Teaching Excellence

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Roadmap

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Introduction: on great teachers

- William A. Ward

"The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires."

- Khalil Gibran

"The teacher who is indeed wise does not bid you to enter the house of his wisdom but rather leads you to the threshold of your mind."

- Henry Adams

"A teacher affects eternity; he can never tell where his influence stops."

Introduction: on great teachers

- Hass School of Business, UC Berkeley:

"Great teachers do not all have a single style - but they do all have a singular goal: to reach students in ways that have deep and lasting influence on how they think and act throughout their lives and careers."

- Otis College of Design and Arts, about a great teacher:
  - Communicates a thorough knowledge of and enthusiasm for the relevant field or subject
  - Presents that knowledge coherently and connects it with other allied fields or subjects
  - Challenges students and increases their capacity for independent thought
  - Transforms, enhances, or innovates teaching methodology and practice.

Introduction: new approaches

- Teaching new generations of students is a challenging task that calls for new approaches and methodologies that will appeal to current generations of both students and educators.
- Aristotle once said: “For the things we have to learn before we can do them, we learn by doing them.”
- Recent theories of education emphasize learning through “reflection on doing”.
- Adopting these new approaches in teaching and in designing new pedagogical tools is an important step in advancing the art of teaching in science, technology, engineering, and mathematics (STEM).

Introduction: new theories

- They include a number of approaches such as:
  - experiential learning
  - experiential education
  - action learning
  - adventure learning
  - free choice learning
  - cooperative learning
  - service learning
- Experiential learning is the process of making meaning from direct experience.
- In this lecture, we use examples from teaching university courses in circuits and systems to illustrate experiential teaching and learning approaches in engineering.

Introduction: motivation

- Providing students with a solid theoretical background greatly improves their ability to solve a variety of practical engineering problems.
- National institutions have long recognized the need for improving engineering education.
- Attracting the best students to science, technology, engineering, and mathematics programs end eliciting their interest has been also subject of a number of ongoing debates over the past two decades.

National Science Foundation, Moving Forward to Improve Engineering Education, NSB-07-122, Nov. 19, 2007.

Current engineering programs

- Offer a number of majors:
  - electronics, computer engineering, engineering physics, bioengineers, mechatronics
- These programs may need courses carefully tailored to fit a program's specific curricula.
- The “cookbook” approach may not be serving future electrical engineers well.
- Lectures, tutorials, and laboratories are often supplemented by software tools such as MATLAB, SPICE, OPNET, ns-2, and ns-3 to enhance understating of the theory taught.

