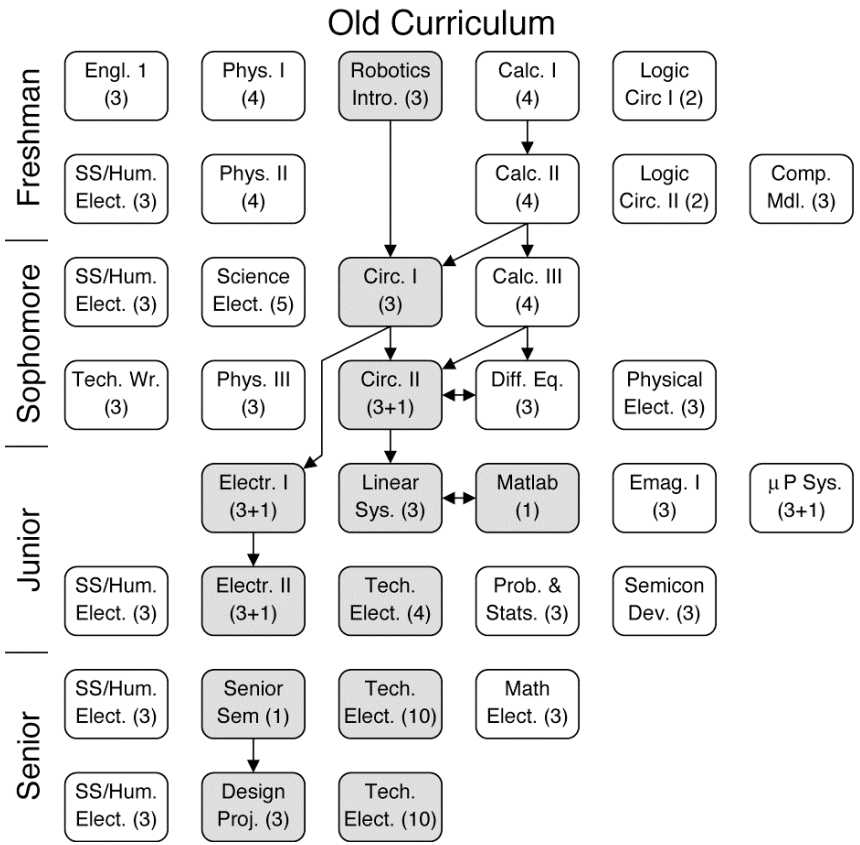
History and Motivation

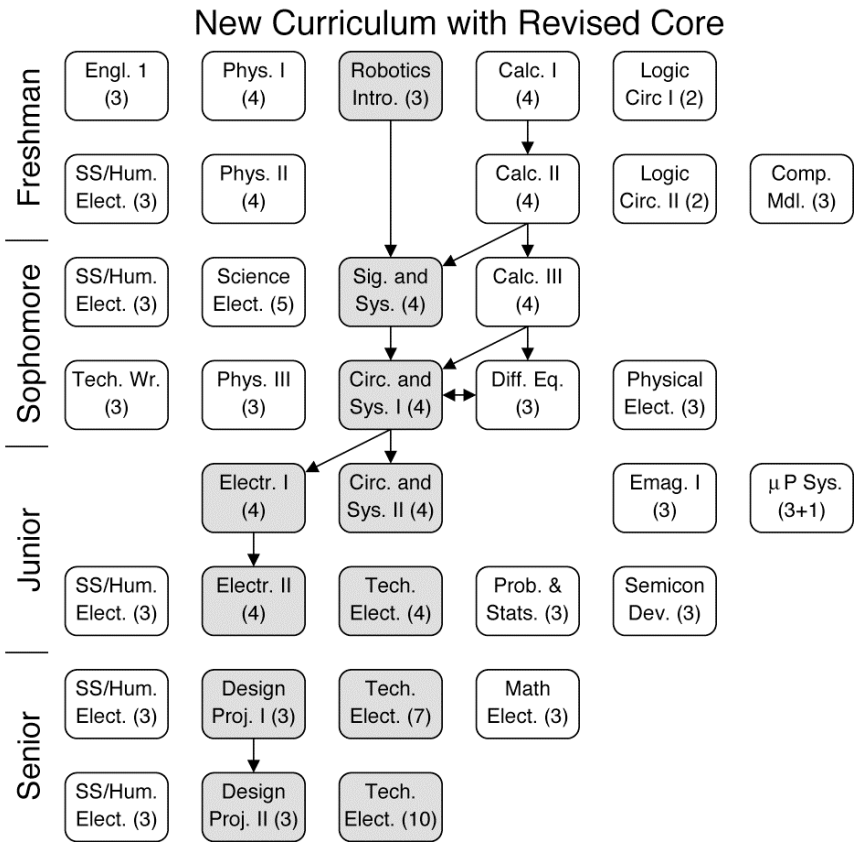
- Began redesign of our circuits/systems curriculum in 2004 with writing and award of an NSF curriculum planning grant; eventually will encompass 38 semester hours
- About six months into the NSF grant, decided to go with the "signal processing first" approach of Ga Tech and others
  - Taught *Introduction to Signals and Systems* for the first time in fall 2005; second time in spring 2006.
  - Follow-on circuits course taught in spring 2006 (Ga Tech authors)
  - Second circuits/signal processing course to be taught fall 2005
  - Courses are packaged in a four-semester-hour format (two periods lecture; one period lab per week; 1¼ hr sessions)
- Really began with successful experience with freshman robotics course appealing to a variety of learning styles

