South Dakota State University

Active Learning Techniques in Automatic Controls

SDSU, ASEE Best Practices Seminar

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Background Notes

M.S., Aerospace Engineering, Università degli Studi di Palermo, Italy, 2001

Ph.D., Mechanical Engineering, Rice University, Houston TX, 2008

Research Associate, Spacecraft Robotics Lab, Naval Postgraduate School, Monterey CA, 2010-2014

Research interests: Robotics, Nonlinear Control, Optimal Control, Small Satellites

More about my ~~M.S.~~ cultural bias:

- 5 years program (less than 5% of enrolled completed it on time)
- 29 courses
- Few homework and no grading (final solutions are abailable), no quizzes/tests, no midterm
- One office hour per week
- One final examination:
    1. Written exam (2 hours closed-book and notes)
    2. Oral exam (0.5-1 hours, in front of most of the classmates)

ME 492 - Automatic Controls

Automatic Controls is an interdisciplinary branch of engineering and mathematics which focuses on:

- Dynamic systems modelling (mechanical, electrical, electromechanical)
    - Time domain
    - Laplace transform domain
- Uncontrolled system behavior assessment
- Controller design
- Controlled system behavior assessment
- Controlled system model development for validation (Matlab/Simulink)

ME 492 - Automatic Controls (some facts)

- Offered every semester
- I have been teaching it since Fall 2016
- 20-45 students per class (average about 35)
- 3*50 min contact
- Topics covered mainly on the whiteboard (few slides)
- 3-4 Matlab/Simulink help sessions (models of mechanical systems)
- Student evaluation:
  1. 7-8 Homework assignments (15%)
  2. 3-4 Quizzes (15%)
  3. Midterm (20%)
  4. Final (30%)
  5. Final group design project (20%)
  6. Discretionary evaluation (up to: ±5%)

Why is Automatic Controls a difficult topic?

1. “I have heard it is a tough course!” (“ps Actually it is not that bad!”)
2. It is interdisciplinary (engineering/mathematics/physics)
3. A good amount of initial effort and time must first be dedicated to learn “the fundamentals”
4. The (abstract) tools building process is somehow tedious
   - Laplace transform
   - Inverse of Laplace transform
   - Transfer function
5. All the topics are interrelated (don’t miss a step!)
6. A lot of topics to cover before getting to something “applicable”

My Active Learning Indoctrination

1. National Effective Teaching Institute Workshop (**NETI 1B**), attended in Spring 2017
2. Workshop facilitators:
   - **Susan Lord**, University of San Diego
   - **Matthew Ohland**, Purdue University
   - **Michael Prince**, Bucknell University
3. Topics covered:
   a) Student motivation
   b) Course planning
   c) Active learning
   d) Inclusive teaching
   e) Assessment of learning

Three Guiding Principles of Effective Teaching

1. **Constructive alignment.** Lessons, activities, assignments, and assessments all address the same learning objectives.
2. **Practice and feedback.** The more students get, the more they acquire and retain the knowledge and the greater their skill development.
3. **Balance.** Balance the needs of different students, emphasis on basics and high-level skills, lecturing and active learning, individual and group work.

Ten Worst Teaching Mistakes

1. Disrespect students
2. Teach without clear learning objectives
3. Get stuck in a rut
4. Give tests that are too long
5. Fail to establish relevance
6. Have students work in groups with no individual accountability
7. Fail to provide variety in instruction
8. Turn classes into PowerPoint shows
9. Call on students cold
10. When you ask a question in class, immediately call for volunteers