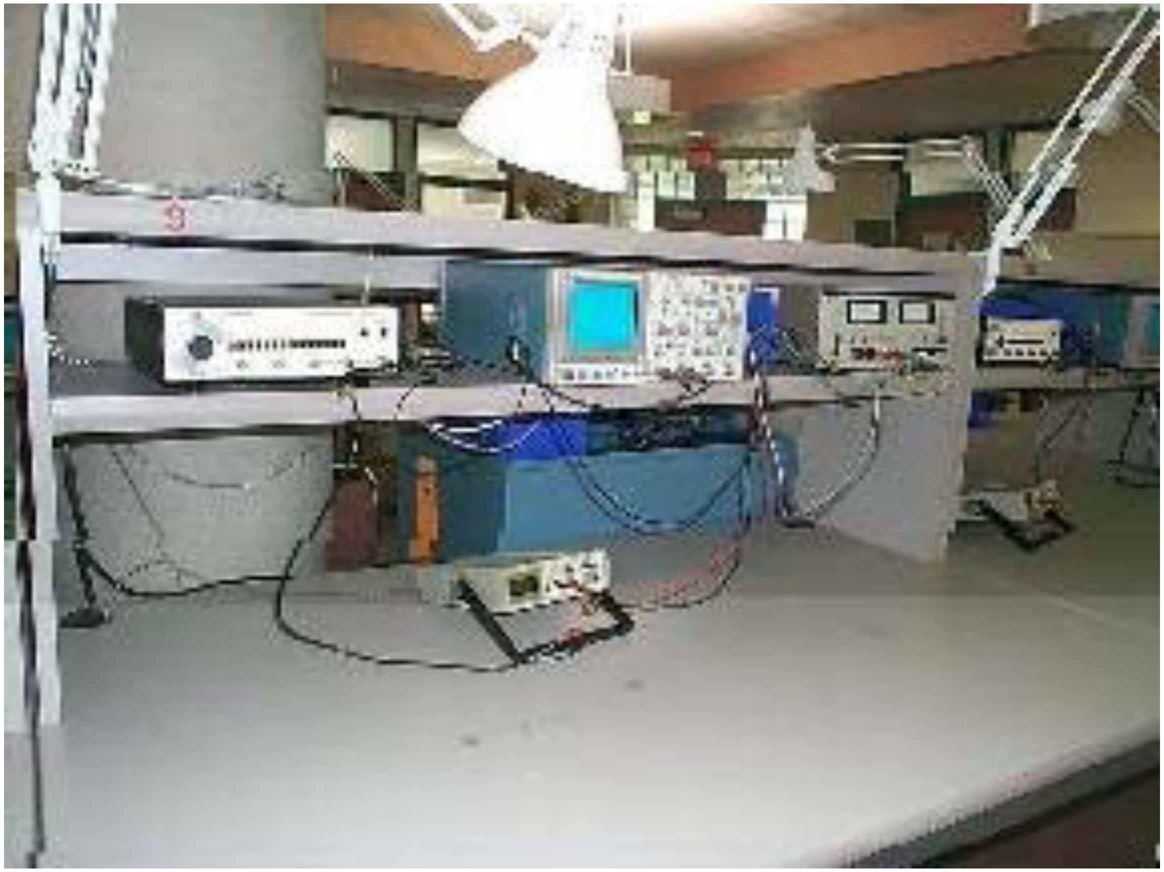
Engineering program at SFU: Electric Circuits

- School of Engineering Science offers two classical undergraduate courses in electric circuits. These courses are offered to second and third year students.
- SFU follows trimester system (three terms per calendar year) and each term lasts thirteen weeks.
- There are weekly homework assignments and the midterm and final examinations.
- In addition to three-hour lectures per week, one-hour tutorials offered weekly for the undergraduate courses deal with solving analytical problems.
- The undergraduate courses have laboratory components and students are expected to submit written laboratory reports. The School follows the 24/7 open-laboratory model.

Engineering program at SFU: Electric Circuits

- There is no required textbook. Several textbook are recommended. A large number of textbooks and references are made available through the University Library reserves.
- Occasionally, a course in nonlinear circuits is offered to senior undergraduate and graduate students as a special topics course.
- There are weekly homework assignments, two short midterm examinations, and a final research project.

Laboratory



First course: Electric Circuits I

http://www.ensc.sfu.ca/~ljilja/ENSC220/

- The first course in electric circuits deals with elementary concepts and analysis tools.
- The course pre-requisites are two first year physics courses and the course co-requisites are two second year mathematics courses.
- This course is a pre-requisites for undergraduate courses in electronic devices and microelectronics.

First course: Electric Circuits I

Topics:

- Circuit elements
- Kirchhoff current (KCL) and voltage (KVL) laws
- Operational amplifiers (op-amps)
- Circuit analysis techniques
- Thevenin and Norton theorems
- First order circuits
- Second order circuits
- Sinusoidal steady-state analysis
- AC power
- Polyphase circuits

Electric Circuits I: laboratories

- Lab bench orientation:
  - Part 1, Power supply and digital multimeter
  - Part 2, Function generator and oscilloscope
- Lab 1, KCL and KVL
- Lab 2, Op Amp
- Lab 3, RL and RC circuits.
- Lab 4, RLC circuits
- Lab 5, AM radio demo

Second course: Electric Circuits II

http://www.ensc.sfu.ca/~ljilja/ENSC320/

- The second course in electric circuits is intended to enhance the knowledge of students in the area of electric circuits and to further develop their analytical skills.
- The course pre-requisite is the first course in electric circuits.

