

The logo for the University of Puerto Rico (UPR), consisting of the letters 'UPR' in a bold, sans-serif font, with a teal triangle to the left of the letters.

Most teachers waste their time by asking questions that are intended to discover what a pupil does *not* know, whereas the true art of questioning is to discover what the pupil *does* know or is capable of knowing.

Einstein



The logo for the University of Puerto Rico (UPR), featuring the letters 'UPR' in a bold, sans-serif font. The letters are white and set against a dark green background that is shaped like a stylized triangle or arrow pointing to the right.

# Developing an Outcomes-Based Course

## Workshop

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The logo for the Center for Academic and Administrative Management (CAAM) at the University of Puerto Rico. It is a circular seal with 'CAAM' in the center and 'UNIVERSIDAD DE PUERTO RICO' around the perimeter.



# Agenda

Introduction

Workshop Goals & Objectives

**Exercise 1:** Outcomes

**Exercise 2:** Syllabus

Course Syllabus Template

**Exercise 3:** Course Rationale

Course Objectives

**Exercise 4:** Objectives





# Agenda...

Student Learning Profile

Teaching & Learning Strategies

**Exercise 5:** Teaching/learning Strategies  
(course activities)

**Exercise 6:** Assessment

**Exercise 7:** Contacts

Completing the Cycle

Reflection & Workshop Assessment





## A little bit of history...

- 1994 NSF – MEEP: The Learning Factory
  - Responding to stakeholders needs
- 1998 NSF & Raytheon – Learning Factory Workshops
  - Disseminating curriculum model
- 1998 NASA PaSCoR
  - Adapting the model curriculum
  - Developing an Outcomes Based Course Workshop offered for the 1<sup>st</sup> time
- 1999 ABET EC 2000
  - Developing an Outcomes Based Course Workshop offered to all CoE faculty & 60 A&S Faculty



