Eng 192 Course Notes

Instructor: Greg Pottie, pottie@ee.ucla.edu

Syllabus

This course is about the responsibilities and joys of teaching as an undergraduate mentor, with a focus on practical skills for engineering labs and office hours. The skills gained in assisting other students in technical matters will help you professionally because 1) facility in discussing technical topics differentiates students in job interviews and 2) in your role as a working engineer you will often be instructing other engineers in technical issues. If you are also playing a role in designing the projects to be used, the project management experience including all the logistics for enabling a class to succeed is prized by employers. However, the main reason to be a mentor is that is fun: helping other students brings rewards in and of itself.

The topics covered in the course are:

- The Basics
    - Why and how to be an awesome mentor, making students welcome, public speaking, lab section prep, one-on-one interactions
- Structure of Knowledge
    - How concepts flow into each other within and across courses; use of concept map for diagnosing and ameliorating student difficulties
- Fostering Student Learning
    - How students learn, how to encourage effective learning habits, barriers to learning + student support services.
- Inclusion and Decorum
    - How to be a role model for respectful and ethical behavior among diverse student populations; implicit bias
- Online Tools
    - Course management systems, forums, grading tools; managing expectations for online availability.
    - Remote labs and office hours
- Team Dynamics
    - Freeloading in group work and how to avoid it; detecting and reporting cheating
- Grading Technical Reports
    - Rubrics and style guides; how to grade quickly and fairly
    - FERPA
- Managing your Classroom & Emergency preparedness
    - Managing difficult students
    - Identifying and getting access to space
    - Classroom set-up (EH&S standards)
    - Safety (Standard Operating Procedures, SDS, etc)

    - What to do in case of emergencies
- Bonus topic: Organizing Design Competitions

Each unit will take the form of a brief lecture followed by an assignment. A second lecture will discuss possible solutions to the assignment.

Notes for Instructors

Many TA preparation courses focus a great deal on the mechanics, and I have included considerable content along these lines, especially focused on tips that can avert disaster. But I believe that the main thing that determines success is attitude towards teaching, since we will select only good students to begin with, and they will have technical competence on the whole. (Obviously, people skills can also be part of the interview process in selecting mentors for training.) A genuinely positive attitude will be rewarded by the class; they are much more forgiving of mistakes if they believe the instructor cares. Consequently, a fair bit of the discussion one way or another comes down to the value proposition of teaching in the context of engineering, and the attitude towards the students being taught.

Normally, instead of having a series of recorded lectures this course would be offered in-person. The exercises would be interactive with the class, with pretty well all the lists in the notes being generated with an active back and forth between the class and the professor. There would be reflections on them, etc. The exercises that are inserted in the lessons are a pale substitute for this. If multiple students are taking these units, I suggest assigning them to groups where they should generate these lists together. Then there could be a discussion of their reactions to the unit with the instructor, specifically to go over things where they disagree with my take on the matter, or where they want additional guidance in the context of the particular course they will be helping with. For example, on "safety" this could include going over the particular SOP and SDS associated with a lab, providing links to the campus online safety training, etc.

Besides the usage for training students to be assistants in classes, most of the content also applies to students who will be tutors for clubs or services such as MESA, or who will be leading the technical teaching functions many student design organizations have as part of their core competition activities.

I have left out a significant component of the mentor training that applies to certain design courses: how to develop lesson plans and develop the design the students will be engaged in. (At UCLA we offer certain freshmen design courses with a team of two student mentors responsible for supervising the projects, with a faculty instructor with overall responsibility.) In my opinion, this part of the training requires interaction with the instructor in charge, so that particular lesson plans can be evaluated and critiqued. Students also require practice teaching before the real thing, with positive feedback. In this case, the student team responsible for teaching should complete the entire project to be taught early on; otherwise it is essentially impossible to come up with the appropriate lessons to support it.

Course Content

The powerpoint slides fairly directly use the material below.

