Vision for Change:

Preparing the Environment for Engineering Program Transformation based upon ABET's Outcomes Based Criteria (EC2000)

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Moscow

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Topics

- ***Who is ABET?***
- Development History – EC2000
- Future Challenges

ABET Vision

ABET will provide world leadership in assuring quality and in stimulating innovation in applied science, computing, engineering, and technology education.

ABET Organization Design

- ABET is a federation of 31 professional engineering and technical societies.
- Neither institutions nor individuals are members of ABET.
- ABET relies on the services of almost 2,200 volunteers and 33 full-time and seven part-time staff.

Member Societies

- Represent “the profession”
- Develop program criteria
- Appoint Board Reps
- Nominate commissioners
- Recruit and assign program evaluators

ABET's 31 Societies

ASHRAE
Advancing HVAC&R to serve humanity and promote a sustainable world

SME Society of Manufacturing Engineers

AIChE

SME Society for Mining, Metallurgy & Exploration

SPIE

ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

NCEES advancing licensure for engineers and surveyors

ASEE American Society for Engineering Education

SFPE Advancing the Science and Practice of Fire Protection Engineering Internationally

IEEE

SPE International Society of Petroleum Engineers

ASABE

CSAB Leading Computing

ISA

ASME Setting the Standard

TMS

BMES

ASSE

American Congress on Surveying & Mapping 1941

AIHA Protecting Worker Health

The Society of Naval Architects & Marine Engineers

American Nuclear Society

WEPAN Women in Engineering ProActive Network

INCOSE International Council on Systems Engineering

National Institute of Ceramic Engineers (NICE)

American Academy of Environmental Engineers®

National Society of Professional Engineers®

SAE International™

AIAA The World's Forum for Aerospace Leadership

MRS Materials Research Society The Materials Gateway

ABET

ABET is Volunteer-Driven

2,000+ *Volunteers*

Board of Directors

- Nominated by member societies
- Provide strategic direction and plans
- Decide policy and procedures
- Approve criteria

4 Commissions

- ASAC, CAC, EAC, ETAC
- Make decisions on accreditation status
- Implement accreditation policies
- Propose changes to criteria

Program Evaluators

- Visit campuses
- Evaluate individual programs
- Make initial accreditation recommendations
- "Face of ABET"

100% of accreditation decisions are made by volunteers

Organization Structure

ABET Board

- **Committees**
- **Accreditation Council**
- **Industry Advisory Council**
- **Academic Advisory Council**
- **Global Council**

Applied Science Accreditation Commission

71 accredited programs at 54 institutions

Computing Accreditation Commission

381 accredited programs at 299 institutions

Engineering Accreditation Commission

2,209 accredited programs at 456 institutions

Engineering Technology Accreditation Commission

633 accredited programs at 213 institutions

Accreditation in the U.S.

- Non-governmental
- Voluntary
- Peer review

What Does ABET Accredit?

- An academic program leading to a specific degree in a specific discipline.
- Misconceptions clarified:
  - Not institutions
  - Not schools, colleges, or departments
  - Not facilities, courses, or faculty
  - Not graduates
  - Not degrees

ABET Accreditation Process – What Does It Involve?

- Criteria developed by member societies, practitioners, and educators
- Self-Study Report by the institution and program
- On-site evaluation by peers (from education, government, and industry)
- Publication of lists of accredited programs
- Periodic re-evaluation (maximum 6 years)

Accreditation Timeline

18 month process

Year 1

January
Institution requests accreditation for programs

February - May
Institution prepares self-evaluation (Program Self-Study)

March - June
Team members assigned, dates set, Self-Study submitted

September - December
Visits take place, draft statements written and finalized following 7-day response period

December - February
Draft statements edited and sent to institutions

Year 2

February - April
Institutions respond to draft statement and return to ABET

May - June
Necessary changes to statement, if any, are made

July
Commission meets to take final action

August
Institutions notified of final action

October
Accreditation actions publically released

History of EC2000

Criteria (as of 2012)

