MICHIGAN ENGINEERING
UNIVERSITY of MICHIGAN

Using Learning Analytics to Coach Students to "Electrifying" Careers in Engineering

Exploring Learning Analytics Project

Justin Foley, Shanna Daly, Catie Lenaway, and Jamie Phillips

What is Engineering?

- What is Engineering?
- What is Electrical Engineering?
- Take a minute and visualize what engineers do, and specifically electrical engineers

Engineer?

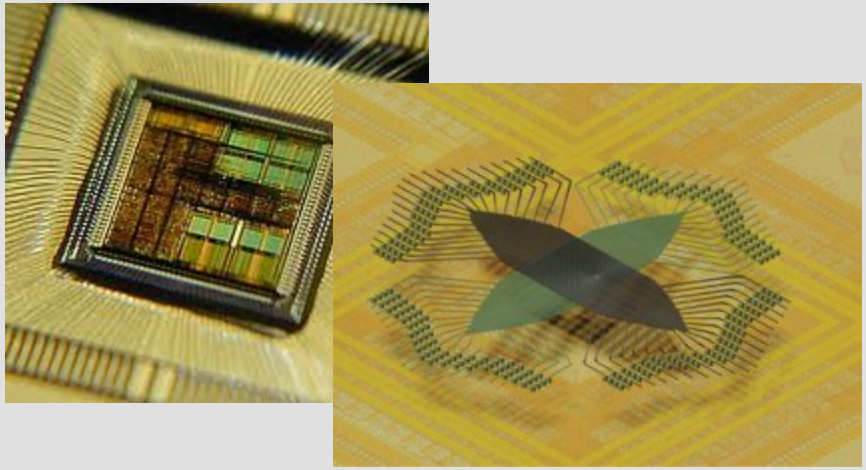
Electrical Engineer?

- Many students only picture this guy
- Don’t know what EE is, even after declaring!

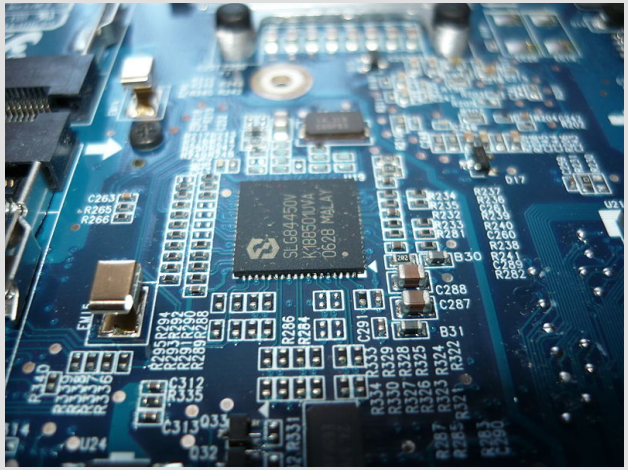
MICHIGAN ENGINEERING
UNIVERSITY of MICHIGAN