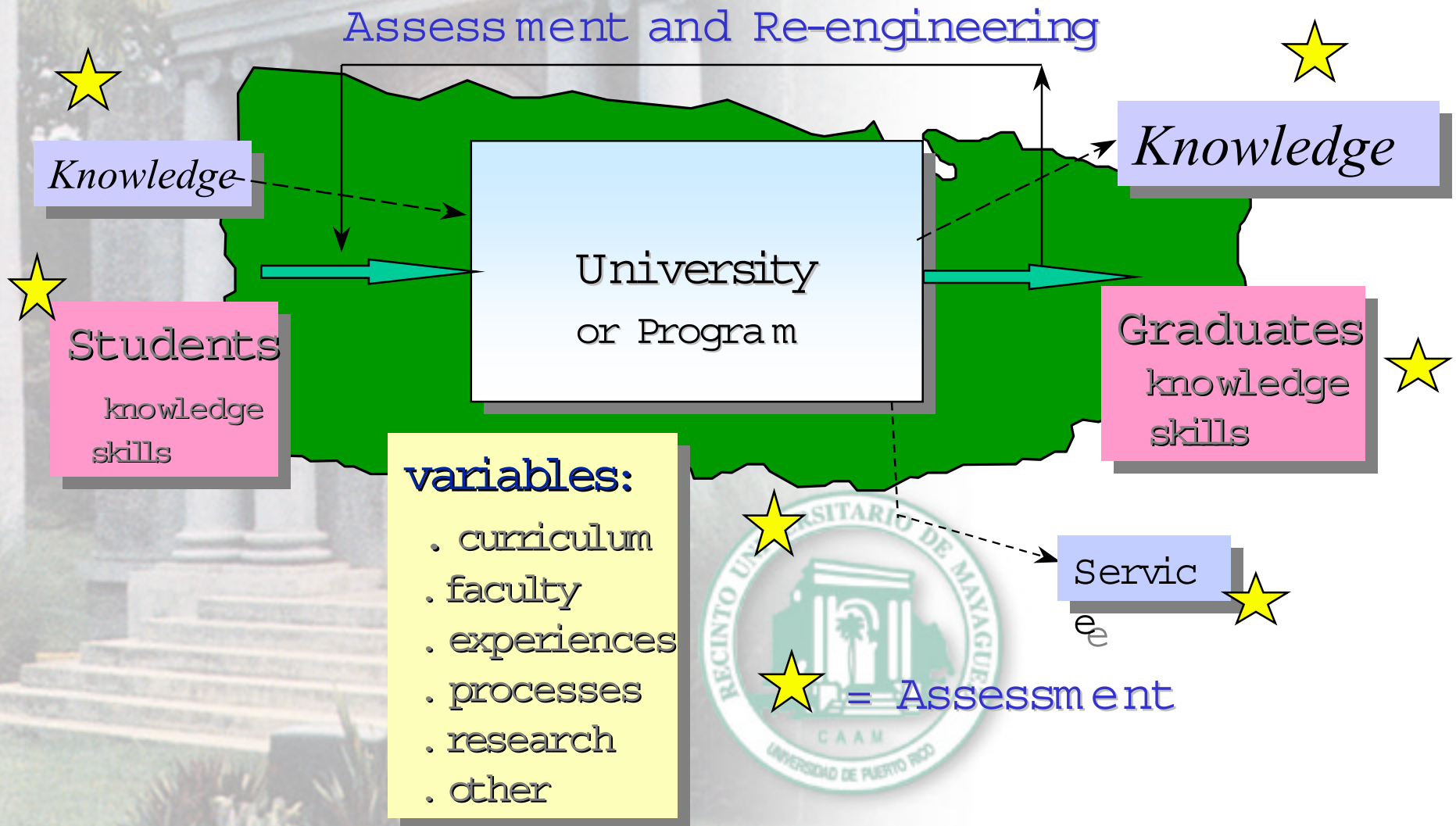


# Workshop Goals & Objectives

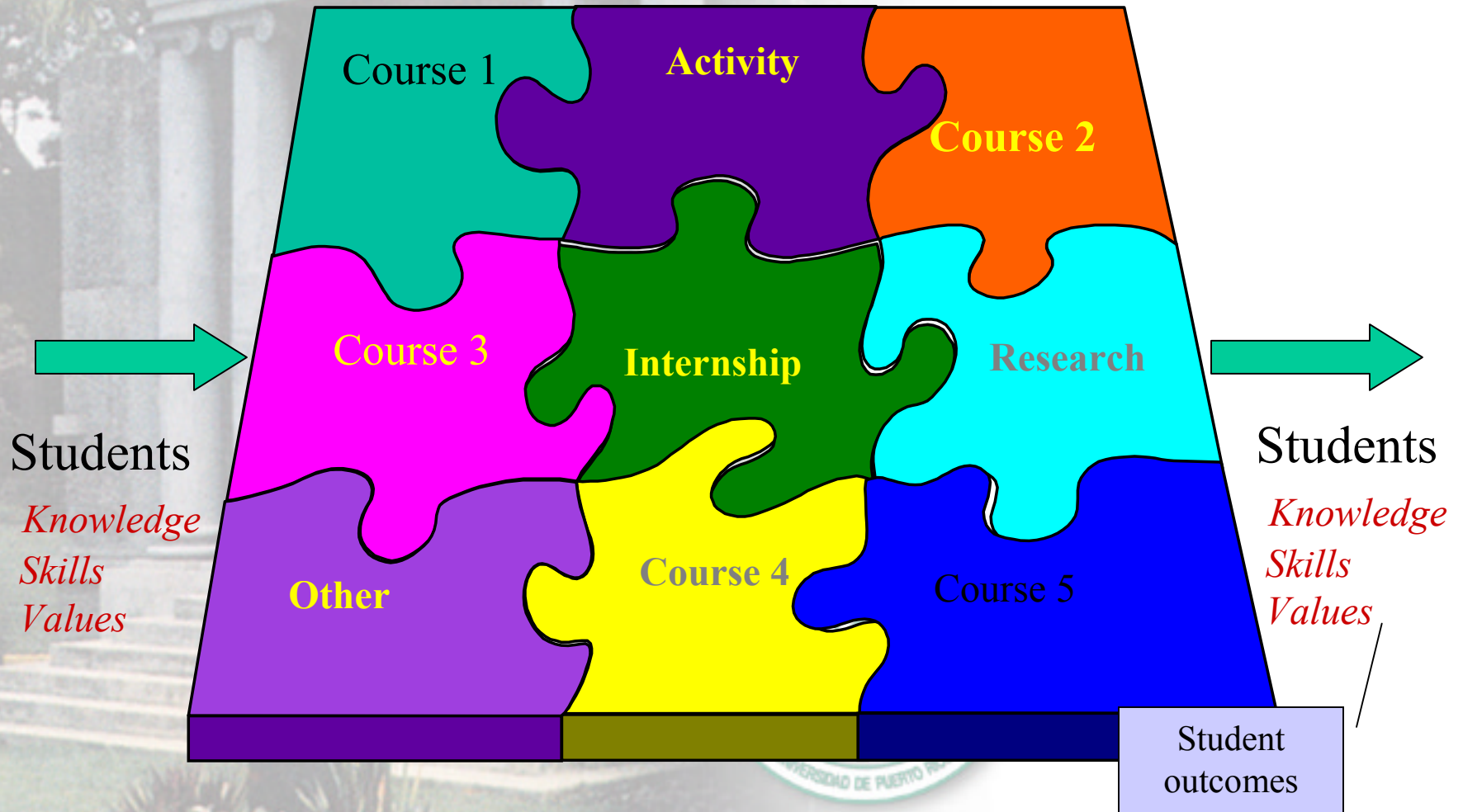
- Provide a guide to develop outcomes-based courses & assess student learning outcomes
  - Establish the importance of planning in course development/revision
  - Become aware of learning styles & the impact on course/course development
  - Develop course goals & learning objectives
  - Design classroom activities to achieve course goals & objectives
  - Identify an assessment strategy/tools to evaluate student performance & learning



# Education "Process"



# Program X



# The graduating engineer profile: what stakeholders want...

*What does he/she know, is able to do?*

## Graduating Student Profile @ UPRM Civil Engineering

1. Ability to understand and apply knowledge of mathematics through differential equations, probability and statistics; science (calculus based physics and general chemistry); and engineering in at least four major civil engineering areas.
2. Proficiency in a minimum of four (4) recognized major civil engineering area such as industry, geotechnical, environment, water resources, transportation, and construction management.
3. Ability to conduct laboratory experiments and to critically analyze and interpret data in more than one of the recognized major civil engineering areas.
4. Ability to perform civil engineering design of systems, components, or processes by means of design experiences integrated throughout the professional component of the curriculum.
5. Ability to use the techniques, skills, and modern engineering tools necessary for civil engineering practice.
6. Ability to work in a collaborative multidisciplinary professional work group environment solving civil engineering problems.
  7. Ability to play the required role when working in groups.
  8. Ability to identify, formulate, and solve civil engineering problems.
  9. Ability to communicate effectively in english and spanish.
10. Understanding of professional practice and ethical responsibilities issues such as: procurement of work; bidding versus quality-based selection processes; how the design professionals and the construction professions interact to construct a project; the importance of professional licensure and continuing in education; and/or other professional, social and moral issues.
11. Broad education necessary to understand the impact of civil engineering solutions issues such as health, general welfare, safety, environmental quality and economy in a global/societal context.
12. Commitments to engage in lifelong learning throughout all of the professional life.