1. Students
2. Program Educational Objectives
3. Student Outcomes
4. Continuous Improvement
5. Curriculum
6. Faculty
7. Facilities
8. Institutional Support

Criterion 3: Student Outcomes (1/4)

- The program must have documented student outcomes that prepare graduates to attain the program educational objectives.
  - Narrow statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Criterion 3: Student Outcomes (2/4)

- The program **must demonstrate that** their students attain the following outcomes:
  a) An ability to apply knowledge of mathematics, science, and engineering
  b) An ability to design and conduct experiments, as well as to analyze and interpret data
  c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

History of EC2000

ABET
Assuring Quality • Stimulating Innovation

Criterion 3: Student Outcomes (3/4)

d) An ability to function on multidisciplinary teams
e) An ability to identify, formulate, and solve engineering problems
f) An understanding of professional and ethical responsibility
g) An ability to communicate effectively
h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Criterion 3: Student Outcomes (4/4)

i) A recognition of the need for, and an ability to engage in life-long learning
j) A knowledge of contemporary issues
k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

- Plus any outcomes specific to field of study

Value of ABET Accreditation

- Widely recognized as “Gold Standard” throughout the world
- Outcomes based approach
- Emphasis on Continuous Quality Improvement
- Flexible criteria: Encourage innovation
- Recognition of the value of accreditation
  - Preparing graduates for entry into technical professions

ABET Accreditation Activities

- Accredited **3278** programs at **671** colleges & universities in **24** countries (As of Oct 1, 2012)

- October 2006 – Accreditation outside the US approved by ABET Board
  - Uniform accreditation criteria, policies and procedures used for all visits, regardless of location
  - Coordinated with national authority/accrediting agency

- Currently accredited **324** programs at **64** institutions in **23** countries outside US

ABET's Role in Globalization

- Assist nations in developing their accreditation systems
- Provide guidance in the implementation of continuous quality improvement in engineering education in other countries
- Work with regions with similar educational systems to develop a regional quality assurance system
- Promote and develop bilateral and multilateral recognition agreements
- Assist in mobility of technical professionals

Topics

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- ***Development History – EC2000***
- Future Challenges

Engineering Criteria 2000

What Were the Drivers?

We Needed a Catalyst For Change

- Proliferation of Criteria
- Need for Innovation in Programs
- Prescriptive Nature of Criteria
- Industry Call for Change

We Created a Paradigm Shift, Employing a New Philosophy

We were going to spend less time examining what students were taught,

And spend more time assessing what they learned.

Paradigm Shift

Institutions and Programs were to define mission and objectives to meet the needs of their constituents – thus enabling program differentiation

Emphasis on outcomes – preparation for professional practice

Programs demonstrate how criteria and educational objectives are being met

New Emphasis

- Practice of continuous improvement
  - Input of Constituencies
  - Process focus
  - Outcomes and Assessment Linked to Objectives
- Knowledge, skills, and behaviors required for entry into the profession
- Student, faculty, facilities, institutional support, and financial resource issues linked to Program Objectives

CQI Starts with Basic Questions

Who are our constituencies?

What services do we provide?

Do constituencies understand our objectives?

What services, facilities and policies must be present if we are to satisfy our constituencies?

Do our suppliers and institutional leadership understand and support our needs?

More Basic Questions

What steps do we perform to provide our services?

How do we measure our results?

How do we use these results to continuously improve the services we provide?

Are we achieving our objectives and improving?

Are our constituencies satisfied?