Areas in Electrical Engineering

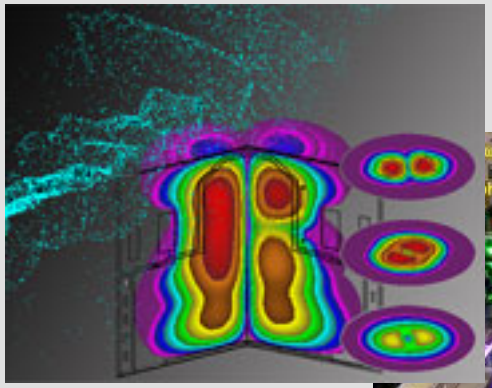
Circuits and Solid State Electronics

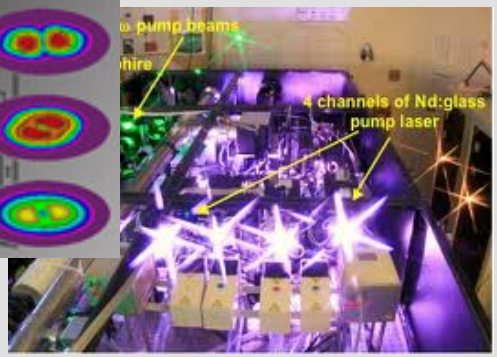


Computers

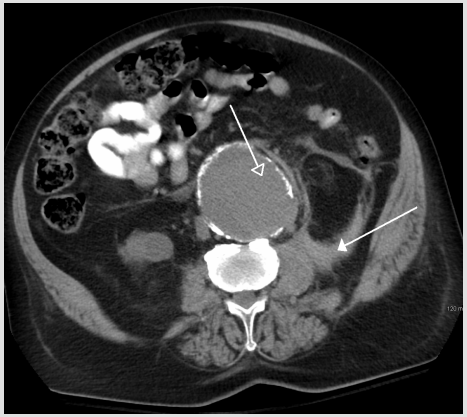


Electromagnetics and Optics





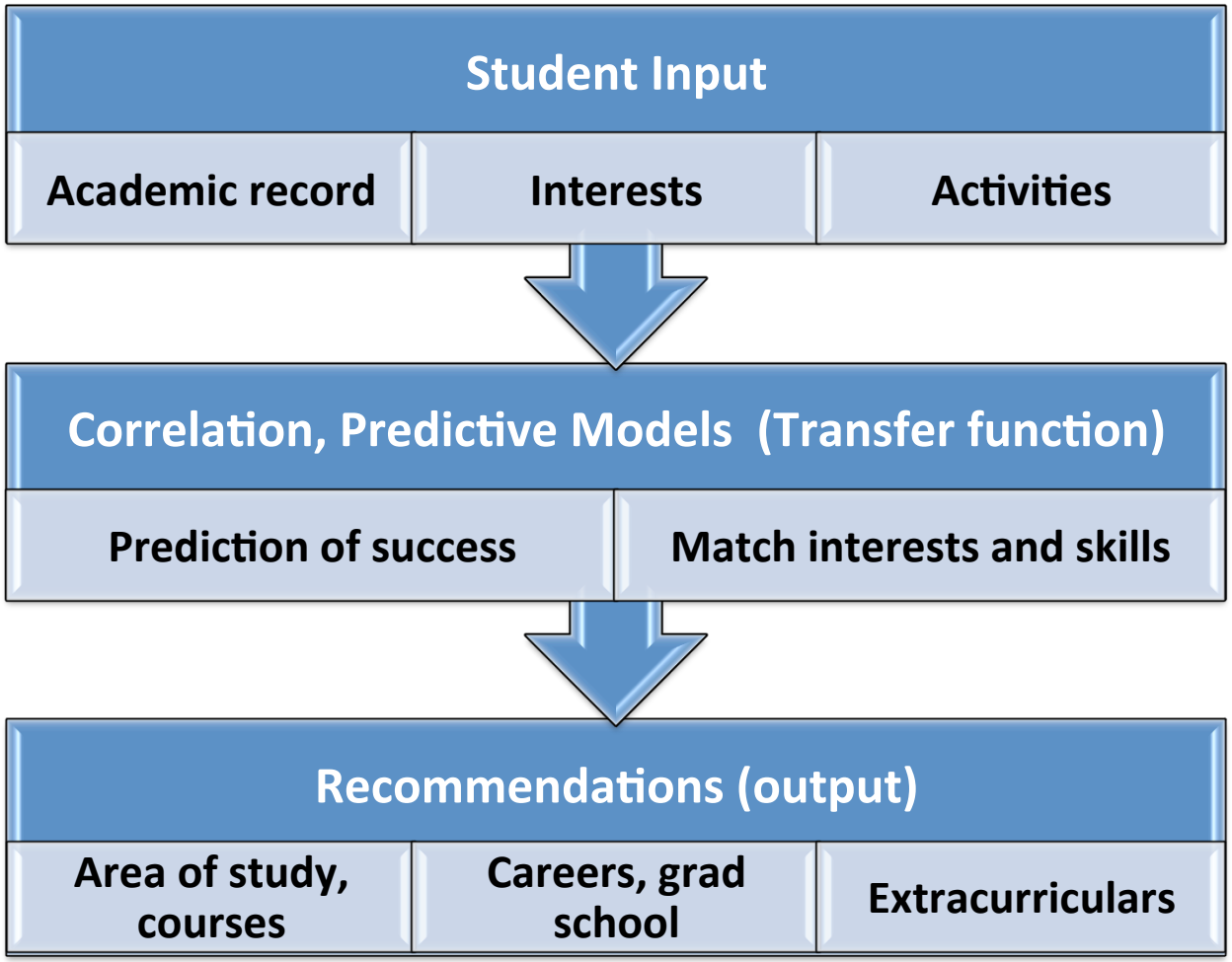
Control, Signals and Systems



How Do We Recruit/Advise/Mentor?

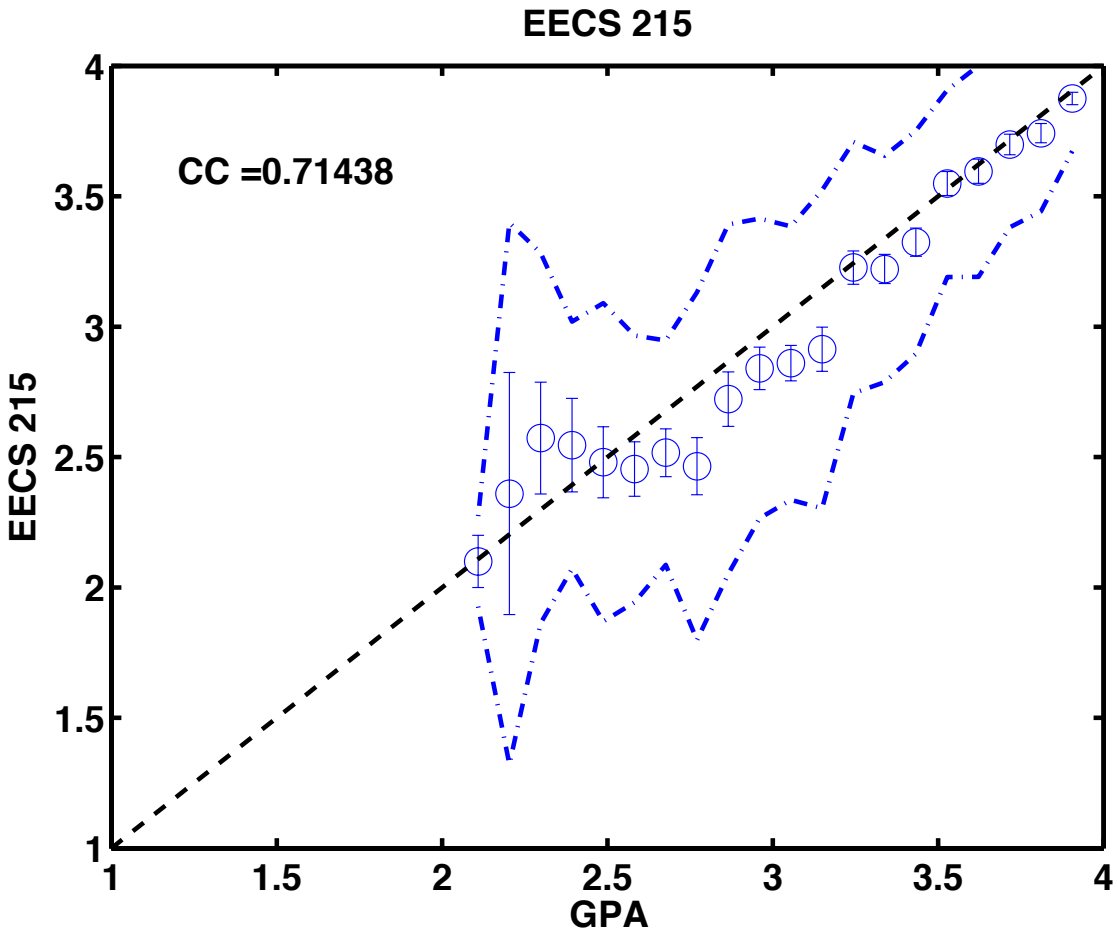
- How/who should we recruit to EE?
- What are common traits of successful EEs?
- How can we best advise our students?
- What can we learn from our students and alumni?
- Data and analytics should help!
  - Student academic records, past 10 years
  - Focus groups with current students
  - Surveys of students, alumni
  - Scrape data on alumni from Linked In