Topics:

- Analysis of circuits in the time domain
- Laplace transform
- Frequency response, filters, and resonance
- Filter design
- Mutual inductance and transformers
- Two-Port networks

Electric Circuits II: laboratory

- The laboratory exercise deals with the design and implementation of an active filter.
- The students are asked to design a low pass filter for telephone speech signals that have bandwidth of 300–3,400 Hz.
- The filter is to be used to suppress interference by attenuating interference signals by at least 30 dB starting at 11 kHz.
- The telephone signal should not be attenuated more than 0.5 dB. Students are given the laboratory assignment and the instructions early in the trimester:

Lab report:

- Describe your design and the performance of your implementation. Explain differences between your expectations and the actual filter performance.

Electric Circuits II laboratory

Design:

- Examine Butterworth and Chebyshev filter realizations that meet the specifications.
- Plot frequency responses using MATLAB. Select the most appropriate filter type, order, and filter parameters.
- Design the filter using Sallen-Key stages with an overall gain (output voltage/input voltage) in the range 2 to 3.
- Simulate your design using PSPICE.
- Build the filter circuit, test it, and compare its performance to the specifications and to PSPICE predictions.

Graduate Course: Special Topics in Theory, Analysis, and Simulation of Nonlinear Circuits

http://www.ensc.sfu.ca/~ljilja/ENSC895/

- This is a research oriented graduate course in nonlinear circuits.
- The course aims to provide insights and understanding of complex static and dynamic behavior of circuits consisting or bipolar and MOS transistors.

Topics:

- Global properties of electronic components, properties of nonlinear circuit equations, existence and uniqueness of dc operating points, stability of operating points and the occurrence of bistability, methods for computing solutions to dc, ac, and transient circuit equations, homotopy methods for finding such solutions and their software implementations.

Graduate Course: Special Topics in Theory, Analysis, and Simulation of Nonlinear Circuits

- Emphasizes is given to the relationship of circuit theory to circuit design and its usefulness in practical applications.
- Students are introduced to various theoretical approaches and numerical methods for analyzing nonlinear electronic circuits.
- The course pre-requisites are undergraduate courses in electric circuits, electronic devices, microelectronics, and a first course in linear algebra.

Graduate Course:
Special Topics in Theory, Analysis, and Simulation of Nonlinear Circuits

Graduate research projects:

- A final research project is an important component of the course. Software tools such as MATLAB and PSPICE are used for circuit simulations.
- Sample projects:
  - Stimulations of negative resistance circuits
  - Analyzing stability of nonlinear circuits
  - Computing dc operating points of nonlinear circuits
  - Analysis, modeling, and design of an IGBT-based power converter.

Engineering program at SFU: Communication Networks

- School of Engineering Science offers two undergraduate and two graduate courses in communication networks.
- The undergraduate courses are offered to third and fourth year students.
- There are weekly homework assignments and the midterm and final examinations.
- In addition to three-hour lectures per week, one-hour tutorials offered weekly for the undergraduate courses.
- There is no required textbook. Several textbook are recommended. A large number of textbooks and references are made available through the University Library reserves.

Undergraduate Course: Communication Networks

http://www.ensc.sfu.ca/~ljilja/ENSC427/

- This course covers the techniques needed to understand and analyze modern data communications networks.
- It covers the basic architecture of packet networks and their network elements (switches, routers, bridges), and the protocols used to enable transmission of packets through the network.
- Quantitative performance analysis and design of data and integrated services networks.
- Re-transmission error recovery schemes, networks of queues, congestion control, routing strategies.
- Multiple access techniques in data networks, design for specified throughput and delay performance.

Undergraduate Course: Communication Networks

- Wireless networks, routing approaches in mobile networks
- Analysis and design of broadband integrated services digital networks, asynchronous time division multiplexing
- Laboratory work is included in this course
- This is a project oriented undergraduate course. Students will be introduced to the OPNET (OPNET Technologies) tool for simulating packet networks
- The course pre-requisite is successful completion of ENSC 327-3 or permission of the instructor

Undergraduate Course: Communication Networks

Topics:

- Communication networks and services
- Application of layered architecture
- Digital transmission fundamentals (overview only)
- Circuit-switched networks
- Peer-to-peer protocols and data link layer
- Medium access control protocols and local area networks
- Packet-switched networks
- TCP/IP

Undergraduate Course: Communication Networks

http://www2.ensc.sfu.ca/~ljilja/ENSC427/Projects/ENSC427_Spring2013_projects.html