Foundation of CQI is Assessment

Assessment of inputs & process only establishes the "capability" or "capacity" of a program

Assessment of "outcomes" determines what is accomplished with that capability

Timeline

1992 Accreditation Process Review Committee formed by ABET

1993 At Summer Engineering Accreditation Commission meeting EAC voted to hold a winter meeting to determine if and how criteria should change

1994 The Vision for Change (NSF Grant DUE-9453820) funded ABET/NSF/Industry Workshops:

May 1994	Criteria Reform	New York City
June 1994	Participation	New Orleans
Aug 1994	Accreditation Process Reform	Atlanta

Timeline

1994 ABET Board of Directors approved Workshop recommendations in principle

1994 ABET publishes *Vision for Change,* summarizing Workshops, for engineering community

1994 ABET Engineering Accreditation Commission Winter Meeting -- voted unanimously to change and start with "clean page"

1994 Committees began drafting new accreditation criteria and process improvements

1995 March ... First draft developed and published for comment

1995 July ... EAC modified and approved EC2000 First Edition

Timeline

1995 October … ABET Board of Directors approved the publication for comment of a new set of criteria for evaluating engineering programs – Engineering Criteria 2000

1995-1997 … Two year comment period

1996 Spring … Technical societies developed draft program criteria

1996 July … EAC approved draft program criteria with more editing expected

1996 November … ABET Board voted final approval of general criteria *(one year early)* with three year phase in to begin fall 1998, and approved program criteria for review and comment

1996-1997 … Two sequences of pilot visits (NSF Grant DUE-9612041)

Timeline

1997 Spring … Technical societies revised program criteria

1997 July … EAC approved revised program criteria

1997 November … ABET Board voted final approval to program criteria

1998-2001 … (12) ABET/NSF/Industry Regional Faculty Workshops
(NSF Grant EEC-9812888)

1998 United Engineering Foundation funds grant (98/AE-18) for program
evaluator training workshops

1999 The Action Agenda for Engineering Curriculum Innovation
("Action Agenda") Program (NSF 99-169 replaces NSF 98-27)

2002 Sloan Foundation sponsors "A Colloquy on Learning Objectives for
Engineering Education Laboratories – *Mission Bay, CA*

Timeline

2002 Longitudinal study initiated through the Penn State Center for Studies in Higher Education

2002 ABET Town Meeting to solicit constituent feedback *(November)*

2003 Accreditation Reform Workshop Leaders *(early 2003)*

2003 Sustainability Retreat with representatives from programs evaluated under EC2000 *(mid 2003)*

2004 *Sustaining the Change* follow up report (after 10 years) to *Vision for Change*

2006 Final Report from Penn State study: *ENGINEERING CHANGE A Study of the Impact of EC2000*

How Did We Get Started With Training?

- 1997 January -- technical societies agree to use core Program Evaluator training materials
- 1997 March -- first evaluator training conducted
- 1997 July EAC Meeting -- Team Chair training
- 1997 Fall -- training materials revised
- 1998 Spring -- training materials revised
- 1999 Fall -- more than 600 Program Evaluators trained

How Did We Get Started With Visits?

1996 Fall -- Pilot Visits – two institutions, 14 programs

1997 Spring -- developed draft Self-Study Instructions

1997 Fall – Pilot Visits – three institutions, 16 programs

1998 Fall -- First round phase-in visits - 12 institutions, 54 programs

1999 Fall -- Second round phase-in visits – 46 institutions, 249 programs

2000 Fall -- Third round phase-in visits – 48 institutions, 270 programs

2001 Fall – required for all programs 51 institutions, 299 programs

2002 Fall – required for all programs 79 institutions, 331 programs

Research Results

PENNSTATE

Center for the Study of Higher Education

Findings from *Engineering Change:* A Study of the Impact of EC2000

Lisa R. Lattuca, Project Director and Co-PI
Patrick T. Terenzini, Co-PI
J. Fredericks Volkwein, Co-PI

