CREATING A CULTURE OF OUTCOMES ASSESSMENT AT NORTH CAROLINA STATE UNIVERSITY

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November 8, 2012

ABET
Assuring Quality • Stimulating Innovation

Background: North Carolina State University College of Engineering

- Large state-supported institution with a mission that includes both high-level research as well as educating large numbers of students at the bachelors, masters, and doctoral levels.
- One of the largest (5th or 6th) engineering programs in the United States
- Offer 18 bachelors, 17 Master's, and 13 Ph.D. programs

Engineering Programs at North Carolina State University

- Aerospace Engineering
- Biomedical Engineering
- Biological Engineering
- Chemical Engineering
- **Civil Engineering**
- Computer Engineering
- Computer Science
- Construction Engineering & Management
- **Electrical Engineering**
- Engineering – Mechatronics Concentration
- Environmental Engineering
- Industrial Engineering
- Materials Science & Engineering
- Mechanical Engineering
- Nuclear Engineering
- Paper Science & Engineering
- Textile Engineering

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Creating of a Culture of Outcomes Assessment

- Why change?
  - Desire to improve the education of our engineering undergraduates
  - National Science Foundation funded engineering education coalition - SUCCEED
  - ABET EC2000
  - University Undergraduate Program Review

Motivating Change

- Research project support for innovation in engineering education – starting in 1992 within SUCCEED
- College-wide focus on educational improvements
- Emphasis on faculty development
- Programmatic accreditation - ABET

ABET Evaluations Before EC2000

- 1998 Visit:
  - College must decide to have programs reviewed under EC2000 or under pre-EC2000 criteria
    - All programs must follow same review criteria
    - Not all programs ready for EC2000
    - Review done with pre-EC2000 criteria
  - Overall, every program received a positive evaluation
  - Environmental engineering was cited for an inoperable vent hood in a teaching laboratory. Problem was remedied in a timely fashion.

Case Study Programs

- Civil Engineering
- Electrical Engineering

Pre EC2000 Civil Engineering Program Criteria

- Faculty
  - **Faculty Qualifications & Size.** Civil engineering programs must have at least *four full-time faculty members who are competent in at least four major discipline areas of civil engineering*, whose primary responsibility is the instruction of undergraduate civil engineering students and the *majority should be registered Professional Engineers*.
  - **Faculty Workload.** A full-time faculty workload must reflect all appropriate activities, e. g., teaching, research, advising, institutional and committee service, and professional society responsibilities. The evaluation of the teaching load should reflect class size, modality of instruction, instructional support, and contact hours.
  - **Faculty Participation.** Faculty members shall be involved with the professional development of students, providing students with the opportunity to interact with practitioners in their major fields through a student organization, or equivalent experience, that has the demonstrated support of the academic unit administering the program.

Pre EC2000 Civil Engineering Program Criteria

- Curriculum
  - **Curricular Objective & Content.** A minimum of one-half year of civil engineering courses. Must achieve broad base of coverage, a minimum of four of the major civil engineering discipline areas must be included.
  - **Engineering Design.** A minimum of one-half year of engineering design is required and programs are encouraged to integrate design concepts and methodology throughout the curriculum. Program must culminate in a major comprehensive design experience. Team design projects are highly recommended. The final design experience should include practitioner involvement and student reports and presentations should an integrated part of the final design experience.
  - **Laboratory Experience.** The laboratory experience should be integrated in the program and include creativity, team effort, open-ended decision making, oral and written communication skills, design of experimental procedures and processes, and use of experimental methods for problem solving, discovery and self-learning.

Pre EC2000 Electrical Engineering Program Criteria

- Faculty
  - **Faculty Qualifications & Size.** Electrical engineering programs must be sufficiently large and diversified to provide breadth in the field and depth in accord with the stated objectives of the program. Faculty must have clearly defined responsibility for establishing curriculum objectives and content and be sufficiently dedicated to ensure it is kept up-to-date.
  - **Teaching Loads.** Teaching loads must leave time for continuing professional development of the faculty through activities such as engineering research, instructional innovation, engineering consulting and sabbatical leaves.