# Outcomes vs. Objectives



Objectives:  
where we  
aim



Outcomes:  
where it  
hits





# Objectives/Outcomes

- Describe an area of knowledge or skills that a person can possess
- Should be stated such that a student can demonstrate before graduation
- Should be supportive of one or more program objectives
- Do not have to include measures of performance expectations



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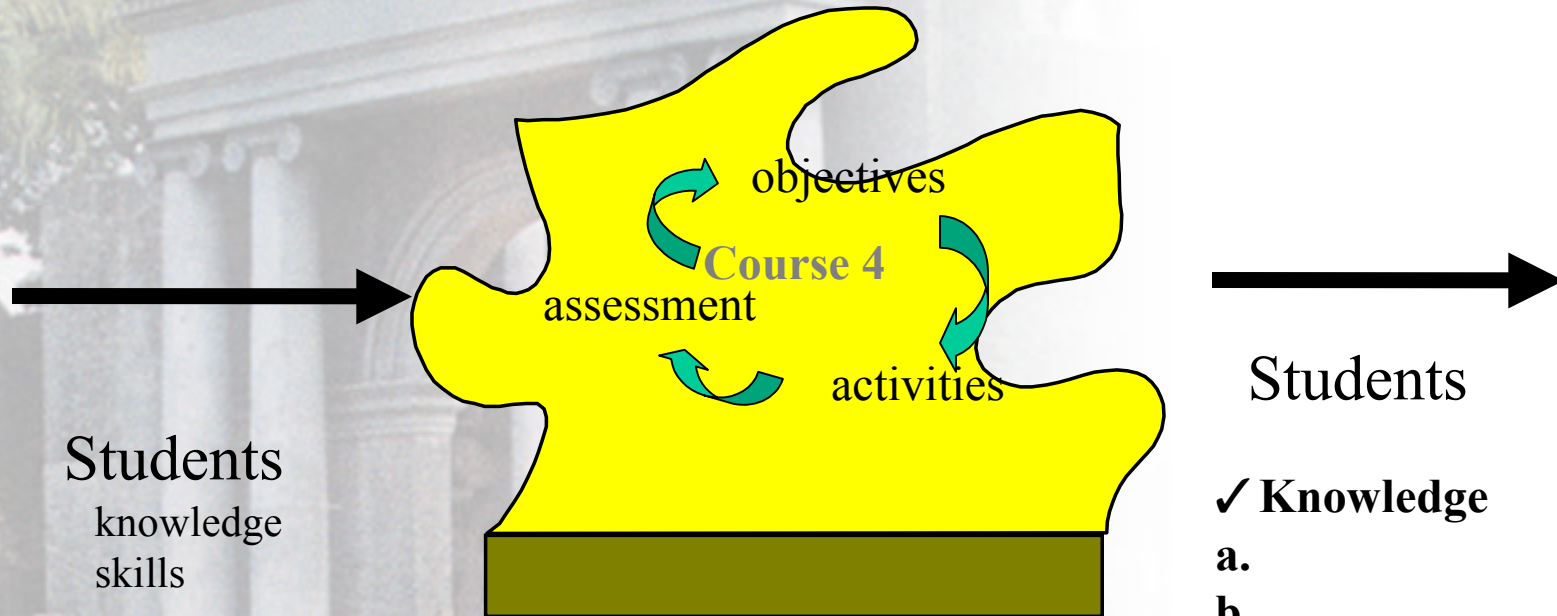
# Exercise 1: Your course...

- Review your course objectives & identify student learning outcomes





# Planning for desired outcomes on our courses



- ✓ Knowledge
  - a.
  - b.
  - c.
- ✓ Skills, Values & Competencies
  - a.
  - b.
  - c.
  - d.
  - e.

*How do we achieve  
desired outcomes?*



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## Exercise 2



- What does the course syllabus represent to you?

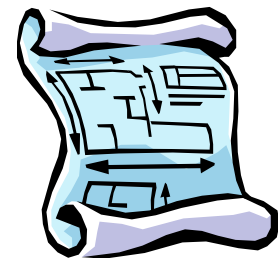




# The syllabus or course plan

- The document that summarizes course design:
  - Content/skills to be developed
  - Teaching/learning strategies to be used to develop skills/acquire knowledge
  - Evaluation of student performance (or how are we going to know if the student has learned?)
  - Other information (e.g., office hours, text, references)
- It establishes what is required & expected from the student

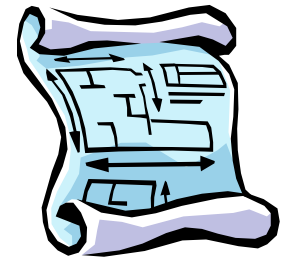
*A Learning & Teaching Map*





# The syllabus or course plan

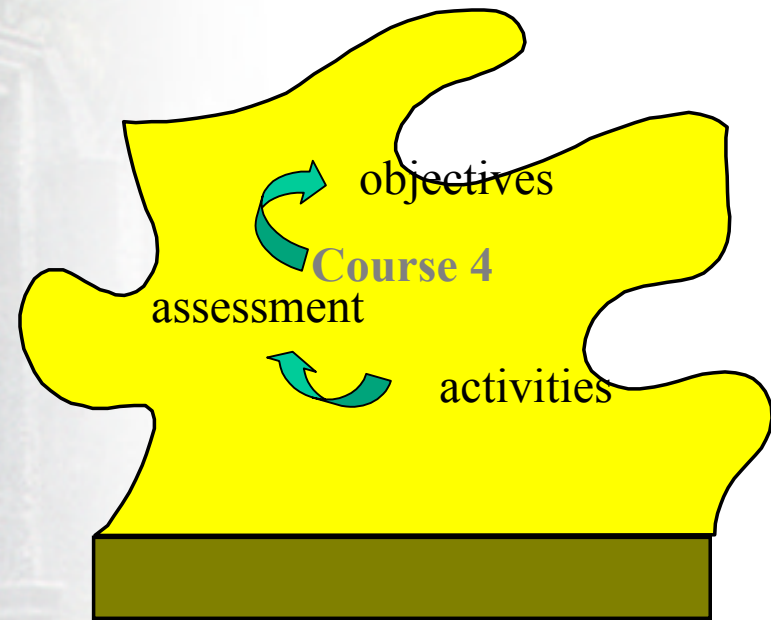
- Should include:
  - Clearly defined course objectives
    - Content
    - Skills, values & competencies
  - Educational activities to achieve goals/objectives
    - Traditional (e.g., lecture)
    - Non-traditional (e.g., hands on lab activities, team experiences, industrial interaction)
  - Student learning outcomes assessment
    - Traditional (e.g., exams)
    - Custom-made (e.g, to evaluate teamwork)