The Basics

What is the job of a learning assistant or mentor?
-Small group engagement
-Individual help
-Reinforce concepts
-Feedback to instructor on course pace

Things to make students comfortable:
-Introduction: your background, some fun detail
-Smiling and relaxing
-Compliments on questions
-Inviting questions
-Inviting speculation, suggestions
-No judgment
-Explicit encouragement of curiosity

Exercise: what qualities do you look for in a mentor? Make a list

Solution:
They mainly come down to being respectful and inviting, and showing competence in the subject. Otherwise students won't come to you to get the help they need. What follows are some tips on how to show your competence.

Speaking and writing:
-Preparation for any formal lesson: write it all down before the first time!
-Handwriting style: neat and large
-Speaking style: volume, breathing, focus
-Question repetition to be sure heard it right
-Creating handouts & powerpoint slides

Lab Prep
-The Prime Directive: do the lab before the students!
-Ask yourself what might be confusing for them: what was hard the first time for you? What steps in the lab manual are open to interpretation? What are the common mistakes?
-Study all the details, including logistics of set up, availability of replacement parts, etc.

-What are potential hazards involved in your activity. What can be done to reduce hazards to prevent accidents?

One on One:
-OK to answer questions with a leading question or give a hint: better to lead to answer instead of just giving it
-Have they brought their textbook or other course materials? Often books aren't needed to get through high school; definitely needed in college
-How do they study (more on this later)?
-Probe for mastery of pre-requisite concepts—often the reason for trouble

Structure of Knowledge

Engineering curricula: hodge-podge of facts, or connected whole?
-Clearly sequential: concepts build on each other within and across courses.
-Example: why do we teach basic calculus before college physics? Answer: because the equations of motion describe the physical laws and these come from calculus; calculus was invented by Newton to describe the motions of the heavens.
-Much of the rest of the curriculum goes in a similar fashion: mathematical basics, simplified physical models, eventually more complicated math and models
-This can be described as a directed graph.

Why are concept graphs important?
-This is how professors build courses: look at what students are supposed to know already, then build progression of concepts that leads to understanding the most complicated concepts in the course
-This is also how entire engineering curricula are constructed: every engineering program follows a graph of prerequisites from one course to another
-But this is all kept secret from the students: students typically only make this explicit in producing their own study notes
-Once created, a very powerful study tool: illuminates the concepts behind the problems and connections to what you have already learned (or perhaps forgotten); a graphical representation helps you to remember it—part of you forming your own view of what the subject really is

Example: graph of knowledge required for Newtonian mechanics

Differentiation and integration→relations among acceleration, velocity, and position (1)
Vector concept→resolution of force vector for set of forces acting on object (2)
F=ma (3)
(1)+(2)+(3)→computation of acceleration, velocity and position over time (5)
Gravitational force equation (4)
(4)+(5)→ Newtonian mechanics for motions of the heavens.

Note that while (1) and (2) are mathematical abstractions, the equations (3) and (4) had to be derived from empirical observations. The combination with calculus then makes the equations useful for examining hypothetical situations (e.g., the moon landing).

Exercise: What concepts are necessary for understanding definition of differentiation?

Solution:
Concept of function (1)
Difference equation (2)
Concept of slope of a line (3)
Concept of tangent (4)
Concept of limit (5)
All of these are needed to formally define and illustrate differentiation.
Note that we can begin with either the forward difference or central difference equation; the latter is actually much superior if we are computing derivatives numerically.
Computation of derivatives obviously requires quite a few more concepts, with the most useful being Taylor series, since a polynomial expansion is the way many derivatives are actually evaluated numerically.

Relevance to one-one interactions
-the main reason for students struggling in a course is imperfect grasp of pre-requisite concepts—either from that course or previous ones
-problems can be broken down into the concepts that are needed for solving them, with two implications:
1) Practice in breaking problems down this way will assist students in solutions
2) Conversation can get to the concepts causing a particular student to have difficulty, leading to a solution: review of those concepts
-tasking students with creation of concept maps can improve how they study for major tests; this causes them to analyze what is behind problems, and makes the concepts easier to remember because rather than being isolated facts, they are connected.