Pre EC2000 Electrical Engineering Program Criteria

- Curriculum
  - **Curricular Objective & Content.** The curriculum must provide depth and breadth in electrical and electronic(s) engineering. Depth requires the study of at least one area of electrical and electronic(s) engineering at the advanced level. Breadth requires coverage of several areas of electrical and electronic(s) engineering.
  - **Mathematics.** Additional work is required in one or more of the subjects of probability and statistics, linear algebra, numerical analysis, advanced calculus, partial differential equations, and complex variables, and must be used in electrical and electronics courses.
  - **Engineering Design.** Advanced courses that emphasize design must have a size and structure that provide for individual attention to each student..
  - **Computer Use.** Appropriate use of computers must be integrated with laboratory and course work. Program must include instruction in software design and must enable students to gain experience programming in a modern software development environment. Students also must be given access to several of the software packages available for engineering simulation, analysis and design.

Characteristics of the Pre EC2000 Approach

- Detailed emphasis on the inputs to the educational process
- Detailed emphasis on the curricular content
- Specific descriptions about laboratories and computer usage
- Specific delineation on what faculty members should do

College Commitment to Change

- Leadership and facilitation by the Associate Dean for Academic Affairs – Sarah Rajala
- Establishment of a college-wide committee of program faculty
- Support and recognition for faculty leaders
- Commitment by college administration to ensure alignment of university program review and accreditation processes

Keys to Success

- Administrative buy-in and leadership
- Commitment of resources
- College level coordination and support
- Faculty ownership
- Faculty development
- Patience
- Flexibility
- Open communication

Peer-to-Peer Sharing

- “If we can take away at least one thing from each of our monthly meetings, it makes them worthwhile – and we’ve done that all year!” Faculty Assessment Leader