Model For Recommendations



Analytics on Graduates (past 10 yrs)

- Start with graduating GPA as metric for success
- Examine correlations with course performance, gender, subdiscipline in EE



Data points: mean

Error bars: standard error (σ/√n)

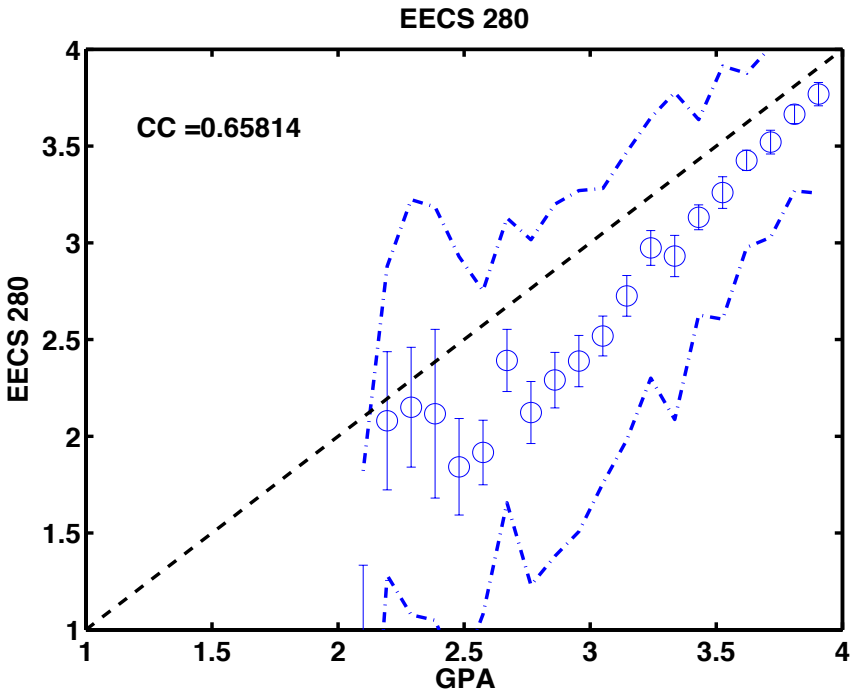
Dashed lines: standard deviation

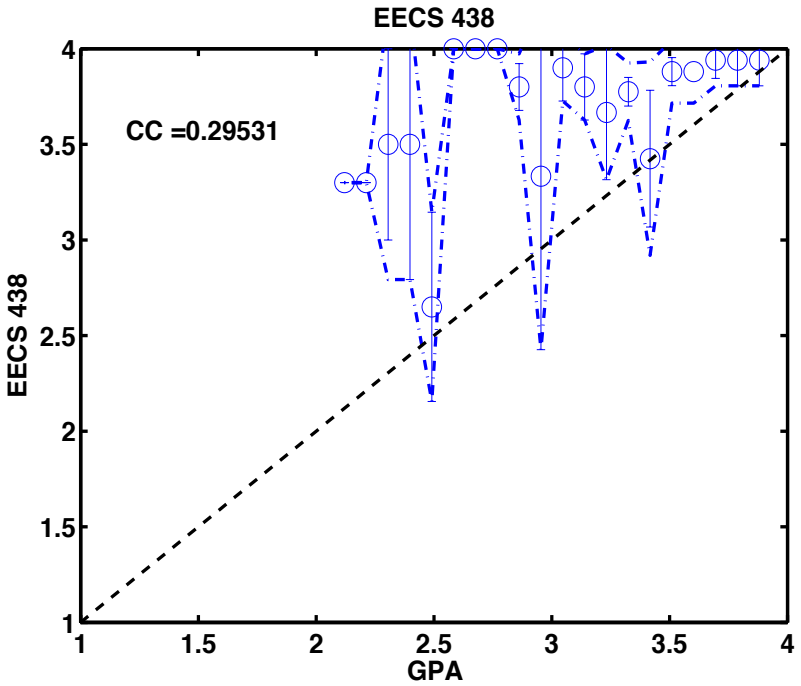
CC: correlation coefficient

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

Some Examples of "Grade Penalty"