Sample projects:

- Space Internet: transmission of large files
- Evaluation and comparison of Spanning Tree Protocol and Rapid Spanning Tree Protocol on Cisco switches via OPNET
- Analysis and simulation of VoIP
- BACnet network
- Analysis of RIP, EIGRP, and OSPF routing protocols using OPNET
- Peer to peer networks
- Wireless network simulation
- Comparative performance analysis of LTE versus WiMAX using OPNET simulation modeler

Undergraduate Course: Communication Networks

Sample projects (cont.):

- Multimedia streaming over WiMAX and LTE networks
- Comparison between LTE and rival wireless technologies
- Analysis and performance evaluation of a Wi-Fi network using ns-2
- Analysis of video conferencing in LTE networks
- An analysis of peer-to-peer traffic over an ad-hoc network
- Analysis of a smart device game protocol
- Evaluation and comparison of wired VoIP systems to VoWLAN
- QoS analysis of wireless ad-hoc network routing protocols

Graduate Course: Communication Networks

http://www.ensc.sfu.ca/~ljilja/ENSC835/

- This course covers the techniques needed to understand and analyze modern data communications networks.
- It covers the basic architecture of packet networks and their network elements (switches, routers, bridges), and the protocols used to enable transmission of packets through the network.
- It addresses techniques for collection, characterization, and modeling of traffic in packet networks.
- It covers aspects of traffic management, such as various call admission control and congestion control algorithms in high-speed packet networks and the influence of traffic on network performance.

Graduate Course: Communication Networks

http://www.ensc.sfu.ca/~ljilja/ENSC835/

- This is a project oriented graduate course. Students will be introduced to various algorithms and software tools for simulating packet networks:
  - OPNET (OPNET Technologies),
  - ns-2 and ns-3 network simulators (Lawrence Berkeley Labs)
  - Ptolemy (UC Berkeley)
  - AutoClass (NASA)
  - S-PLUS (Insightful) tool for statistical analysis
- The course pre-requisites is successful completion of ENSC 427-3 or permission of the instructor.

Graduate Course: Communication Networks

Topics:

- Computer networks and the Internet
  - history and networking principles
  - network services and organization
  - network protocols (Ethernet, Internet, Token rings, FDDI)
  - circuit-switched networks
  - packet-switched networks (wired, wireless, Internet, ATM)
  - switching, scheduling, naming, and addressing, routing, error control, flow control.
- Introduction to simulation tools for evaluating network performance
  - OPNET: tutorial and case studies (GPRS, M-TCP)
  - ns-2: tutorial and case studies (mapping the Internet)

Graduate Course: Communication Networks

Topics:

- Application Layer
  - case study: Gnutella
- Transport Layer
  - case study: modeling TCP/RED
- Network Layer
  - case study: analysis of BGP
- Link Layer and Local Area Networks
- Analyzing Internet topology
- Wireless and Mobile Networks
  - case study: M-TCP, TCP+
- Traffic collection, characterization, and modeling

Graduate Course: Communication Networks

http://www.ensc.sfu.ca/~ljilja/ENSC835/Projects/ENSC835_Spring2013_projects.html

Sample projects:

- Performance of video conferencing over dual band WiFi network
- Comparison of OPNET simulations between PAN network and WiMAX
- Simulation of GPRS network
- Evaluation and improvement of BitTorrent implementation in ns-3
- Implementation of ITR and ETR devices in the ns-3 network simulator

Online resources

- The entire course material is available online.
- Course web pages contain links to homework assignments, laboratory exercises, and supplementary references.
- Topics to be covered in class are posted weekly
- Each course lecture is audio recorded and these recordings are made available shortly after each lecture to students enrolled in the course.
- Puzzles and games

Lessons learned: background

- School of Engineering Science at SFU offers a five-year undergraduate program in engineering.
- The program is highly ranked among the comprehensive Universities in Canada.
- However, many students are entering the engineering program without having necessary mathematical background and analytical skills to excel and enjoy the subjects taught.
- Changing undergraduate engineering curriculum to adopt new approaches to teaching circuits is a difficult task.
- The curriculum already contains a large number of required courses, which leaves little room for implementing desired changes such as, for example, offering separate laboratory courses as a follow-up to lecture-intensive courses.