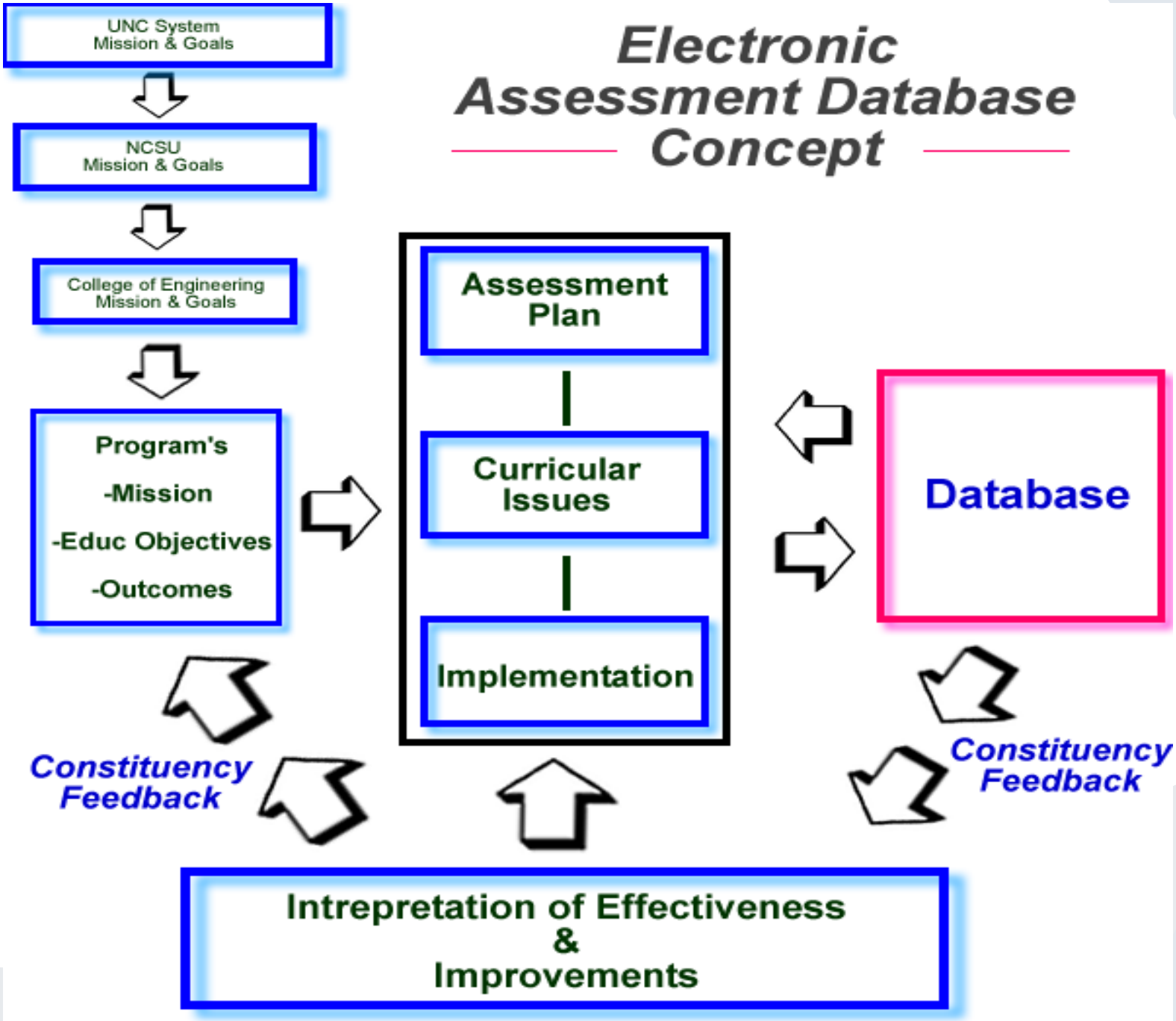
Classroom Embedded Assessment

- Linking courses, curricula and program outcomes
  - Course contribution matrix
- How does “my” course relate to the program outcomes?
  - Syllabus changes
- To what extent does my course relate to the outcome?
  - Major, moderate, minor

Course-based Assessments

- Clear identification of learning outcomes
- Development of assessment rubrics
- Example - TE 402
  - Weaknesses
    - Ability to identify specific customer groups for whom the product would solve the problem or meet the need
    - Ability to effectively sell the product in terms of its potential economic, technical or environmental viability
  - Change
    - More guided practice of these two issues

Electronic Assessment Database Concept



Database

- Information About Students
- Course Assessments
- Student's Ability Reported by Students
- Satisfaction Reported by Students
- Student's Ability Reported by Employers
- Nationally Normed Tests
- Information about Faculty & Courses
- Information about Facilities & Equipment

Biological Engineering
Assessment Database

Program Educational Objectives
Department of Biological and Agricultural Engineering
North Carolina State University