# Course Syllabus Template:

*a proposal*

- Course Title
- Description
- General Course Objectives and Student Learning Outcomes (instructional objectives)
- Course Outline
- Student Outcomes Assessment & Evaluation Criteria



**COURSE XXXX 1234**

**COURSE TITLE:**

**COURSE DESCRIPTION:**

**GENERAL OBJECTIVES AND STUDENT LEARNING OUTCOMES**

**The Template:  
General Description**





# Course Development Steps



- **Step 1:** Establish Rationale
- **Step 2:** Define General Course Objectives and Student Learning Outcomes (Instructional Objectives)
- **Step 3:** Design Teaching/Learning Strategies
- **Step 4:** Develop Criteria/Tools to Assess Student Performance/Outcomes
- **Step 5:** Determine Special Contacts Needed
- **Step 6:** Pilot Test & Assessment
- **Step 7:** Re-engineer & Report



## Exercise 3

- **Step 1:** Write Course Rationale\* (**green areas**)
  - Course title (page 1)
  - General description (page 1)
  - Identify topics to be covered (page 2, column 1)
  - Establish:
    - class size
    - requisites
    - faculty/student ratio
    - role of instructor



\*For new courses...

**COURSE XXXX 1234**

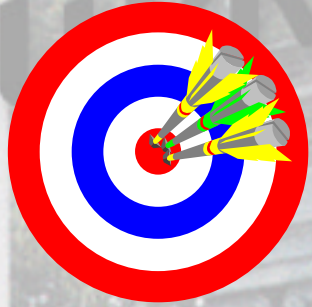
**COURSE TITLE:**

**COURSE DESCRIPTION:**

**GENERAL OBJECTIVES AND STUDENT LEARNING OUTCOMES**

**The Template:  
General Description**





## Why establish instructional objectives?

- Identify critical course material
- Facilitate the design of in-class activities
- Facilitate effective student evaluation
- Focuses the student's attention on learning tasks by telling them what they can expect...

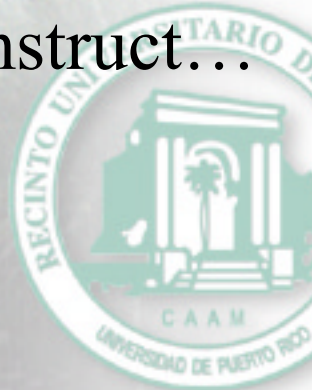
*To know where you are going!*





# Instructional Objectives

- Example: *“At the end of this (course, week, lecture), the student will be able to...”*
- “...” is an action word like:
  - calculate, estimate, solve, derive
  - describe, compare, distinguish, list
  - explain, outline, construct...
- Can be measured





# Instructional Objectives

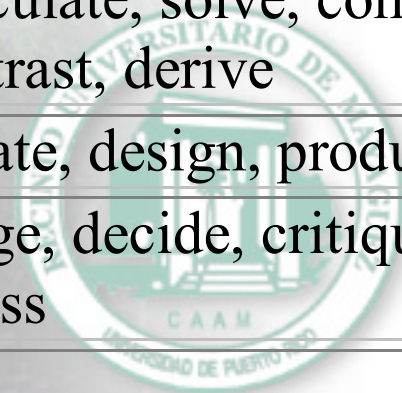
- Resources to write objectives:
  - Bloom Taxonomy
  - ABET EC 2000
  - Stakeholders input (graduate profile)
    - Industry Advisory Boards
  - Professional societies
  - *Skills for the Millenium*





# Bloom's Cognitive Objectives

Bloom Cognitive Level	Description
Knowledge	Define, repeat, name, relate, identify, remember
Comprehension	Describe, explain, discuss
Application	Apply, interpret, demonstrate, illustrate
Analysis	Calculate, solve, compare, contrast, derive
Synthesis	Create, design, produce, propose
Evaluation	Judge, decide, critique, justify, assess



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# ABET 2000 a-k competencies

- a. ability to **apply knowledge** of math, science & engineering
- b. ability to **design & conduct experiments, analyze data**
- c. ability to **design a system** component or process
- d. ability to function on **multi-disciplinary teams**
- e. ability to **identify, solve & formulate** engineering problems
- f. understanding of **professional & ethical responsibilities**
- g. ability to **communicate** effectively
- h. understand the impact of engineering solutions in a **global & societal context**
- i. **life-long learning**
- j. knowledge of **contemporary issues**
- k. ability to use techniques, skills & **engineering tools** necessary for engineering practice



# Course Development Steps

- Step 1: Establish Rationale
- **Step 2: Define General Course Objectives & Student Learning Outcomes (Instructional Objectives)**
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- Step 7: Re-engineer & Report