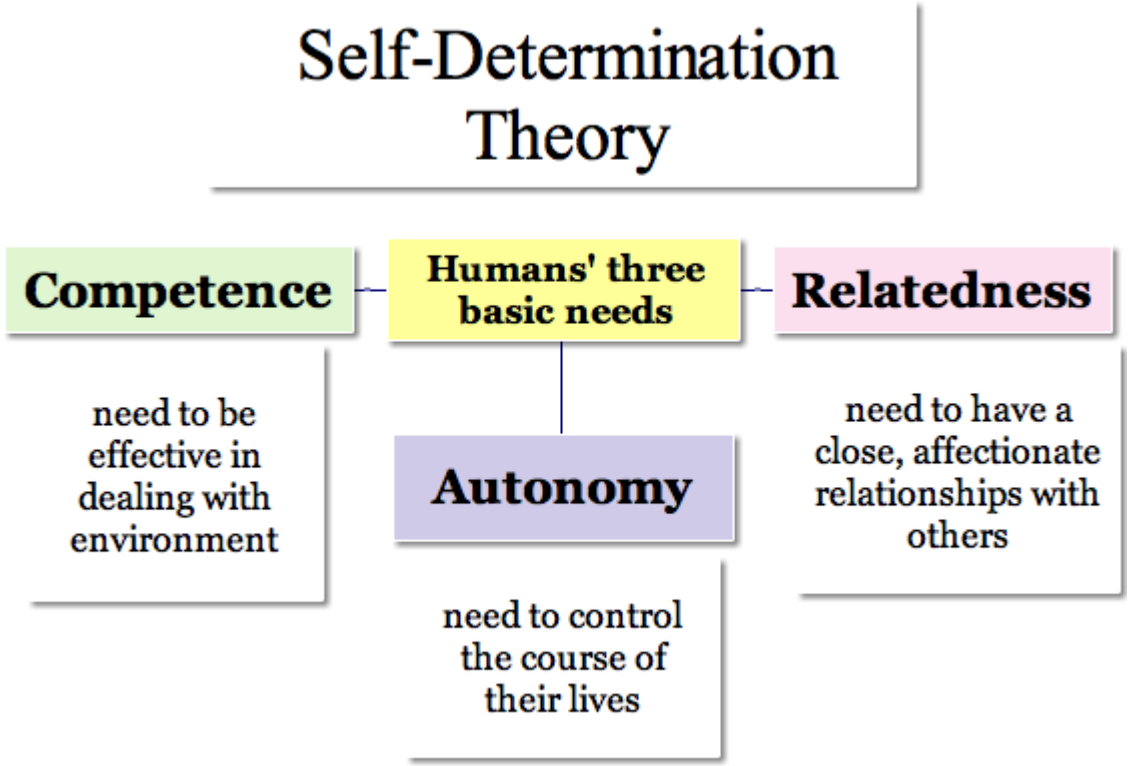
Student Motivation

Three categories:

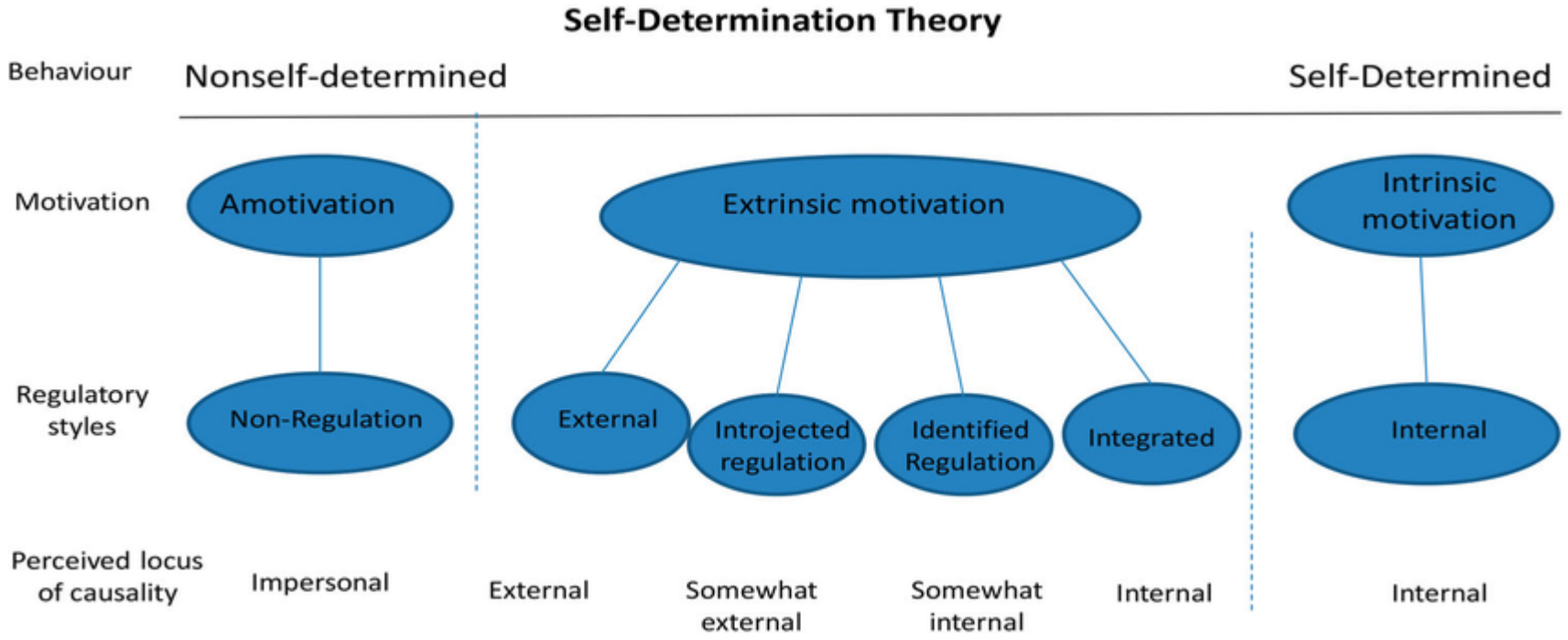
1. Students with high level of in the course topic
   - Usually a minority
   - They will do just fine
2. Students with complete lack of aptitude for the subject and/or antipathy toward it
   - Usually a minority
   - Trying to motivate them may be more trouble than it is worth
3. Students with no burning interest in the subject but they also don’t hate it
   - Great majority
   - The teaching approach can profoundly affects how these students approach the course

Student Motivation

Self-determination theory: Antecedents of Motivation



Student Motivation



Student Motivation in ME 451

Self-determining factors

1. Competence
   - Fill out lack of background knowledge (as much as possible)
   - Challenge them with simple questions
   - “Embrace” occasional failures
2. Autonomy
   - Offer extra points for alternative approaches
   - Offer open final project topics
3. Relatedness
   - Introduce myself!
   - In-class discussion
   - Promote office hours

Course Planning

Learning objective (instructional objective): A statement of something *observable* and *clear* that students should be able to do after receiving instruction

- **Observable**: Instructor should be able to watch students doing it and see the results
- **Clear**: Students should be able to look at the objective (after being taught) and known whether of not they can do what the objective specify

Non-learning objectives (the forbidden four): …. the student will

- know …
- learn...
- appreccciate…
- understand...

Learning Objectives/Outcomes in ME 451

Student Learning Outcomes:

Upon completion of this course, the student will be able to:

a. Solve mathematical equations in the modeling of dynamic systems in both the time and frequency domains.
b. Draw functional block diagrams and determine the corresponding transfer functions.
c. Use matrix methods for solving and interpreting systems of differential equations.
d. Analyze the transient response, stability, and steady state response of control systems.
e. Analyze and interpret the stability and response of control systems using Laplace Transform Methods, Root Locus Plots, and Bode Plots.
f. Become adept in communicating the outcomes of control system analysis and understand its relevance towards system design.
g. Experience system modeling and the estimation of physical parameters.
h. Know the current technology and techniques including analysis and design tools used in modern engineering practice, such as MATLAB and Simulink.

Active Learning

How to actively engage students?

During the first week:

1. Introduce myself
2. Establish student-instructor and student-student communication mechanism
    - Ask them to introduce themselves
    - Learn their names
3. Assess what students know and want to know
    - Test on prerequisite
    - What do they know about the course
4. Establish expectations
    - Summarize my expectations
    - Distribute advices collected from previous students
5. Motivate students' interest in the course
    - Get the students to brainstorm on real-world applications
    - Present results of final group projects

“Do you have any questions?”