Motivation

- Multiple goals
  - Appeal to students' interest in and use of modern devices such as iPods, CD players, cell phones, etc.
  - Address multiple learning styles – sensing/feeling, watching, thinking, doing (Kolb – perception and processing)
  - Encourage
    - More hands-on experience (lab meets weekly – tied to course)
    - Earlier and continued computer use (lab, computation, plotting)
    - More written communication experiences (formal lab reports)
    - Set a pattern for lifelong learning (multiple learning experiences)
    - Exposure to undergraduate research (students pushed to look up material from a variety of sources)

Old and New Curricula Compared

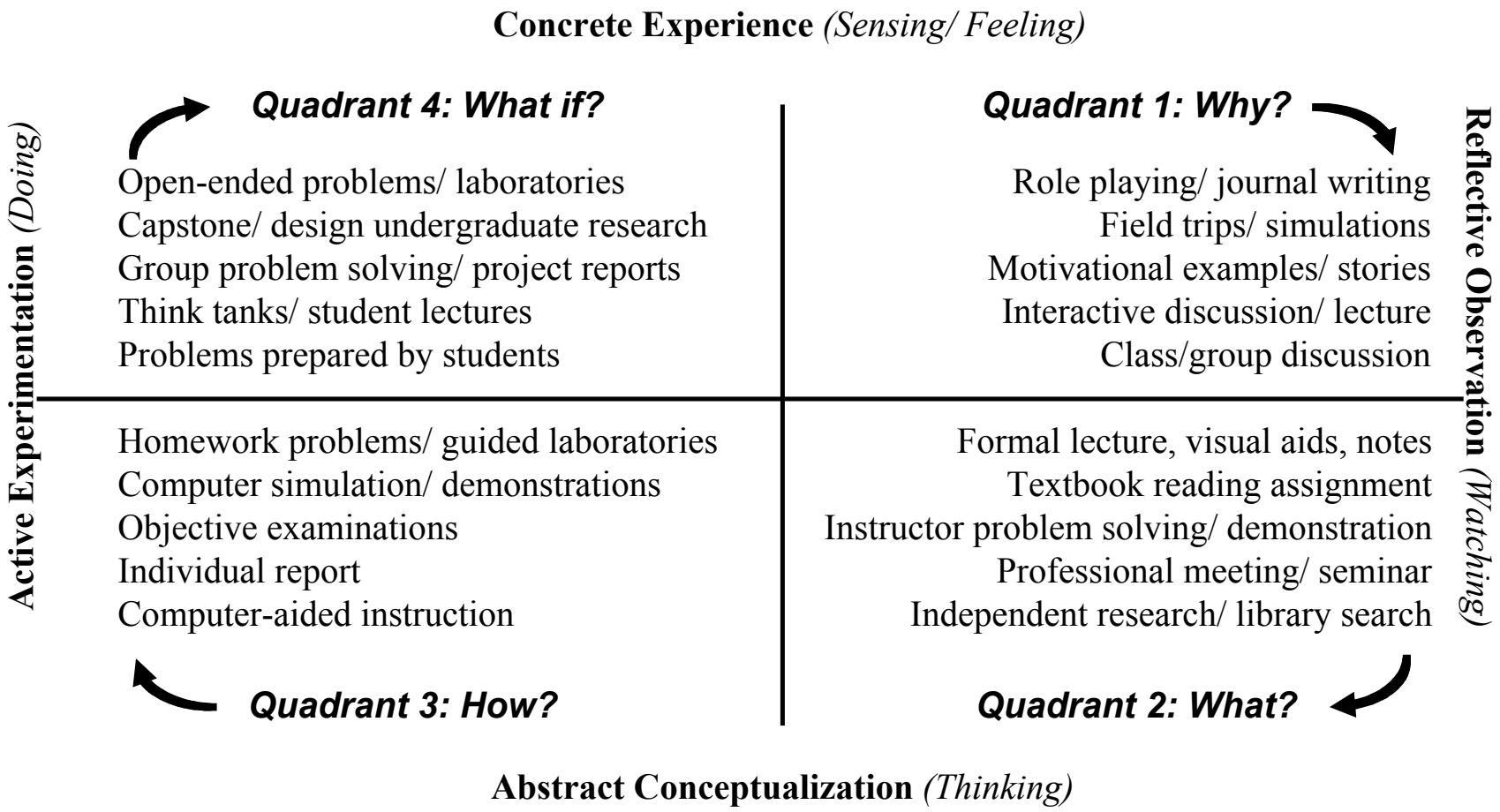




Topical Outlines for *Introduction to Signals and Systems, Circuits and Systems I, II*