# Exercise 4

- **Step 2:** Write General Course Objectives and Student Learning Outcomes (Instructional Objectives) (page 1) (*blue*):
  - Student Outcomes
    - What do you expect students **to learn** ?
    - What do you expect students **will be able to do** with what they learn?
  - Determine what **knowledge, skills & competencies** will be developed in the students
    - Context area
    - ABET 2000 a-k skills & competencies
    - Recommended by stakeholders
      - » Industry
      - » Professional societies
      - » *Skills for the Millenium*



**COURSE XXXX 1234**

**UPR**

**The Template:  
General Description**

**COURSE TITLE:**

**COURSE DESCRIPTION:**

**GENERAL OBJECTIVES AND STUDENT LEARNING OUTCOMES**

# Example: EE Pattern Recognition

“At the end of the semester the students will be able to *know, comprehend, apply, and analyze* principles and techniques such as classifiers, clustering, neural network...and... *to evaluate* the different models of machine learning and applications of pattern recognition and define the different components of a pattern recognition system sensor, classifier, and result visualization. ...be able *to describe* the concepts of detection...to use these concepts and techniques to *analyze the data collected by different sensors*. Based on a mathematical background in matrix algebra and probability the student should be able *to model and contrast* the different approaches in pattern recognition such as supervised/unsupervised classification, parametric/nonparametric classifiers, and statistical vs. neural network methodologies. She/he should be able *to ensemble a pattern recognition system* to solve specific problems such as fingerprint verification, optical character classification, and face recognition. Finally they will *critique and judge different methods* .... The students will *work in teams* to solve different problems in fields such as medicine, marine science, biology, environmental studies, geology, and agriculture. *Develop through oral and written presentations the ability to communicate in multidisciplinary groups*. Students will understand the impact of pattern recognition engineering in *a global perspective and societal context*. Through case studies and contemporary issues students will *know, comprehend, analyze, imagine and evaluate the ethical implication of the technology*”



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# Exercise 5: The Course Outline

- From your general course objectives:
  - Select one desired student learning objective/outcome
  - Go to page 2 on course syllabus template (Course Outline)
  - Identify one topic on the course outline (*green*) where you could develop that objective/outcome
  - Re-write selected objective/outcomes & make it operational (more specific to the topic) (*white*)





# Example: ChE 4005 Mass & Energy Balances

TOPIC	OBJECTIVES & SKILLS	TEACHING/LEARNING STRATEGIES	ASSESSMENT STRATEGY AND TOOLS
Introduction to Chemical Engineering	Know the role of chemical engineers in society including the different disciplines and opportunities relevant to the profession.		
	Define and apply concepts of excess reactant, limiting reactant, conversion, degree of completion, selectivity and yield.		



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Let's take a Break...

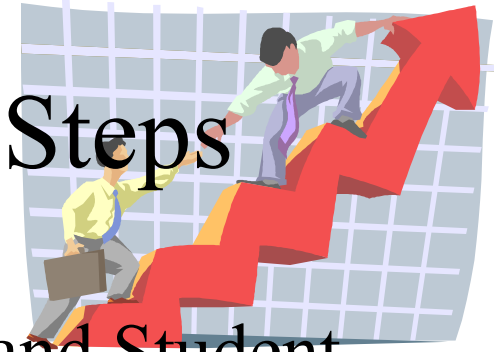
*"Education's purpose is to replace an empty mind with an open one."*



Malcom S. Forbes

# Course Development Steps

- Step 1: Establish Rationale
- Step 2: Define General Objectives and Student Learning Outcomes (Instructional Objectives)
- **Step 3: Design Teaching/Learning Strategies**
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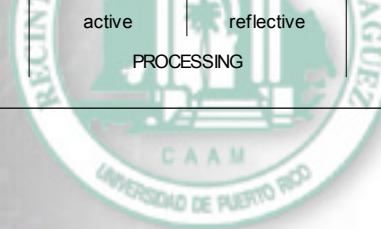
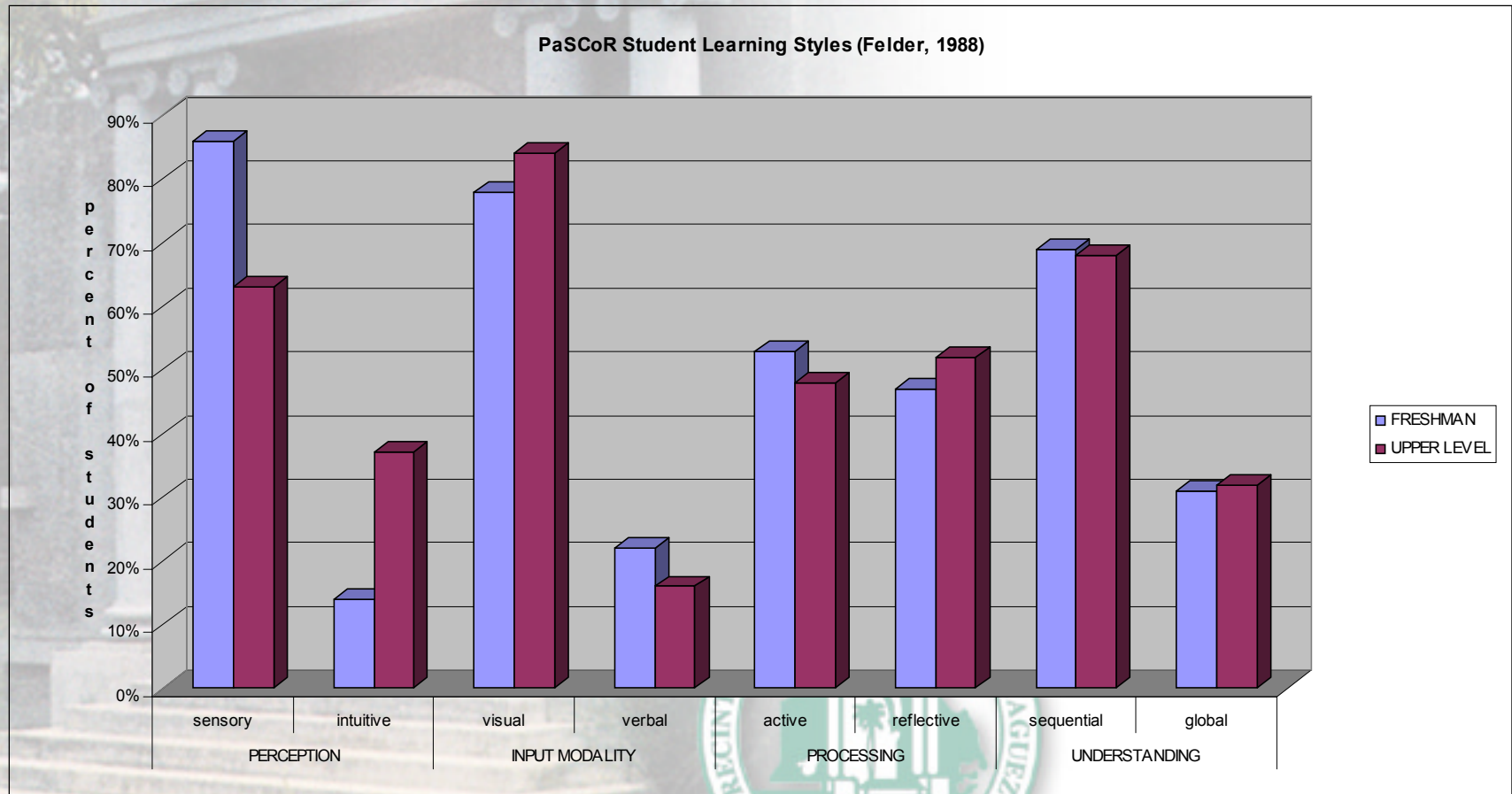
# How do students learn?