05/5/00

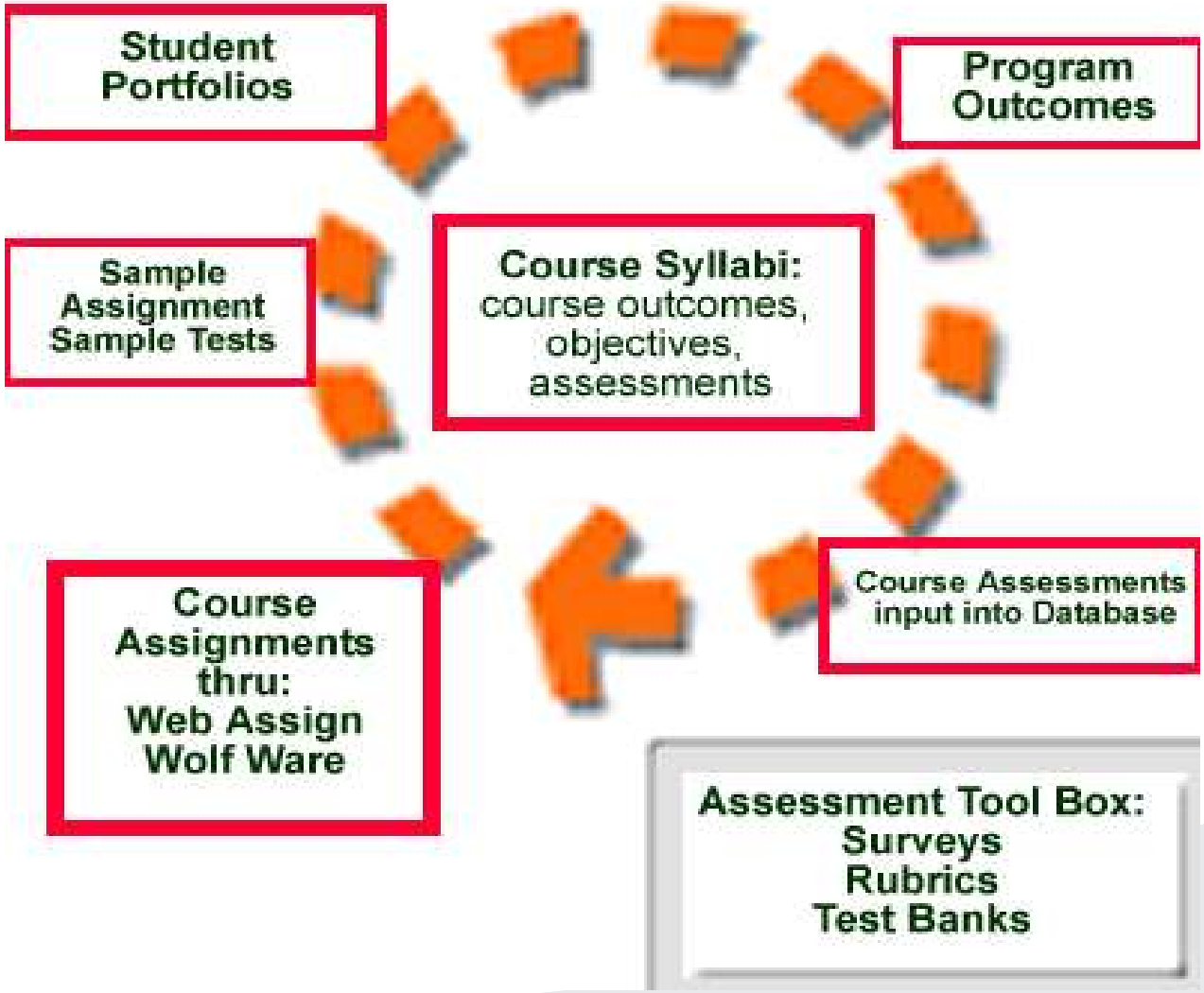
Mission Statement

The Department of Biological and Agricultural Engineering offers an undergraduate BS program in Biological Engineering. Four areas of educational focus are provided under this program: Agricultural, Biomedical, Bioprocessing and Environmental. The faculty of this department have developed the following undergraduate educational objectives.

Program Educational Goals:

1. To educate students for successful careers in engineering, as related to one of the specialized program focus areas: Agricultural, Biomedical, Bioprocessing and Environmental. Emphasis is placed upon mastering the fundamentals of engineering and biology, the ability to solve engineering problems, and understanding the creative process of engineering design.

Links to Curriculum



Biological Engineering
Assessment Database

DEPARTMENT OF BIOLOGICAL AND AGRICULTURAL ENGINEERING
ASSESSMENT PLAN

September 22, 2000

(a) To demonstrate that graduates have an ability to apply knowledge of mathematics, science, and engineering, they should:

Evidence for Assessment

Portfolios: Samples from homework and tests in which students apply their knowledge of mathematics, science, and engineering to problem sets, showing that they can do so following the above three steps.

Results of Fundamentals of Engineering exam: Percentage of students and graduates who take it and percentage of those who pass it.

Survey of graduates: My education at NC State has given me the ability and the confidence to apply general principles of mathematics, science, and engineering to the engineering problems I encounter at work.

Survey of employers: The NC State graduate is entirely satisfactory in his or her ability to apply general principles of mathematics, science, and engineering to engineering problems.