- *Intro Signals & Systems*
  - Sinusoidal/phasor signals
  - Spectrum representation
  - Sampling and aliasing
  - FIR filters
  - *Z*-transforms
  - IIR filters
  - Continuous-time signals/systems
  - Frequency response
  - Fourier transform
  - Final project
- *Circuits and Systems I*
  - Circuit elements/models
  - Writing circuit equations
  - Subnetworks
  - Operational amplifiers
- *Circuits and Systems I* – Continued
  - Op amps: 1st and 2nd order solutions
  - Laplace transform
  - Circuit solutions in the Laplace domain
  - System functions
  - Final project
- *Circuits and Systems II*
  - Circuits/systems – sinusoidal steadystate
  - AC power and transformers
  - Frequency response and Bode plots
  - Routh array; active feedback example
  - Analog filter circuits
  - Digital filter design (versus analysis)
  - Hybrid system integration
  - Final project

Kolb 4MAT Learning Cycle



Introduction to Signals and Systems Compared with Kolb Cycle

- Quadrant 1: Why?
  - Motivational examples in lecture sessions
  - Examples in lab (e.g., inverse FIR filter for echo and image blurring cancellation)
- Quadrant 2: What?
  - Lectures
  - Visual aids on CD
  - Handouts
  - Solved examples by instructor, in book and on CD
- Quadrant 3: How?
  - Homework problems and weekly quizzes (solutions provided)
  - Lab reports (prelab and formal)
  - Computer aids for labs and lecture material (on CD)
- Quadrant 4: What if?
  - Project (noisy speech signal with echo; design filters to enhance)
  - Some aspects of lab experiments

Survey and Anecdotal Data: *Introduction to Signals and Systems*

- Used a student-scored survey instrument. Fall 2005/spring 2006 percentages in parentheses (about 1/3 of class responded for each offering):
  - active versus reflective learners (75%/57%)
  - sensing versus intuitive learners (75%/43%)
  - visual versus verbal learners (75%/71%)
  - sequential versus global learners (63%/30%)
- Anecdotal results
  - Students come into course knowing trig; applying it a challenge
  - Workload heavy – for professor, lab instructor, and student
  - First part of course a challenge; z-transform and on easier
  - High expectations encouraged higher performance by students

Other Observations

- Early exposure to DSP in the baccalaureate program allows merging of analog and digital processing concepts at the first semester junior year.
- “Signal processing first” requires a systems faculty dedicated to the concept.
- Book, CD- and Web-based materials almost give the student too much to read, use, and digest.
- Students get very good at manipulating things on the computer, perhaps at the expense of understanding.
- Will breadth come at the expense of depth? It is too early to tell.
- The use of viewgraph presentations should be done carefully (and sparingly).
- Any course with the degree of hands-on content as these require lab assistant(s), no matter what the enrollment (not necessarily graduate student assistants).

Student Performance: % drops and below C

Course	Fall 2005	Spr 2006
Introduction to Signals and Systems (19, 25)	31.6%	16%
New *Circuits and Systems I* (11)		9.1%
Old *Circuits I*; Fall 2003; Spr 2004 (28, 18)	14.3%	28.2%
Old *Circuits II*; Spr 2004 (39)		11.1%

Development of "Threads"

- In addition to redoing the content of courses, we are developing content and application threads to be woven throughout the curriculum.
- Proposed ones were: (1) Sensors and control; (2) Signal processing; (3) Wireless communications; (4) Microelectronics
- Later simplified to (1) Robotics; (2) Wireless communications; (3) Core electronics
- So far, the robotics thread has been carried from freshman *Introduction to Robotics* to sophomore *Circuits I*:
  - Programming in C
  - How control systems work
  - How electronics work
  - How sensors work
  - How motor drivers work
  - Robot design project (digital logic)
  - Light sensor design
  - Servo and dc motor control
  - Basic feedback circuits (op amp)
  - Robot design project (analog logic)

Future Plans

- Teach *Circuits and Systems II* for the first time fall semester, 2006 – much development yet to do
- Propagate the format developed for *Intro to Signals and Systems, Circuits and Systems I & II* to following courses – *Electronics I & II*
- Continue development of the *Robotics* thread
- Begin development of one additional thread, probably *Wireless*