- Learning Style Model, Felder 1988
  - Perception - Sensory, Intuitive
  - Input Modality - Visual, Verbal
  - Organization - Inductive, Deductive
  - Processing - Active, Reflexive
  - Understanding - Sequential, Global





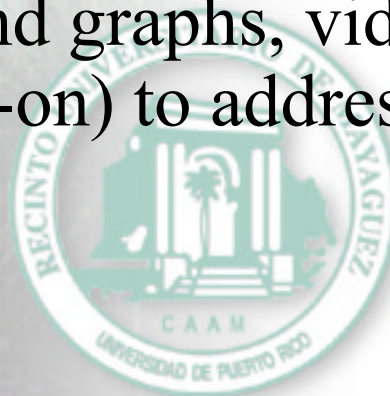
# Student Learning Styles Profile





# Teaching/Learning Strategies

- Are **relative** to course objectives
- Establish **relevance & applications** for all course material
- Should **balance** concrete information (facts, observation) & abstract concepts (model, theory)
- Should **use a variety of delivery modes** (e.g., use pictures, schematics and graphs, videotapes, demonstrations, hands-on) to address most of learning styles





# Teaching/Learning Strategies

- Traditional & non-traditional
- All are needed to address learning styles!
  - Lectures
  - In-class demonstrations
  - Laboratory experiences
  - Consultations
  - Field trips to industry
  - Oral presentations
  - Written reports
  - Working in teams





# Teaching/Learning Strategies

- Use numbers, not just algebraic variables
- Give time to think
- Use cooperative learning (small group exercises)
- Use computer-assisted instruction
- Assign open-ended problems for analysis & synthesis.





# Teaching/Learning Strategies Suggested by Wankat

TEACHING AND LEARNING ACTIVITIES (Harb et al., 1991; McCarthy, 1987; Svinicki and Dixon, 1987)

Diverger (1)	Assimilator (2)	Converger (3)	Accommodator (4)
Motivation "War stories"	Information and Facts	Try it	Do it themselves
Brainstorming	Lecture	Homework problems	Self-select projects
Observation: Field trips, "on street", Logs, Journals	Reading	Laboratory	Design
Role Playing	Instructor or TV demonstration	Simulations	Open-ended problems
Discussion	Patterns	CAI	Write problems
Questioning	Organizing	Problem solving	Field trips
Visualization	Objective tests	Short answer	Work experience
	Library Work	Report	Simulations
	Problem-solving examples	Demonstrations	Teach yourself
	Seminars	Experiment	Teach someone else
		Tinker	Think tank
		Record	
		Make things work	

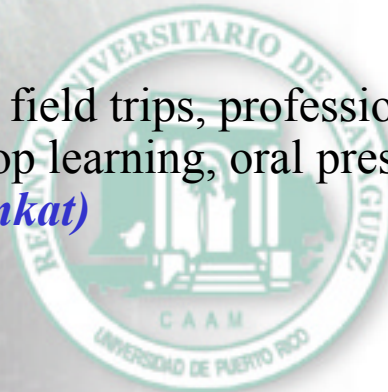
From: "Teaching Engineering" by Wankat & Oreovicz Mc Graw-Hill, 1993



# Exercise 6



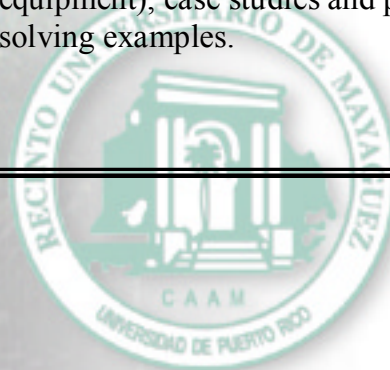
- **Step 3: Design Teaching/Learning Strategies** (page 2) (yellow)
  - For the topic & objective selected:
    - What **classroom/lab activities & strategies** will be necessary for students to learn the desired concepts?
    - What classroom (or otherwise) activities & strategies will be necessary for students to develop desired skills & competencies?
    - Examples:
      - lectures, labs, demos, field trips, professionals in the classroom, working in teams, coop learning, oral presentations, written reports, etc. (See *Wankat*)