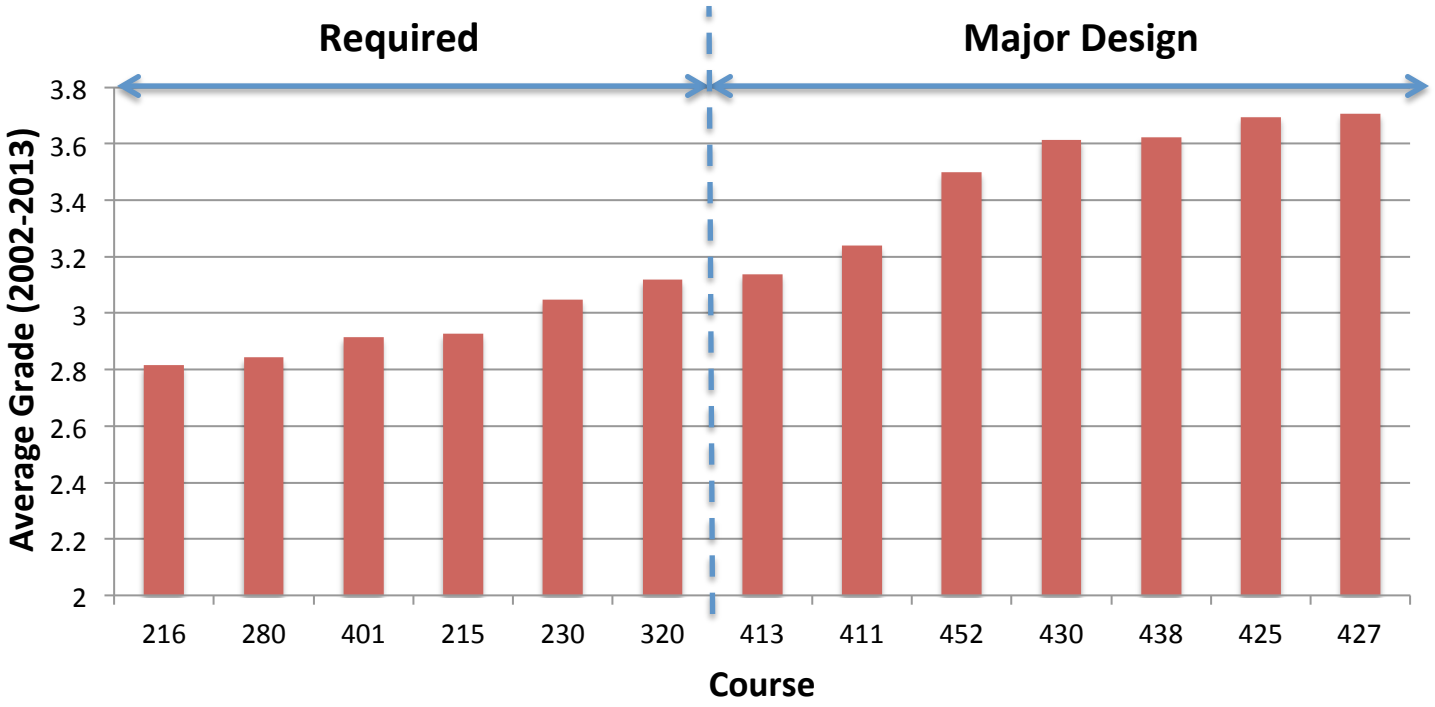
- EECS 280 (programming): grade penalty (grade-GPA < 1:1 line)
- Major Design: higher grades across the board
- No obvious differences among gender
- What is statistically significant?