Lessons learned: strategy

- Attracting students to take engineering courses and motivating them to complete these courses is an essential component of teaching the course.
- Very early in the trimester, simple examples of electronic components (diodes, nonlinear resistor, op-amps, and transistors) are used to illustrate modeling circuits and to emphasize that linear circuits are only an approximation of electric and electronic elements.
- Examples employing linear op-amps are then used to introduce various linear analysis methods.
- Early exposure to software tools such as MATLAB, PSPICE, and ns-2 provides a valuable complement to analysis. The analytical and simulation results are then confirmed by laboratory measurements.

Lessons learned: student feedback

- Feedback received from students indicates that majority of current undergraduate students find the circuits courses difficult and demanding.
- Past experiences with choosing a variety of textbooks showed that almost any of the textbooks would prove adequate. More important was the delivery of lectures, selection of topics covered, choice of assignments and examination questions, and quality of the laboratory equipment.
- Students overwhelmingly enjoyed having laboratory exercises and course projects, which they often complete by working in teams of two or three.
- Such laboratories, however, should be properly maintained and equipped.

Lessons learned: presentation styles and delivery

- Full circle: from blackboard to overhead projectors to PowerPoint sides and back to the whiteboard.

Communication tools:

- Web pages. online notes, electronic handouts, audio recordings of lectures, examples from industry, fun exercises and puzzles. And endless stream of email messages
- Presentation styles and delivery are often enhanced by good textbook supplements: master slides, tutorial problems, solution manuals.
- Ongoing demand for new tutorials, video-taped lectures, educational games, design kits, fun and motivational lectures, and online content.

Lessons learned: course instructors

- In many engineering departments, introductory courses are considered to be service courses.
- They are often taught by sessionals and instructors as a service to the department.
- These instructors are often unmotivated and can hardly generate students' enthusiasm.
- More senior faculty teaching service courses often have their research interests in areas not related to the courses they teach.
- Lack of industrial experience often deprives instructors from appreciating the importance of practical applications in science and engineering education.

Resources

- Stanford University: http://ctl.stanford.edu/
  Center for Teaching and Learning
  Effective Teaching, Effective Learning, Effective Speaking

- In its broadest terms, our purpose is to promote excellence in teaching at all ranks and excellence in student learning inside and outside the classroom.
- Our goal is to see teaching equally valued with research as a professional commitment of faculty and teaching assistants and to provide the training and resources to make excellent teaching possible.
- Effective teaching encompasses more than just the transmission of subject matter, however.

Resources

- Excellent teaching, first of all, gains the students' attention and convinces them of the importance of what is being taught and learned.
- It goes on to communicate not only information and concepts but to develop powers of analysis, synthesis, judgment, and evaluation, all in a context of considered values.
- When teaching has truly succeeded, students leave with an ability to learn, question, and commit on their own.
- Our goals for student learning are complementary—that students not settle for just learning the “stuff” or enough “stuff” for a decent grade.
- They should be training their minds and sensibilities for a lifetime responsibility of critical, independent thought and commitment to personal and community goals.
- They should have high expectations of their own efforts and of their teachers' efforts.
- They should see learning as extending far beyond the classroom to most of what they experience.

Resources

- University of California Berkeley

  Center for Teaching and Learning

  http://teaching.berkeley.edu/lecturing

  http://teaching.berkeley.edu/large-lecture-classes

- A Berkeley Compendium of Suggestions for Teaching with Excellence

  (first published in 1983)

  http://teaching.berkeley.edu/compendium/

  Barbara Gross Davis

  Lynn Wood

  Robert C. Wilson

Resources

- Carnegie Mellon University
  http://www.cmu.edu/teaching/designteach/

- How to Prepare to Teach a Course
  http://www.wikihow.com/Prepare-to-Teach-a-Course

In closing and looking forward

If we wish to generate interest among the incoming engineering students, we need to do a better job of promoting the profession by:

- providing betters teaching tools and delivery methods
- combining theory courses with laboratory exercise
- illustrating the applications in fields relevant to environment, biotechnology, and medicine
- recognizing and rewarding teaching, and
- doing a better job in sharing our enthusiasm for the engineering profession.