Fostering Student Learning

How do students learn?
Main mechanism is recall: using concepts in a variety of contexts over a period of time. Contexts include
-listening in lecture
-writing notes
-re-writing notes
-creation of concept map/cheat sheet
-textbook
-problems: in class, homework, extra ones with answers in back of book

-study group: teaching other students
-office hours
-tutoring (e.g. by student honor societies)
-studying: continuous vs. cramming; retain twice as much with the former

Barriers to Student Learning
Big Ones:
-Family and personal issues
-Financial issues
-Health issues (mental/physical)
Students may confide problems: become familiar with the many services most universities have available for counseling, medical assistance, and financial aid. Students consumed with these problems will not be able to concentrate sufficiently on their studies
Common Ones:
-Weak preparation in prerequisites: be explicit about what is required and suggest resources (especially near beginning of course)
-Motivation: half-hearted engagement doesn't make it in college; actually is often due to feeling of inadequacy due to weak preparation, or not understanding how the material fits into the discipline
-Anxiety: could be first time not getting an A (a growing problem); level setting, personal anecdotes can help, but counseling may be needed in extreme cases

Exercise: what habits can improve the efficiency of the learning process in college? Hint: "Studying Engineering" by R. Landis has the answers.

Solution:
-Concentrated effort: multi-tasking is an illusion the brain creates for the higher cognitive levels
-Practice: time is needed; must schedule classes, individual study, group study ahead of other activities
-Planning: step by step, concept by concept, course by course with enough time set aside to integrate them into coherent view
-Extracurricular reinforcement: student design organizations, technical internships research; they motivate, provide a network, and teach additional skills

Inclusion and Decorum

Overriding Principle: R-E-S-P-E-C-T
-Start from the premise that all students should have equal opportunity to experience and gain from your course.
-Politeness
-Addressing people as they wish to be addressed (names are best!)

-Patience: no cursing, even when the computer deserves it; to quote Kipling, inanimate objects are perverse (they don't do what we want, only what we make them do).
-Setting example of professional behavior
The Climate Rule: don't tell jokes, share racy images etc. in situations where someone around you might be offended
Simple test: would you exhibit that behavior in front of your mother/most proper relative/stern authority figure? If not, don't do it in a work situation.
Harassment: behave professionally in a work setting. Don't date your students; wait until the class is over before flirting. Strongly advised to take the harassment training available at your institution; it is a life skill that will keep you out of trouble.

Value Proposition: practicing leading a team
-Team will have varied skills, personalities, identities
-Bias, harassment or perception of unfairness is fatal to team effort, and may lead to sanctions that damage your life/career.

Exercise: What are some of the components of individual identity?

Solution
Identity Components
-Gender (expression)
-Age
-Ethnicity
-Socio-economic status
-Sexual orientations
-Academic or business hierarchy
-Hobbies
-Family history
-Religion
-Relation to addictions
-Political belief
-Medical conditions
-Profession
-Home town/state/country
Etc.
The relative importance of these to identity shifts over time, and thus cannot make assumptions about what is important to other people.
The major commonality for your course is that they are fellow students who need to learn the material in order to become engineers; stressing that identity helps to create community.

Implicit Bias
-Everyone has it, online tests can demonstrate it
-Product of our own innate desire to belong to particular groups; along the way form positive/negative associations of our/other groups

-Most operate subconsciously
-Unless aware of them, may act in ways that discourage student participation
-Best way to overcome them in a small group is to interact with people as individuals
-Example of your fair interaction provides model to students for how professionals act
-The only scientifically confirmed bias is against (insert rival university or sports team of your choice).

Online Tools

A webpage is necessary for your course. With instructors, mentors, and students needing to have regular access to course materials and communication we highly encourage you to integrate them into your campus' course management system.

What types of software functionality are used to ease management of a regular course?
-Course management systems: Canvas, CCLE, Moodle. These provide multiple features (e.g., linkage to grades, homework submission, testing, announcements, forums, posting of syllabus, posting of homework, posting of videos, etc.)
-The formal management system may be deficient compared to other products
-Gradescope: many nice features for dealing with grading homework and tests
-Piazza: notification feature and threads can be better than native forums in management system
-Discord servers: enable students to directly work with each other, not mediated by instructors

Forums are your friend: students often have the same question. If asked during in-person office hours or by email, post the question and answer to forum

Online hazards
Online responses generate more online inquiries; you aren't paid to be available 24/7.
--must set expectations about times you will respond to inquiries. E.g., other students can respond to forum posts; check at your regular time to see if they are correct, or if there are unanswered posts
--instructor can incentivize student responses by "class participation" score (convenient feature for this can be set in most forum tools).