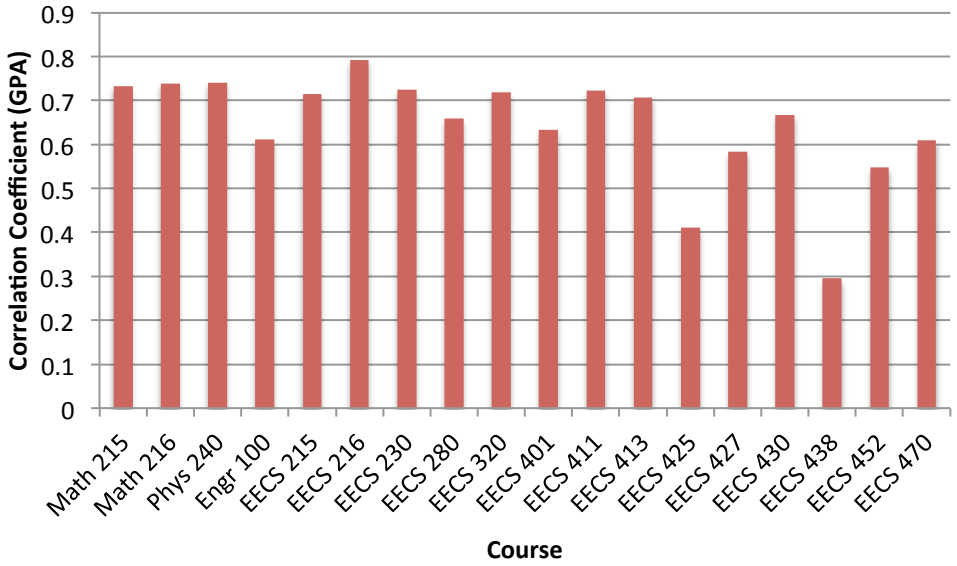


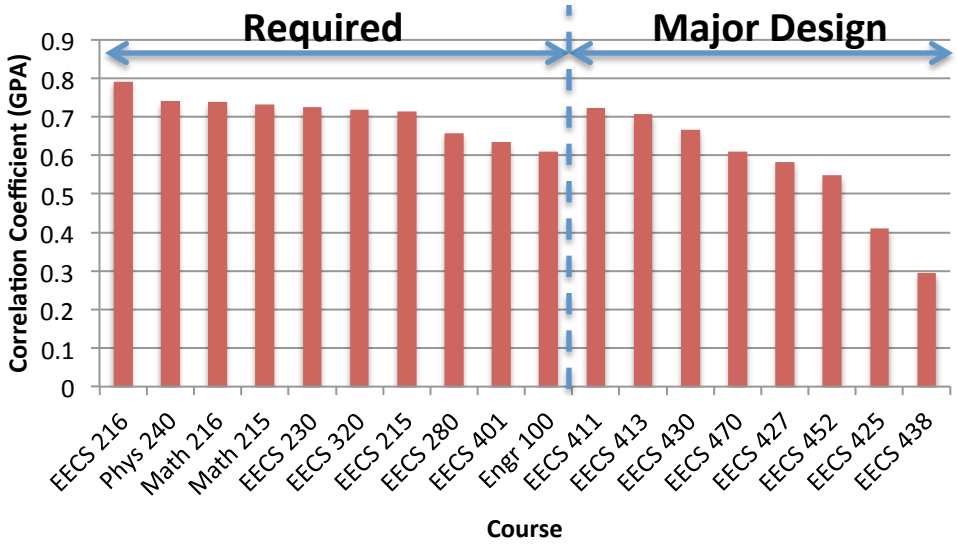
Some Examples of "Grade Penalty"

- EECS 280 (programming): grade penalty (grade-GPA < 1:1 line)
- Major Design: higher grades across the board
- No obvious differences among gender
- What is statistically significant?



Comparison of Correlation

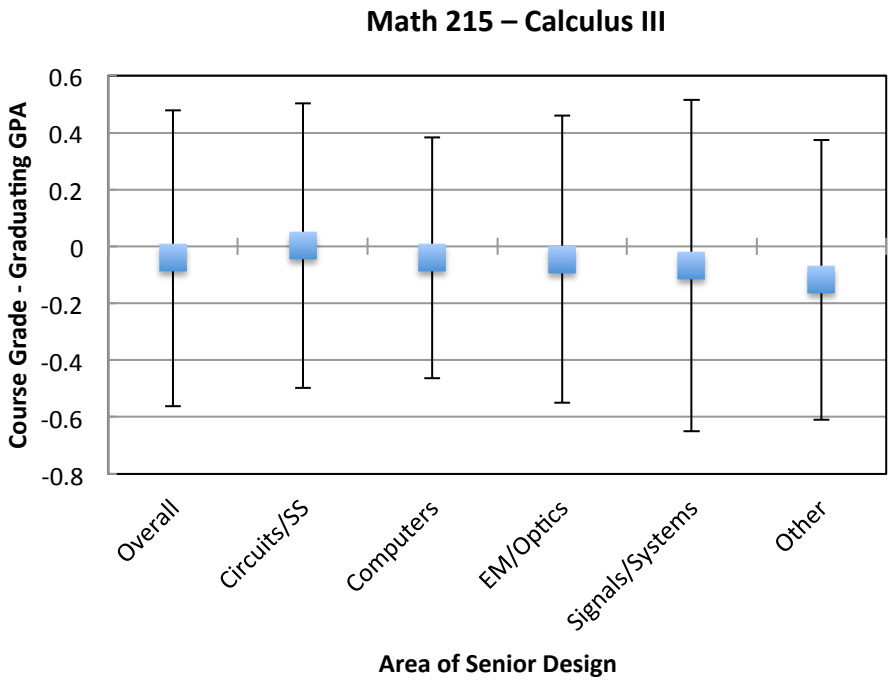


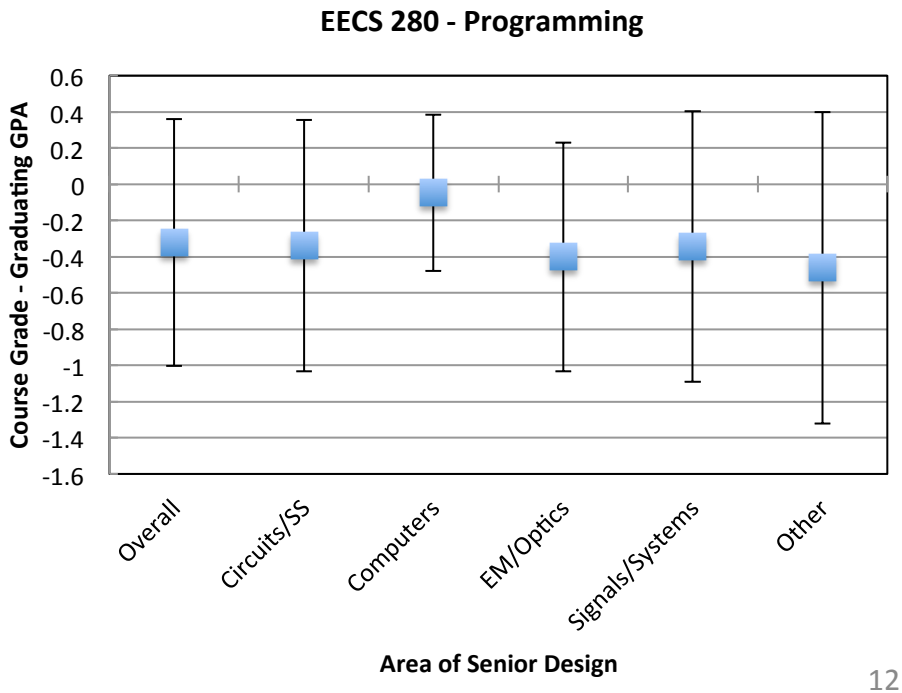


- Early required courses have strong correlation
- Weaker correlations for major design (typically high grades for all students)
- Weaker correlations for EECS 280 and 401 (turn out to have grade penalty!)