# Example: EC Design of Transmission & Distribution Systems

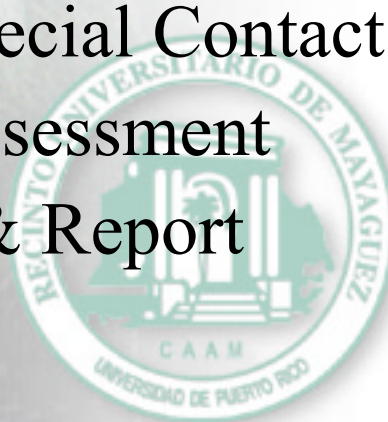
TOPIC	OBJECTIVES & SKILLS	TEACHING/LEARNING STRATEGIES	ASSESSMENT STRATEGY AND TOOLS
1. Load characteristics and forecasting	Define and apply load characteristics and forecasting techniques.	Lecture, problem-solving examples and questioning.	
2. Industrial, commercial and residential energy rate structure	Define and apply energy rate schedules. Understand ethical, legal and economical considerations of energy rate schedules.	Lecture, supplementary reading, problem-solving examples and own life experience.	
3. Distribution transformers: connections, protection, harmonics	Identify and apply distribution transformer connections. Define harmonics, voltage distortion and system protection.	Lecture, pictures (photographs of actual connected and damaged equipment), case studies and problem solving examples.	





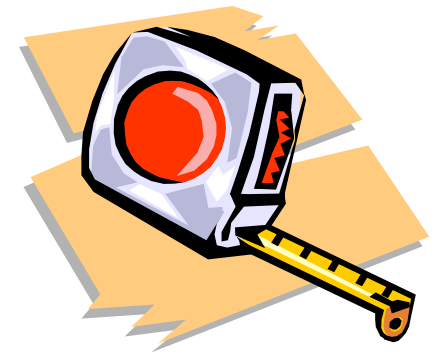
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## Evaluating Student Performance

- Depends on course goals/objectives
- Tools
  - Traditional & Non-traditional
    - exams, quizzes, homework
    - oral reports assessment
    - written reports assessment
    - team experiences assessment





# Classroom Assessment

- Classroom assessment is a **systematic & continuous** approach to formative evaluation
- Classroom assessment techniques (CATS) are simple tools for collecting data on student learning in order to improve it.
  - CATS are “feedback devices,” instruments that faculty can use to find out how much, how well, & even how students are learning.



Reference: Angelo and Cross (1993)



# The Classroom Assessment Cycle

(adapted from Angelo & Cross, 1993)

## **Phase 1: Planning for Classroom Assessment**

1. Choosing a class to focus on
2. Focusing on an assessable teaching goal or question
3. Designing a classroom assessment tool

## **Phase 2: Implementing the Assessment**

4. Teaching the course or target lesson
5. Assessing student learning by collecting feedback
6. Analyzing student feedback





# The Classroom Assessment Cycle

## **Phase 3: Responding to the Results**

7. Interpreting the results & formulating an appropriate response
8. Communicating results
9. Making decisions
10. Documenting the process





# Basic Criteria for selecting tools

- Is it context-sensitive?
- Is it flexible?
- Is it likely to make a difference?
- Is it mutually beneficial?
- Is it easy to administer?
- Is it easy to respond to?
- Is it educationally valid?





# Program assessment: Student Outcomes Assessment Matrix

	Pre-Engineering	<b><i>BS in Engineering (5 years)</i></b>	Post-Graduate
	Assessment Tools	<b><i>Assessment Tools</i></b>	Assessment Tools
Program objectives/outcomes (inc. ABET 2000)			
Knowledge of Math, Science and Engineering			
Experimentation & Data Analysis			
Engineering Design			
Multi-disciplinary Teamwork			
Problem Solving			
Professionalism & Ethics			
Communication Skills			
Broad-based Education			
Lifelong Learning			
Contemporary Practice and Issues			
Other			

**classroom assessment**

# Student Outcomes Assessment Matrix

	Pre-Engineering	<b>BS in Engineering (5 years)</b>	Post-Graduate
	Assessment Tools	<b>Assessment Tools</b>	Assessment Tools
Program objectives/outcomes (inc. ABET 2000)			
Knowledge of Math, Science and Engineering	29,2	3,4,7,10,15,22,26,30,32	1,16,17,9,8,28,23
Experimentation & Data Analysis	25	19,5,7,27,18,33,26,30	1,16,17
Engineering Design	25	26,30	
Multi-disciplinary Teamwork			
Problem Solving	25	18,33,26,30	
Professionalism & Ethics		6,7,20,26	
Communication Skills	25	35,21,26,33	
Broad-based Education			
Lifelong Learning		24,20,36	
Contemporary Practice and Issues	25	7,26,27,33,18,24,5	
Other			

**classroom assessment**

**\*\*See UPRM's Civil Engineering Matrix**



1. Alumni Survey
2. CEEB Math Score
3. Course specific assessments (CAT's)
4. Departmental GPA
5. Design/other competitions
6. Ethics module assessment form
7. Exams, homework, special problems
8. Exit interviews
9. Focus group (satisfaction)
10. General GPA
11. Graduate School advisory questionnaire
12. Graduate school placement data
13. Graduates post-graduation satisfaction survey
14. GRE
15. Honors, recognitions and awards
16. Industry Advisory Board evaluation
17. Industry/employer satisfaction survey
18. Internships evaluations

