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A Hands-on Graduate Real-time Control Course: Development and Experience

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Standard Paper Assessment Methods Are Inadequate for Graduate EE Education

- **A qualified graduate EE:**

  Possess critical thinking abilities, design abilities, team-work, management skills in additional to fundamental scientific/engineering knowledge
- **Standard classroom evaluation:**

  Heavily based on individual paper accomplishments: assignments, quizzes, exams, term projects, etc.
- **EE graduate level courses:**

  Theoretically oriented with little or no experimental work
- **Traditional graduate engineering education:**

  Appeals to a focused group of candidates: those who wish to pursue an R&D career
- **Master's Degree in EE:**

  Almost a necessary requirement for professional competitiveness and growth across all electrical engineering (EE) subfields
- **Influx of “non-traditional students”:**

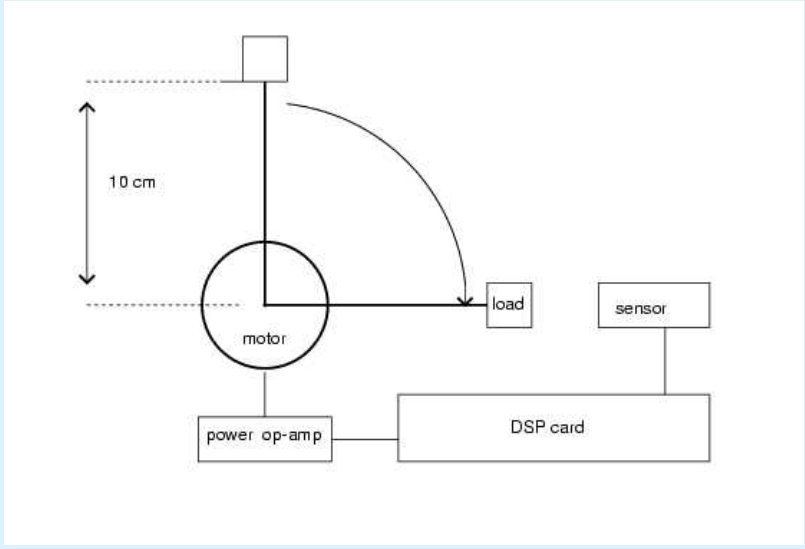
  Special challenge to the curriculum design and student assessment processes

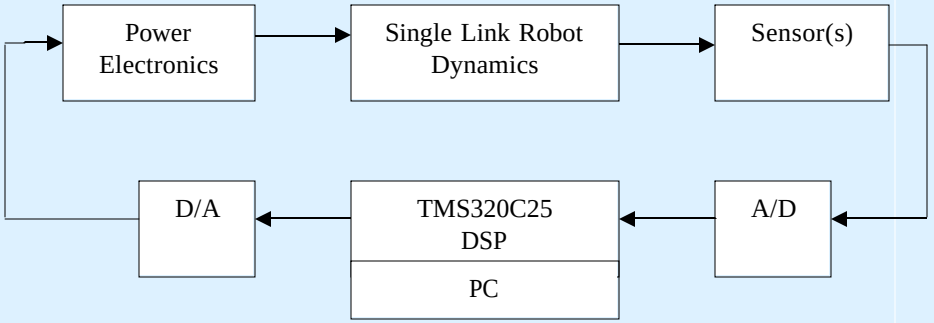
Course Description: ECE664 Real-time Control Systems

- First graduate course in digital automatic control systems analysis, design, and implementation.
- Grades :Classroom 60% & Experiment 40%
- Interdisciplinary graduate course with broad student base
- Comprises of classroom instruction and team design experimental project
- Over the years, a widening decorrelation between theoretical and experimental performances is observed with the class grades resulting in a bimodal distribution

The Experiment is Free-structure & Team-oriented

- Each team, consisting of two to three students, is given an Airpax DC motor, an LM675 high current operational amplifier, and small machine tools.
- The goal is to design, build, and to control a single link robot arm to rotate a 50 gram load with a radius of 10cm to 90 degrees +/- 1 degree with less than 25% overshoot and in minimum time, while holding the load in that position for at least two minutes.





Some Typical Students Designs

Myers-Briggs Type Indicator & Its Applications

- Based on Jung's theory
- Indicates the interactions among the preferences of perception and judgment (mental functions) and attitudes of orientation toward external world.
- Classifies into 16 distinctive personality types.
- Identify students' learning styles,
- Provide career guidance
- Improve student retention
- Develop leadership and group dynamic/ teamwork training

Four Scales of MBTI

EI scale: Where does one focus attention?

- ***Extraversion*** tends to direct energy in the *outer world* , communicate more by talking.
- ***Introversion*** tends to be *reflective observational* learning type, like lecture format.

SN scale: How does one acquire information?

- ***Sensing*** *type* tends to have *concrete experiential learning* and/or *abstract sequential learning* styles with *high factual retention* .
- ***iNtuitive*** *type* tends to be *abstract conceptual learner* , high in academic comfort, reflective judgment and likes *self directed* learning.

TF scale: How does one make decisions or draw conclusions?