Relative Performance in Courses

- Compare performance in course relative to graduating GPA (Grade – GPA)
- Does a student generally perform better or worse in particular courses?
- Are there correlations with choice of major design?





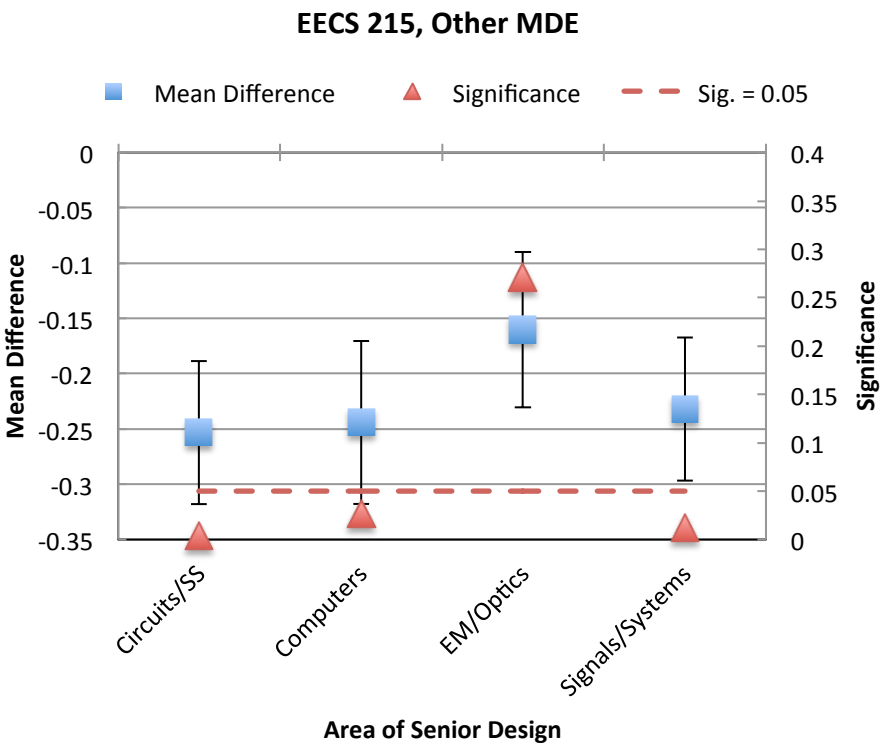
Analyzing Differences Between Groups

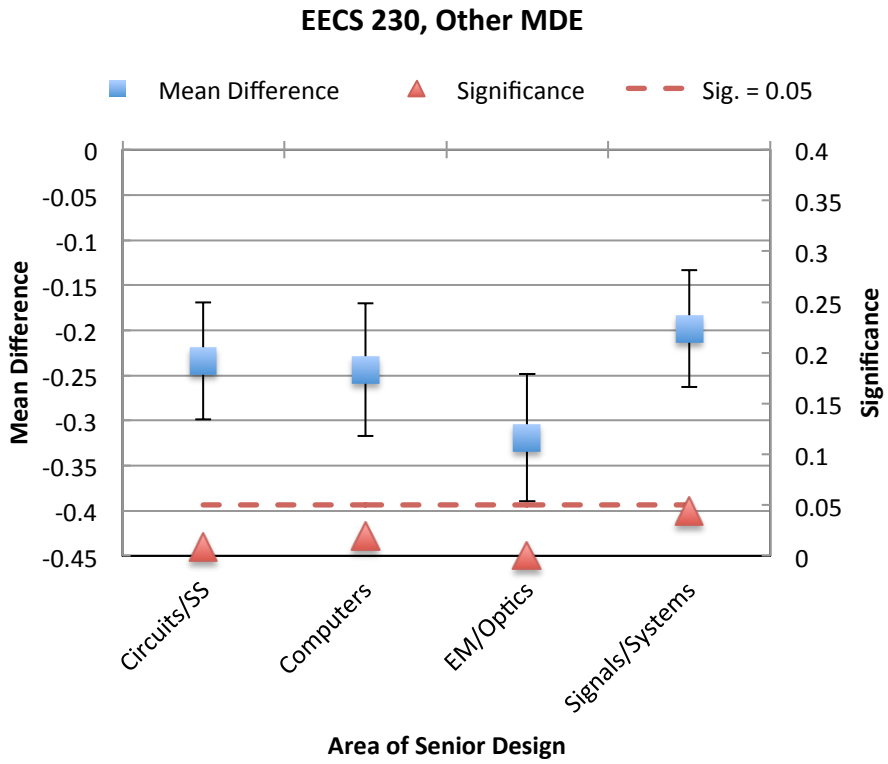
- Use analysis of variance (ANOVA) to determine statistical significance
- Scheffe post-hoc analysis
- Cases where significance (p-value) < 0.05
  - EECS 215: Other MDE vs EECS MDE
  - EECS 216: Signals/systems vs EM/optics
  - EECS 230: Other MDE vs EECS MDE
  - EECS 280: Computers vs EM/optics, Circuits/SS
  - EECS 320: Circuits/SS vs all

(MDE = Major Design Experience)