TE 402: Textile Engineering Senior Design
Date: Spring 2002 Summary

Percentage Of Students Who Meet Each Dimension

PROBLEM DEFINITION : The student should:	N/A	poor	good	superior
identify specific customer groups for whom the product would solve the problem or meet the need		30	40	30
describe the project requirements such as parameters related to finances or time and constraints on equipment and raw materials	X			
analyze the technology necessary and available for meeting market needs, 10 20 70 including a survey of existing technology, potential technology, and technology used by potential competitors		10	20	70

CONCEPT REFINEMENT : The student should:				
create an appropriate and useful prototype, model, or other visual representation of the proposed product		10		90
test the design by performing a technical analysis on the product representation (how well it works)				100
test the design by performing an economic analysis (cost/benefit ratio, viability of production, etc.)		20		80
address the environmental impact of the manufacturing, disposal of by products, and overall risk to society of the potential product				100
effectively sell the product in terms of its potential economic, technical, an environmental viability		20	20	60

Evaluation of Student Outcomes

Student Outcome:

- To demonstrate that graduates have an ability to apply knowledge of mathematics, science, and engineering…

Assessment Report:

- Assessment of FE data and Survey data indicated that students had difficulty in differential equations and other math concepts
- Added Math 245 in Fall of 1998.
- Student's reported ability in math has risen since the new course was added to the curriculum. Also higher than other students in engineering programs at NCSU.

Civil Engineering Assessment Database

Outcome A: Graduates must have knowledge of mathematics, science, and engineering

Choose Same Outcome for Different Program: Civil Engineering Go

Choose Different Outcome for Same Program: Outcome A Go

Results of FE Exam

Graduating Senior Survey

Faculty Perception Survey

How to Interpret Survey Data

Interpretation of Data by Faculty

Graduating Senior Survey*

What extent do you think your college education contributed to your knowledge in using mathematics skills?

Year	Not At All (Percent)	Very Little (Percent)	Somewhat (Percent)	Very Much (Percent)	Mean	N
1997	.	6.67	26.67	66.67	3.6	45
1998	.	.	14.71	85.29	3.85	34
1999	.	.	11.54	88.46	3.88	26
2000	.	.	11.76	88.24	3.88	51

What extent do you think your college education contributed to your knowledge in applying scientific methods of inquiry?

Year	Not At All (Percent)	Very Little (Percent)	Somewhat (Percent)	Very Much (Percent)	Mean	N
1997	.	4.44	48.89	46.67	3.42	45
1998	.	2.94	32.35	64.71	3.62	34
1999	.	.	11.54	88.46	3.88	26
2000	2	.	22	76	3.72	50