- ***Thinking*** type: abstract conceptual and sequential learner and a talent for analyzing a problem or situation.
- ***Feeling*** type: concrete experiential learner and/or abstract random learner.

JP scale: How does one orient toward the external world?

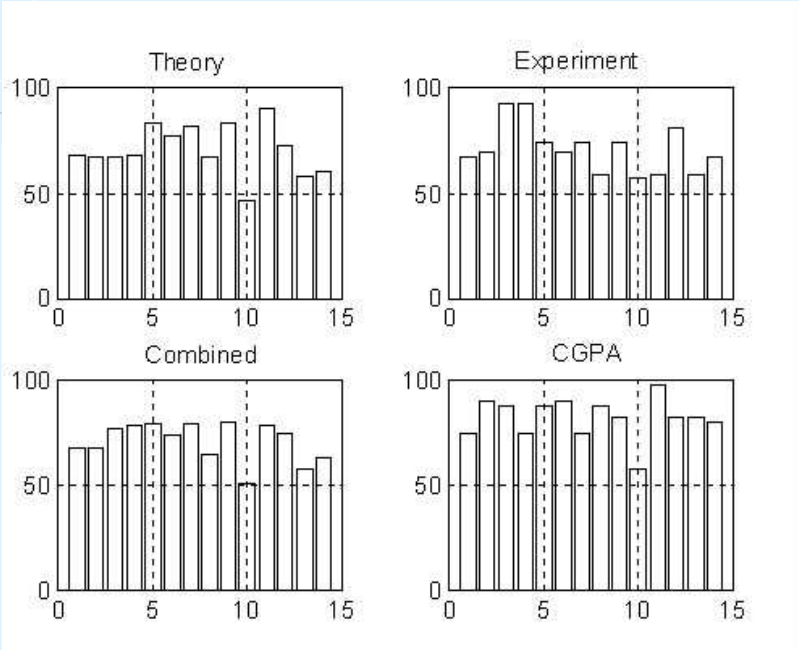
- ***Judging*** type: abstract conceptual learner, like structure and motivation in learning, high in fact retention and academic comfort.
- ***Perceiving*** type: concrete experiential learning style, active experiential learning and collaborative learning.

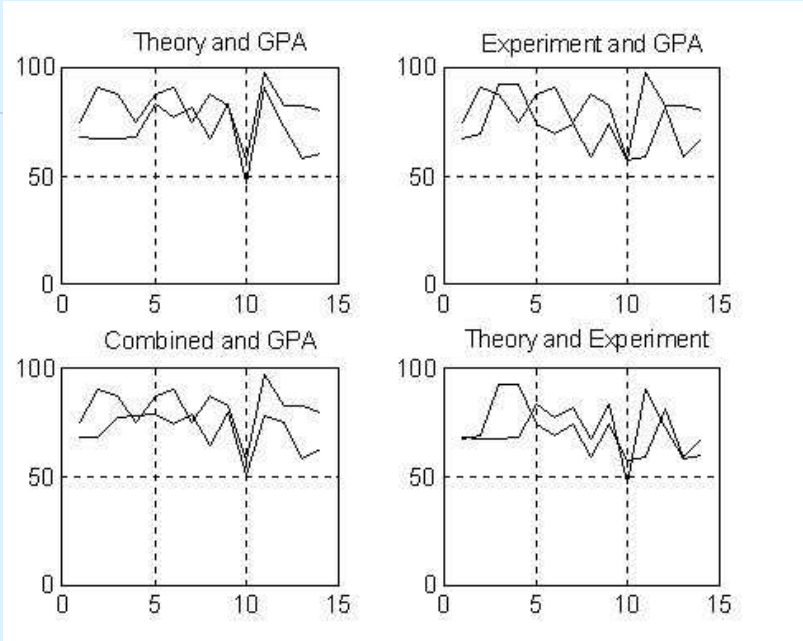
Samples of Type Distribution

- Population in the United States: 38% **SPs** , 38% **SJs** 12% **NTs,** and 12% **NFs**
- **SJ** types: valued **hard work,** demonstrated **dependability &** often being labeled **"good student**" in academic setting,

  do better in theory class when they can follow outlines
- **SP** types : least represented in higher education & **lowest correlation** between **academic ability and GPA**
- **NT** types: largely represented in **science** & **engineering**
- **NF** types: largely represented in **humanity** & **social behavior science**