Remote labs and office hours
The most useful features of Zoom to support these functions are screen sharing, breakout rooms, chat, and participants
Screen sharing
--makes it possible to look directly at software or documents on the student's screen
--can look at their whiteboard (which might be something like Goodnotes or other apps, as opposed to the Zoom whiteboard which is limited in its tools)

--could be a phone mounted above a desk, to enable sharing of writing on paper or showing assembly of a circuit or other design
Breakout rooms
--can pre-assign students (e.g., lab groups)
--allows focused discussion on individual problems
Chat
--enables posting of links to materials under discussion, responses to entire class
Participants window
--displays students with hands raised to get attention to problems

Exercise: what is harder about remote interactions as compared to being there in person? What are some workarounds?

Solution:
Problems
--harder to debug hardware, since views are limited and you cannot physically manipulate it; the same problem applies to team members
--logistics can be difficult; can't just replace a part from stock in lab
Workarounds
--allocate more time to debugging: flipped mode, where students first attempt to the do the lab (including messaging each other for help), then formal lab time devoted to debugging only
--order materials far in advance of course, including plenty of spare parts
--problems are of the same type as would be seen in-person; if you have done the lab yourself before the students you are likely to have encountered many of the same problems
--video recording of the procedure step by step can be useful reference both for doing the lab and writing up the report

Team Dynamics

What is the educational value of group work?
--professional preparation: much engineering is done as a team
--team members helping each other learn the material better
--diverse skills and points of view can enable more ambitious and original design projects

What are the downsides?
--Freeloading: one group member does bare minimum, relying on the rest of the group
--Cheating: copying homework solutions without contributing to the process, and claiming work as their own

What accounts for the negative behaviors?
--laziness is commonly cited, but is often not the true reason
--shyness: having difficulty expressing point of view with others

--overbearing personality: steamrolls others, and they let the “leader” do oversized share
--lack of confidence: may be lacking some pre-requisite skill, or be anxious about trying something new

Exercise: what measures can be taken to reduce freeloading within groups?

Solution
--Progress reports - have each member explain to you what they are doing and why, every week. This puts them on notice that they’ll be held accountable, and also gives an opportunity to help people who are struggling
--in projects, require individual written reports (one page) with plans for previous week, what was accomplished, what are new plans, and then have them explain it directly to you. Benefits are similar to the first point, and also communicates need for regular progress, rather than leaving it all to the end.
--instructor has announced that there will not necessarily be the same grade for everyone in a group
--have project group draw up formal plan for design responsibilities of each team member; this is reflected in group presentations, where team members present their own part

Grading Technical Reports

What are the required components of any technical report?
These can vary somewhat in how they are labeled and the order they appear, but the following is fairly standard for a technical paper.
-Abstract: main idea and results
-Review of state of the art: theory, common experimental methods
-Approach: methods, theory used
-Results: theorems proved, simulation results, experimental results, with sufficient commentary or references to make it reproducible
-Discussion: sometimes integrated with results, compares the results to theory or to prior approaches in the technical literature to show their significance
-Conclusion: brief recapitulation of main results, often with suggestions on how procedures might be improved or other possibilities for future work
-References: to material used in preparing the report; must be complete, with a style that varies by discipline

A summary of the style is: say what will be shown, show it, say what was shown.

How should figures and other graphics be integrated into a report?
-Figures must be labeled with descriptive title
-All text must be large enough to be read
-Curves plotted must be easily distinguishable from each other
-The main text should reference the figure and comment on its significance—otherwise what was its point?