Employer Survey

Added Math 245 Here

ABET

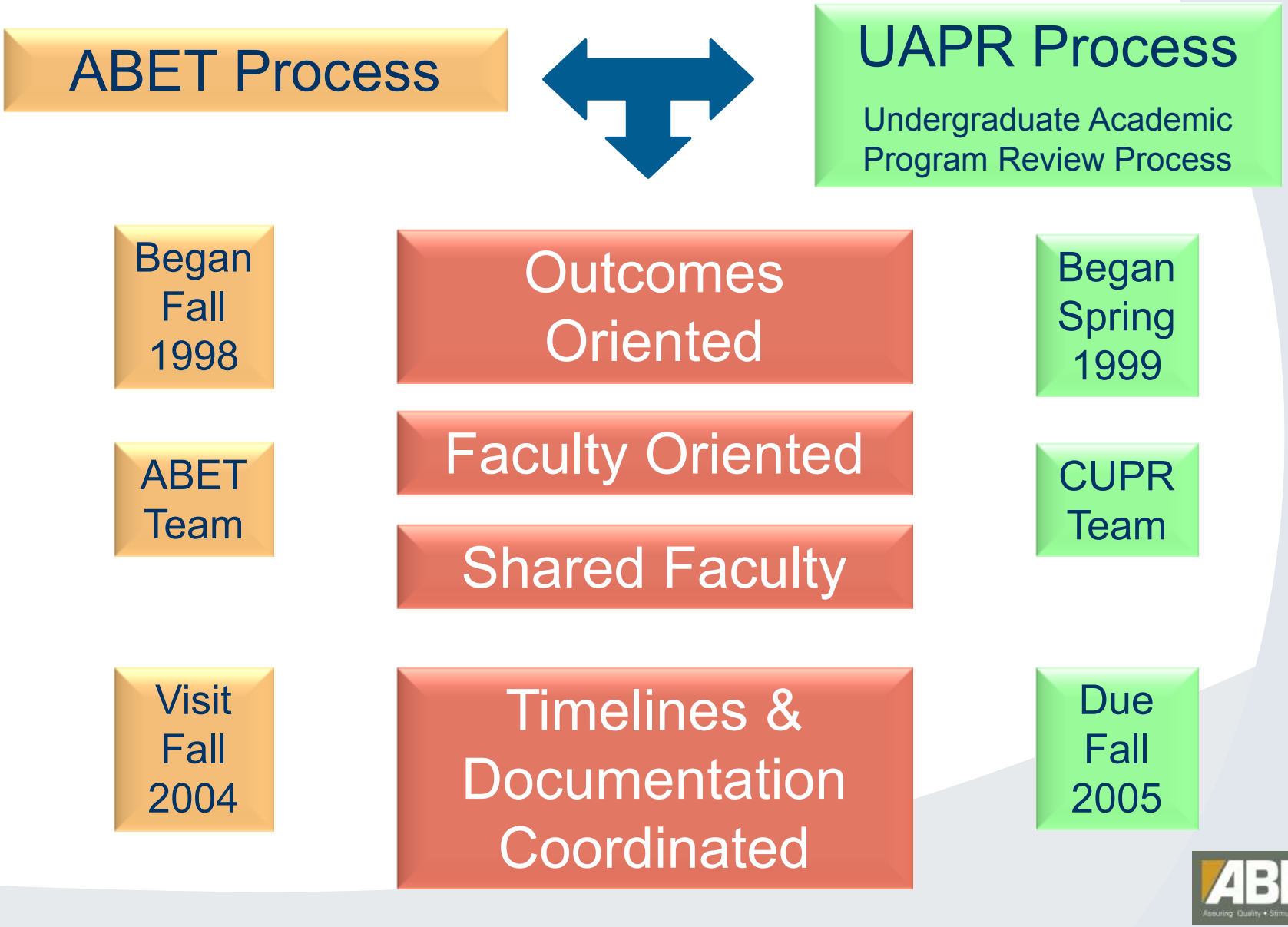
External Review

- Constituency input and review
  - Periodic and ongoing
- Programmatic accreditation of engineering and computer science programs by ABET
  - Fall 2004, Fall 2010
- University academic program reviews (UAPR)
  - Fall 2005, Fall 2011

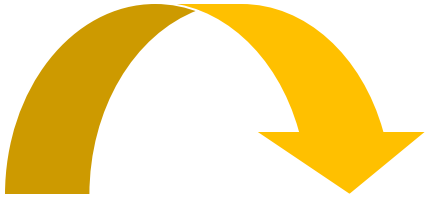
Developing Database and Website

- Based on Assessment Model
- Outcomes Oriented
- All data, findings, reports in one place
- Available to ALL faculty, at ALL times
- Several years of data can be displayed
- Evaluators may use website/CD
- Keep it Simple!