MDE's Outside EECS

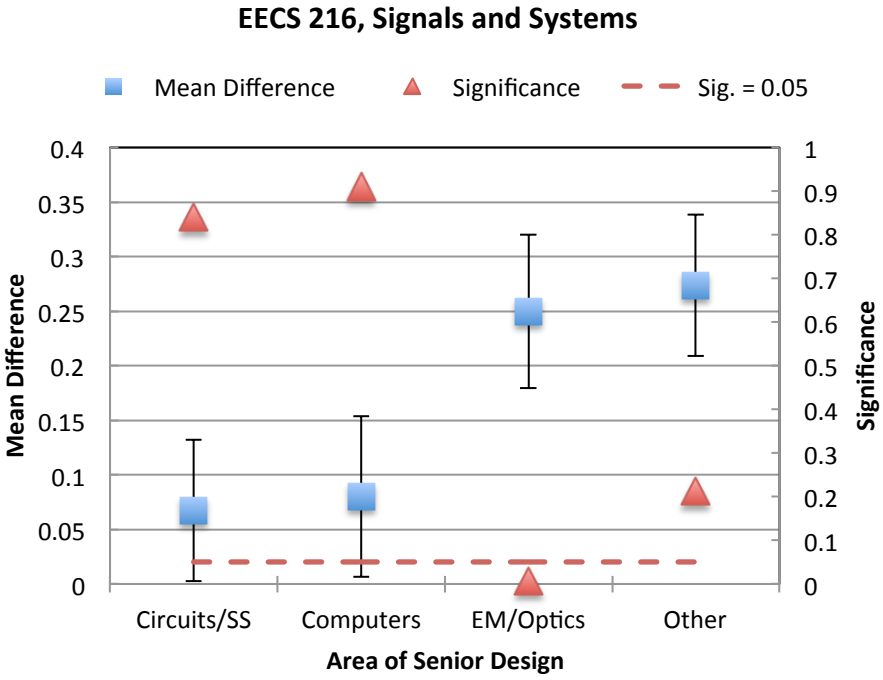
- Lower relative performance in EECS 215 (circuits) and 230 (electromagnetics)
- Exception: Comparison to EM/Optics in EECS 215
- ***Students choosing MDE outside EECS did worse in required courses (215 and 230) than other students***

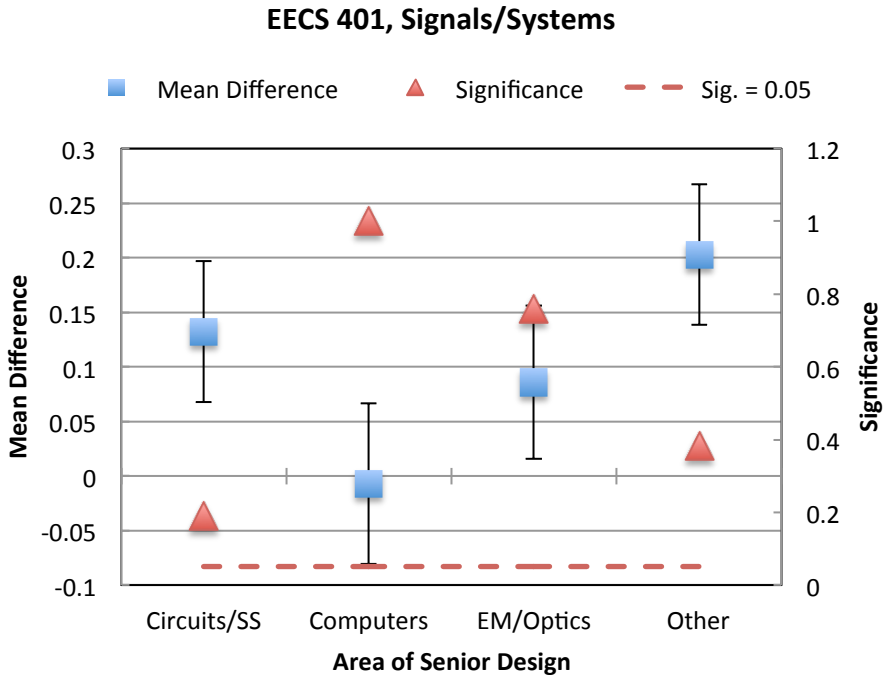




Signals/Systems MDE

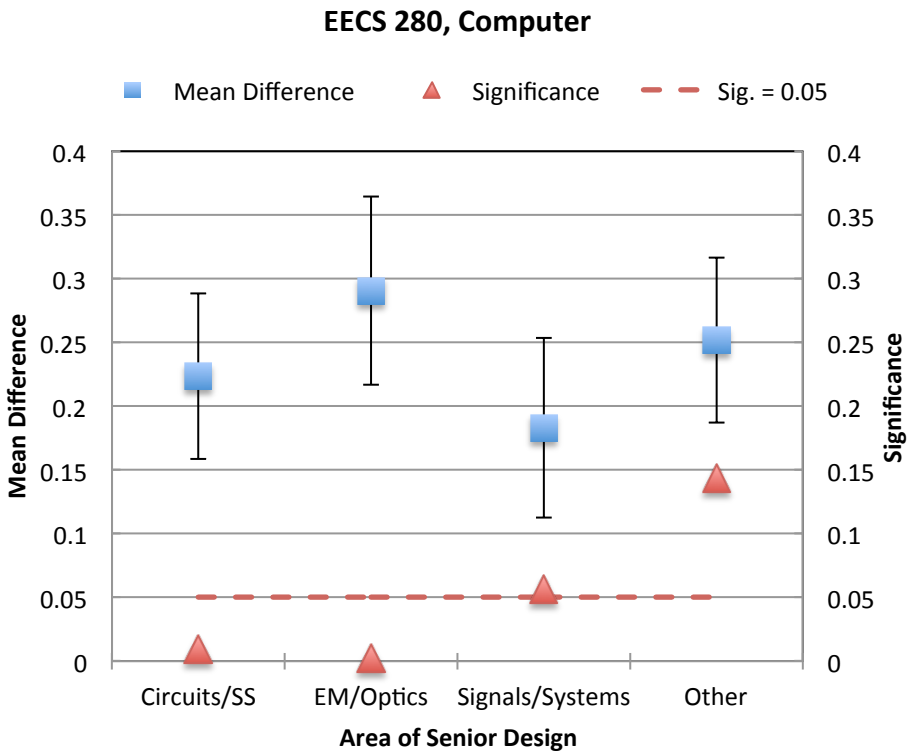
- Signals/Systems "math heavy", did they do better in required signals/systems courses?
- Not necessarily! (high significance not observed)