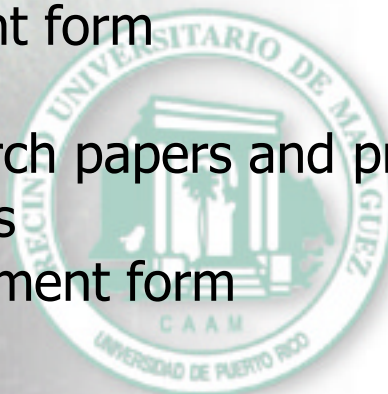
**Tool Box**





19. Laboratory Reports
20. Membership in professional societies
21. Oral presentation assessment form
22. Portfolio evaluation
23. Professional Exam (Fundamental & Discipline specific)
24. Report of attendance to seminars
25. Science Fair participation, awards
26. Senior Project (capstone)
27. Simulations (real world situations)
28. Standardized examinations
29. Student college entrance index (IGS)
30. Student Projects
31. Teamwork Assessment form
32. Transcript
33. Undergraduate research papers and presentations
34. Video of presentations
35. Written report assessment form
36. Other

**Tool Box**





# Assessment Tools File

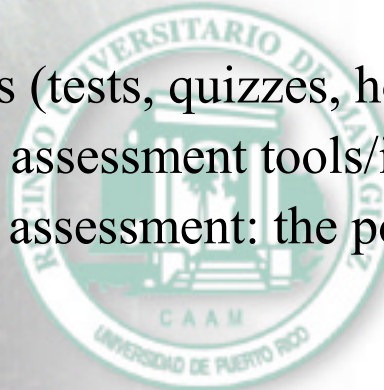
- Oral presentations
- Written reports
- Teamwork (3)
- Undergraduate research experience (2)
- Summer internships (2)
- Faculty teaching
- Course evaluation
- Other



# Exercise 7



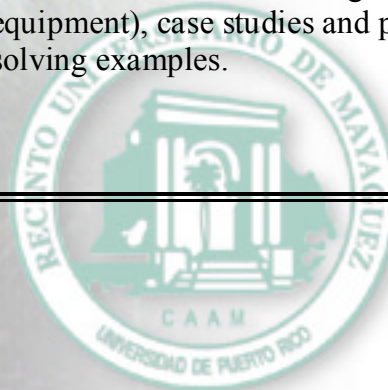
- **Step 4:** Develop Criteria/Tools to Assess Student Performance/Outcomes (page 3) (purple)
  - From the selected topic/objective/strategies:
    - Make a list of possible assessment tools to measure student learning outcomes
      - how will you know if students have learned concepts and developed skills?
        - » traditional tools (tests, quizzes, homework)
        - » non-traditional assessment tools/instruments
        - » overall student assessment: the portfolio





# Example: EC Design of Transmission & Distribution Systems

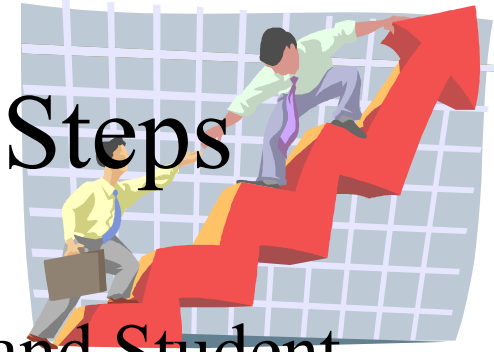
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2. Industrial, commercial and residential energy rate structure	Define and apply energy rate schedules. Understand ethical, legal and economical considerations of energy rate schedules.	Lecture, supplementary reading, problem-solving examples and own life experience.	Team homework and quiz.
3. Distribution transformers: connections, protection, harmonics	Identify and apply distribution transformer connections. Define harmonics, voltage distortion and system protection.	Lecture, pictures (photographs of actual connected and damaged equipment), case studies and problem solving examples.	Team case investigation and short presentation.





# Course Development Steps

- Step 1: Establish Rationale
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## Next steps...

- **Step 5: Determine Special Contacts Needed**
  - Laboratory Facilities
  - Industry collaboration
  - Course materials
    - Textbooks, references
    - Visuals
  - Other



# Next steps...completing the cycle

- **Step 6:** Pilot test & assessment
  - All course materials & assessment tools ready
- **Step 7:** Re-engineer & Report





# Resources

- Classroom Assessment Techniques
  - (Angelo & Cross)
  - NSF Coalitions Assessment Strategies
  - Engineering Programs ABET websites
- Description of Bloom's Major Categories
- R.M. Felder & R. Brent
- Skills for the Millennium (Morell)



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# Workshop Closure & Assessment

- Reflection & Comments:
  - What have you learned?

*“Education is the single most important issue our generation faces today that influences our nation’s course for the future.”*



Daniel Goldin  
Administrator, NASA

From testimony before the U.S. House  
Committee on Science, April 28, 1999

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# Workshop Closure & Assessment

- Workshop evaluation

Thanks!





# Q U O T A B L E


**"The scientist seeks to understand the world and operate against an absolute standard. His findings either describe nature accurately or they do not. By contrast, the engineer is problem-oriented. He seeks not to describe the world but to change it.. The engineer also lives in the world where science and values meet."**

*- Edward B. Fiske, The New York Times  
March 29, 1989*



The logo for the University of Puerto Rico (UPR), consisting of the letters 'UPR' in a bold, sans-serif font, with a teal triangle pointing upwards behind the 'U' and another teal triangle pointing downwards behind the 'R'.

UPR

A faded background image of a classical building with a portico supported by columns and a set of steps leading up to the entrance.

*"What we urgently need today is a more inclusive view of **what it means to be a scholar** - a recognition that knowledge is acquired through research, through synthesis, through practice, and through teaching."*

Ernest L. Boyer  
Scholarship Reconsidered, 1994