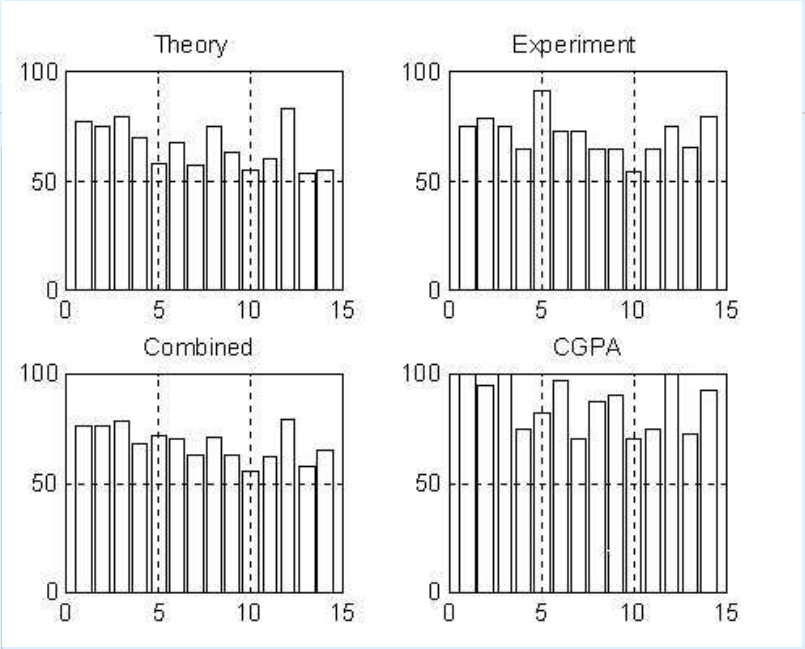
Course Data And Analysis: Set 1

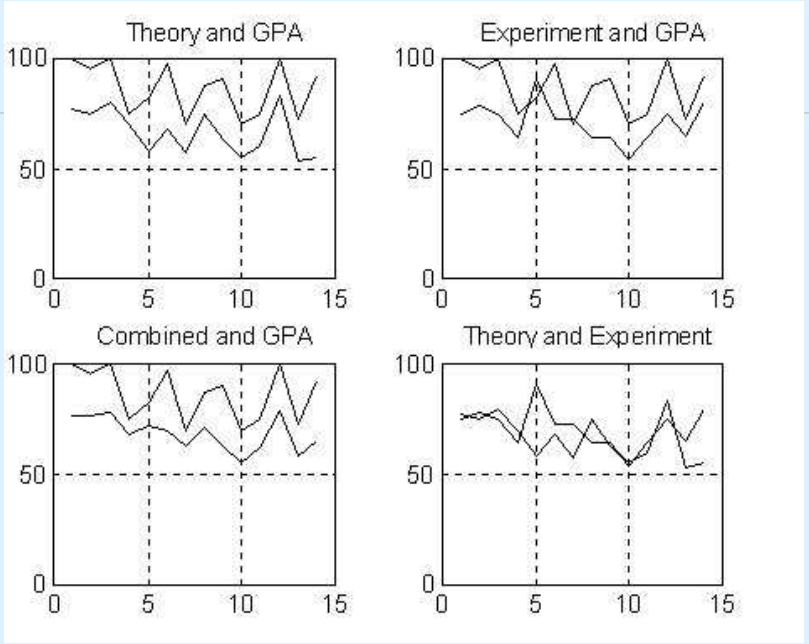




- Best theory grades: ISFJ, ISTP, ESTJ, ISFJ types
- Best experiment: team with INFP, INTJ, ISTJ members
- The lowest theory grades -- P type students
- The lowest experimental grades -- S_P and S_J type students
- GPA curve correlates very well with the Theory curve
- The experimental grades correlate poorly with the GPA curve

Course Data And Analysis: Set 2





- Best Theory grades: ESTJ, INTJ, ISFJ ISTJ
- Best experimental grades: team with INTP, ISTJ, INTJ members
- Lowest Theory grades: ESFJ, ESTJ, INTP
- Lowest experiment grades: Team with ISTJ, ISTJ, ISTJ members
- Correlation between the GPA curve and Theory Curve is high
- Correlation with experiment is lower (correlation coefficient=0.48)
- Performance slightly correlates with I type instead of the E type

Further Considerations

- Both sets exhibit similar characteristics in terms of MBTI distributions, GPA, Theory & Experiment performances
- Experimental abilities:
  - N-type students consistently outperform the other types (for free-structure experiments that require innovation and creativity)
- This ability is not reflected in their GPAs since almost all graduate EE courses are theory-based
- SJ type students:
  - thrive in a highly structured environment (i.e. good standard classroom performance) but are less apt to doing a “real” engineering project
- P type students:
  - more problematic (with respect to the EE curriculum) in that they tend to procrastinate and leave many loose ends
- Team with a mix of N type and SJ types students:
  - tend produce the best experimental results as they are complementary to each other

Conclusions and Recommendations

- This work describes the development and performance assessment for a master level electrical engineering course titled: “Real-time Control Systems”.
- This course adopts the “motivation-by-challenge” approach by incorporating an experimental design module.
- The Myers-Briggs Type Indicator inventory provided an extra analytic dimension and led to the conclusion that psychological types play an important role in student “performance” in (1) a highly structured classroom environment and (2) a free-structure experimental project.
- The following recommendations are made:
  - Reconsider assessment criteria for Master level EE students
  - Emphasis more on experimental projects, team-work, and communication skills
  - Use MBTI to help students modifying their work habit and forming teams with complementary types
  - Pay particular attention to the F and P type students who tend to experience difficulties in EE program.
  - Design curriculum and program to accommodate and challenge students of different types.