Parallel Process



Influence



ABET Process

Terminology was defined that matched both processes (ABET driven)

Assessment personnel worked with engineering faculty to develop Assessment Plans (ABET oriented)

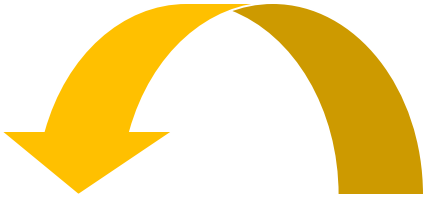
Engineering piloted workshops that were offered to other faculty

Course based assessment pushes other programs to consider course assessment

UAPR Process

Undergraduate Academic Program Review Process

Influence



ABET Process

UAPR Process

Undergraduate Academic Program Review Process

Cooperation among departments such as mathematics and engineering helps all programs

Deadlines for submission and subsequent review of documents reinforces ABET process

Faculty Facilitators: more training for faculty in engineering

EC 2000 Criterion 2: Program Educational Objectives

- Civil Engineering - 2004 & 2010
- The educational objectives of the civil engineering are to prepare graduates to:
  - Function successfully in a professional environment by utilizing and enhancing their problem-solving and communication skills;
  - Continue learning through graduate or other professional education and obtain licensure where appropriate;
  - Provide professional leadership within their companies, engineering societies and civic organizations, and to provide mentoring for those under their supervision and influence; and
  - Promote organizational success with consideration to cost and time management while practicing and promoting ethical behavior and stewardship of a sustainable environment.

EC 2000 Criterion 2: Program Educational Objectives

- Electrical Engineering - 2004, 2010
- The electrical and computer engineering programs are preparing their graduates for the following professional and career accomplishments:
  - Engineering problem development and solution using engineering analysis, experimentation, and creativity based on sound mathematical and scientific principles;
  - Electrical/computer systems, components, processes design requiring knowledge of the discipline, teamwork, communication skills and an ability to work with a diverse set of constraints;
  - Productive engineering practice, research or management using technical, hands-on and professional knowledge, skills and initiatives required for success in the public, private or academic sectors; and
  - Continuing education and learning on the job, experiential learning, leading and mentoring others and the ability to apply lessons learned to new situations.

New Definition of Program Educational Objectives

- 2010 Definition
- Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing the graduates to achieve.
- EE program was cited in 2010 because program educational objectives did not meet current definition

2010 Definition of Civil Engineering Program Criteria

- **Curriculum**
- The program must demonstrate that graduates can
  - apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of science, consistent with the program educational objectives;
  - apply knowledge of four technical areas appropriate to civil engineering;
  - conduct civil engineering experiments and analyze and interpret the resulting data;
  - design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and
  - explain the importance of professional licensure.

2010 Definition of Civil Engineering Program Criteria

- Faculty
- The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.

2010 Definition of Electrical Engineering Program Criteria

- **Curriculum**
- The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program.
- The program must demonstrate that graduates have
  - knowledge of probability and statistics, including applications appropriate to the program name and objectives;
  - knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives.

2010 Definition of Electrical Engineering Program Criteria

- **Curriculum**
- Programs must also demonstrate that graduates have a knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics.
- **Faculty**
- No additional requirements.

North Carolina State's Experience

- Have gone through two cycles using EC2000
- Learned more each time and have gotten much better at managing assessment and evaluation workload
- Assessment tools used to evaluate PEO achievement
  - University-wide tools for alumni surveys
  - Active engagement of Departmental Advisory Boards
  - Alumni and industry focus groups
  - Documentation maintained in database

North Carolina State's Experience

- Kept to the basic a-k ABET student outcomes
  - Used the ABET a-k student outcomes
  - Developed a web-based tool for capturing assessment data
  - Used the Undergraduate Curriculum Committee to perform frequent evaluations of assessment data
  - Used university-wide resources for surveys: first year students, graduating senior, alumni, and employer
  - Established a College of Engineering wide ABET committee which meets regularly to share information and address problems

North Carolina State's Experience

- 2010 ABET review
- Civil engineering
  - Initially cited for a facilities weakness for laboratory safety – safety plans and procedures were not being followed
  - Correction made in due process to overcome shortcoming

North Carolina State's Experience

- 2010 ABET review
- Electrical engineering
  - PEOs cited for not clearly stating what the program expects its graduates should achieve
  - Survey used to assess PEOs did not clearly measure attainment
  - Correction was made in due process

Final Comments

- Academic program assessment is a continuous process
- Providing support and encouragement is important
- Providing opportunities to share best practices, as well as concerns, among the academic programs is beneficial