-The figure should illustrate something that is difficult to convey in either prose or a table: it should advance the story you are trying to tell

How is a technical report similar to a history essay?
-In both cases, one is trying to tell a story using logical arguments based on facts. For history, one begins with historical facts, and then builds on these to argue for a story that explains them. In a technical report, the facts are established theory and the data, and the arguments are a combination of mathematical reasoning and logical reasoning that explains what was observed.
-The story can be false if either the premises (facts) are wrong or the arguments make use of logical fallacies (including math derivation errors).
-The story can be irrelevant to most human purposes even if absolutely true: it might apply to a unique historical situation unlikely to be repeated, consider conditions very unlikely to exist together in practice (called a set of measure zero), or simply repeat an old conclusion with minimal variation. These are the main ways in which scientific papers fail to generate impact.
-A report can be influential if it is novel, true, relevant and presents a compelling narrative that attests to these qualities.

Exercise: given the variety of ways arguments can be expressed, how can one grade reports both quickly and fairly?

Solution:
The way to fairly grade is with a rubric provided by the instructor. Review it with the instructor before starting to grade to be sure you have interpreted it properly. It should include:
--number of points per section of the report; this can be highly prescriptive for data obtained in a standard lab
--list of alternative valid premises, with points associated with each up to some maximum
--list of alternative valid conclusions to draw from premises, with points associated with each up to some maximum
--points for format: referencing figures, neatness of figures, appropriate use of references; a style guide should have been provided to students before the report is due (typically, in the lab manual, or on the class website).
--points for grammar: deductions for grammatical mistakes up to some maximum

The way to grade quickly is to give the benefit of the doubt to the student
--agonizing over whether something is exactly right is a waste of time; the difference in the grade is negligible.
--this strategy also minimizes appeals, saving the instructor time (NOTE: a student reader is NEVER responsible for hearing appeals, since the instructor is responsible for grades, having determined the rubric).

Some common style issues in technical writing
-Missing articles (the, a, an)

-Muddled singular and plural usage within a sentence
-Sentence fragments (require a subject, action, object in most technical prose)
-Missing labels in figures
-Missing discussion of figures within main text
-Muddled voice (1st or 3rd person should be used throughout; never 2nd person)
-Incoherent story: the whole should have the structure of a logical argument, with consistency between conclusions and the evidence presented.
-Insufficient references
-Flat recitation of facts: it is a story being told to other humans, not a data table. Some effort should be expended on engaging the reader on the main points of interest (e.g., occasional use of question/answer format, use of hypotheticals, speculation where the data does not yield definite conclusions, etc.)
-Plagiarism: flat prose gives way to something florid; a tell-tale indication that a section has been copied from somewhere else (on-line, the textbook). If the whole thing is top rate but the students were clueless in the lab, possibly they paid someone else to write it. In either case, report it to the instructor. It is not your job to interrogate the students.

FERPA
-These are federal regulations on confidentiality of grades. You cannot share student grades with any parties beside the student or student group assigned the grade, or other instructors in the course. Strictly speaking, if the grade is visible on top, the graded object should be returned directly to the student (as opposed to being in a pile they paw through).
-Instructors love these regulations: no information can be given to parents, thus avoiding interference on grading policy.
-Remember: refer all disputes or inquiries concerning grades to the instructor

Managing your Classroom & Emergency Preparedness

- Common situations with difficult students in the classroom
    - Providing direction to students on what they should be doing.
    - The quiet student who doesn't engage.
    - The alpha-type student
    - What to do when students start to argue
- Identifying and getting access to space
    - Every campus will have a different procedure and guidelines to access space for your activities. These guidelines can impact and shape your classroom plans.
- Classroom set-up (EH&S standards)
    - Review your campus EH&S standards on space safety particularly if you plan to re-configure a space.
    - Think about a classroom space that will be conducive to your activities. If the table students are sitting at are small, you may need to identify a place for them to leave their backpacks. It isn't

reasonable for your students to listen to a lecture while sitting at a lab table that is housing the computer projector.
    - Think like a parent – look around your classroom space for potential hazards (cords in the middle of walk-ways), good access, etc.
- Expectations aka Classroom Rules
    - What will be the rules of the classroom? Will you allow food or drink? What clean-up activities do you want help with? How do students submit work? Are there items they need to ask before using/touching? It's easier to set expectations at the start and maintain them rather than implement midway through the program.