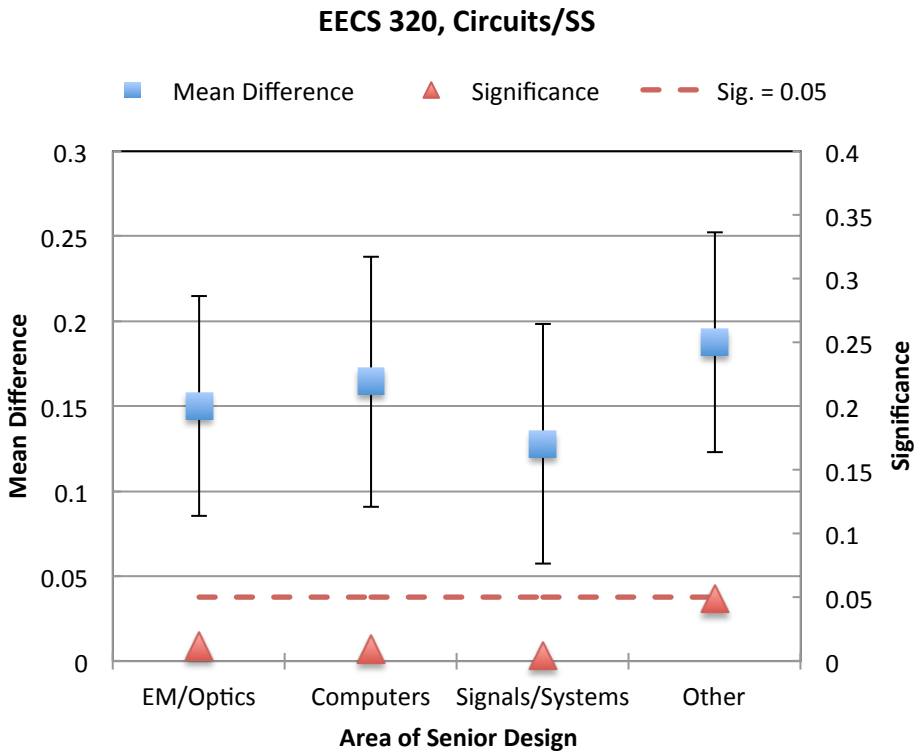


Computers, Circuits/SS MDEs

Students choosing Computers MDE generally received higher grades in computer programming (EECS 280)



Students choosing circuits/solid state generally received higher grades in semiconductor devices (EECS 320)



Subdiscipline Analysis

- Some required courses serve as predictors for choice of subdiscipline
  - EECS 280: computers
  - EECS 320: solid state and circuits
  - EECS 215 and 230: all ECE
- Some do not!
  - EECS 216 and 401: signals and systems
- Need data beyond grades

How are Major and Subfield Chosen?

- Get information from surveys
- First gather key feedback through focus groups
  - Undeclared EE
  - Recent declares (EECS 215, 216 students)
  - Juniors
  - Seniors in MDE courses
- Designing a good survey is important!

Focus Groups

Determine how students make academic decisions

- Freshmen, sophomores, juniors, seniors
- Role of a good instructor cannot be overemphasized
  - A single professor can affect the course trajectory of students
- Job prospects dictate decisions
  - EE careers perceived to require graduate school
  - Computer Science positions are in large demand for B.S graduates

Use this information to help tailor surveys to improve program development

Survey Design

- Surveys must be:
  - Valid: are we measuring what we think we are measuring?
  - Reliable: do we obtain the same results over time?
- Exit survey includes:
  - Demographics, choice of major, quality of program, extracurricular activities, post-graduation plans
  - Quality of instruction and influences
- Rolling out to 2014 graduates (fill out for senior audit!)
- Plan to design/issue another survey to all current CoE students

Surveys based on past work:

M.Carnasciali, "Factors influencing students' choice of engineering major", *2013 ASEE Annual Conference*, Paper 7721 (2013).

K.Walstrom, T. Schambach, K. Jones, W. Crampton, "Why Are Students Not Majoring in Information Systems?", *J. of Information Systems Education* 19(1), 43 (2008).

Plans for the Survey Data

- Examine regression models for several dependent variables
- Where do we see strong correlations, high confidence?

$$y_i = \beta_1 x_{i1} + \ldots + \beta_p x_{ip} + \varepsilon_i, \quad i = 1, \ldots, n$$

Dependent variables

Choice of sub-discipline
Job placement
Grad/professional school acceptance
Confidence to succeed in future
Overall satisfaction with program
Graduating GPA

Predictor variables

Age
Gender
Parental education
Prior awareness of engineering
Student societies
Student projects
Internships and co-ops
Research
Awards and scholarships

(With advice from CSCAR, of course!)

Conclusions

- Strong correlations observed between required courses and graduating GPA (predictor, or is “a good student a good student”?)
- Improved relative performance in required courses appears to correlate with choice of design project, but only certain subfields
- Survey information expected to help identify how EE and EE subfields chosen by students, and where to target recruiting and advising
- Big challenge: connection with alumni!

Acknowledgements

Thanks to the Learning Analytics Fellows and Exploring Learning Analytics program for support of this project, and to Center for Statistical Consultation and Research for advice in statistical analysis.