- Safety for tools, equipment, and chemicals (Standard Operating Procedures, SDS, etc)
    - Anything that can cause harm should be reviewed to identify hazards and think about ways to reduce the hazards.
    - Standard Operating Procedure (SOP) (instructions for use) should be created for anything that could potentially cause an accident.
    - Safety Data Sheets (SDS) should be reviewed for any chemical beyond what you might find in your kitchen. You will want to know proper storage, handling (and inappropriate mixing of chemicals), and disposal of chemicals.
    - All SOPs and SDSs should be reviewed and approved by a faculty member.

- Exercise: What to do in case of emergencies
    - What is your responsibility to your students during the following situations?
        - Fire
        - Earthquake
        - Evacuation
        - Active Shooter

BONUS TOPIC: **Organizing a Design Competition**

Nothing motivates a classroom more than a friendly competition. This can be implemented throughout the course or as a culminating activity related to a final project.

Competition criteria
- Identifying the challenge: What will the students need to create/ build and what will it need to do?
- How will it be judged: prototype performance, design review, etc.
- Explicit instructions for the day of the competition and judging.

Teams

Creating excitement

- Set the stage. Create your arena, play-field, judging table, etc. Implement fun features such as score cards, referee jerseys and whistles for officiators, etc.
- Team names help identify groups, increases the excitement around the competition, allows spectators to cheer for their team, and will add to the memory of the experience.
- Opening statement that explains the challenge a quick overview of what students experienced during the design-build-test phase, and a feeling of accomplishment of getting to the competition.
- Judges – having a judge who has not worked with students through the course/program adds a bit of unbiased grading to the judging. Additionally, students are less likely to try to negotiate with a visiting judge. Bringing in a higher-profile judges make the competition exciting.
- Inviting the outside community (optional) – this will bring excitement for the students and visibility to your activity. However, having additional people present means that you will have to manage their participation in addition to your students.

Competition rubric

The goal of this rubric differs from grading rubrics in the sense that your goal is to identify a clear winner for your competition. It is detrimental that your rubric has the ability to identify a 1st, and/ or 2nd and 3rd, place winner.

Exercise: what are some of the possible issues in judging the results of the design competition? What relation do these have to issues in grading?

Solution:

Some of the common issues are:

- Task cannot be accomplished. Let's say, for example, you decide that a team is able to score points for the number of goals their robot is able to make. At the end of the competition, no team has made a goal. Who wins?
- Varied interpretation of a rubric**.**
    - One score for multiple variables. How do we score this?
    - Creativity. Do you mean in technical design, aesthetic, or both?
- Value of points. Things to consider**:**
    - Binary items. There could be a number of items that each group either has or does not have.
    - Despite your attempts at creating equal teams, there could be a group of teams that have an advantage over the other teams. Make sure your rubric doesn't amplify the stronger groups' advantage. The rubric is your last ditch effort to equalize the challenge. In particular, you should be having most of the points go to things that were explicitly taught in the class.
- Judges are not consistent in their grading. You will need to spend some time normalizing the judges and making sure they interpret the rubric correctly.

Connection to grading:

- A key requirement for success is that the awards process be perceived as being “fair.” The greater the clarity of the rules, the easier it is to grade or judge, and the more likely that students will accept the outcomes with good grace.
- This can involve some negotiation in progress; a set of “clarifications” based on student input are usually needed in advance of the competition day. Be sure that these are communicated to everyone.

Competition Day

Like any lesson, you will need to know all details of the activity, prepare the artifacts and resources (wifi, software, Zoom session break-out rooms, etc.) you will need for the activity, and instruct others on what they need to do. Prepare an agenda that includes: a) set-up, b) instructions to judges, c) instructions to others who will help you to run the activity, d) instructions for students, e) all your talking points (plans to introduce the activity, judges, and announce the winners).

Do a physical run through to make sure you have enough space to accommodate the activity, judging, and what can be done to speed up the process of the competition. The goal is to reduce the set-up/break-down of each team. Doing a run through also means you can focus on creating excitement on the day of your activity rather than trying to figure out what to do.