Presentation to the ABET Annual Meeting

October 27, 2005
San Diego, CA

Key Questions

1. What impact, if any, has EC2000 had on graduating seniors’ preparation to enter the engineering profession?

2. What impact, if any, has EC2000 had on practices that may be related to changes in student preparation?

Significance of the *Engineering Change Study*

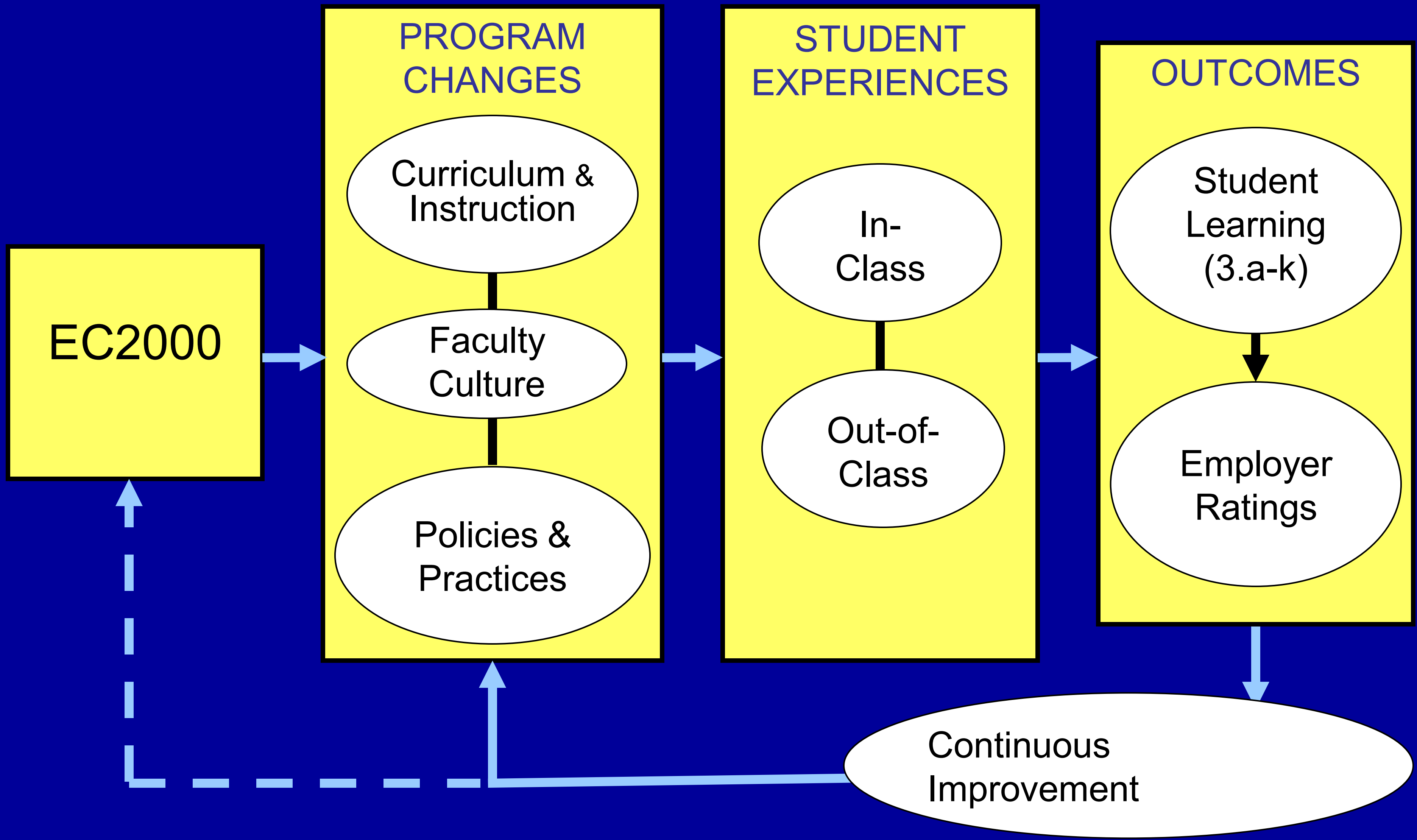
Engineering Change Study provides:

- The first national study of the impact of outcomes-based accreditation in the U.S.
- A model for future assessments in engineering, applied science, technology, and computer science, as well as other professions.

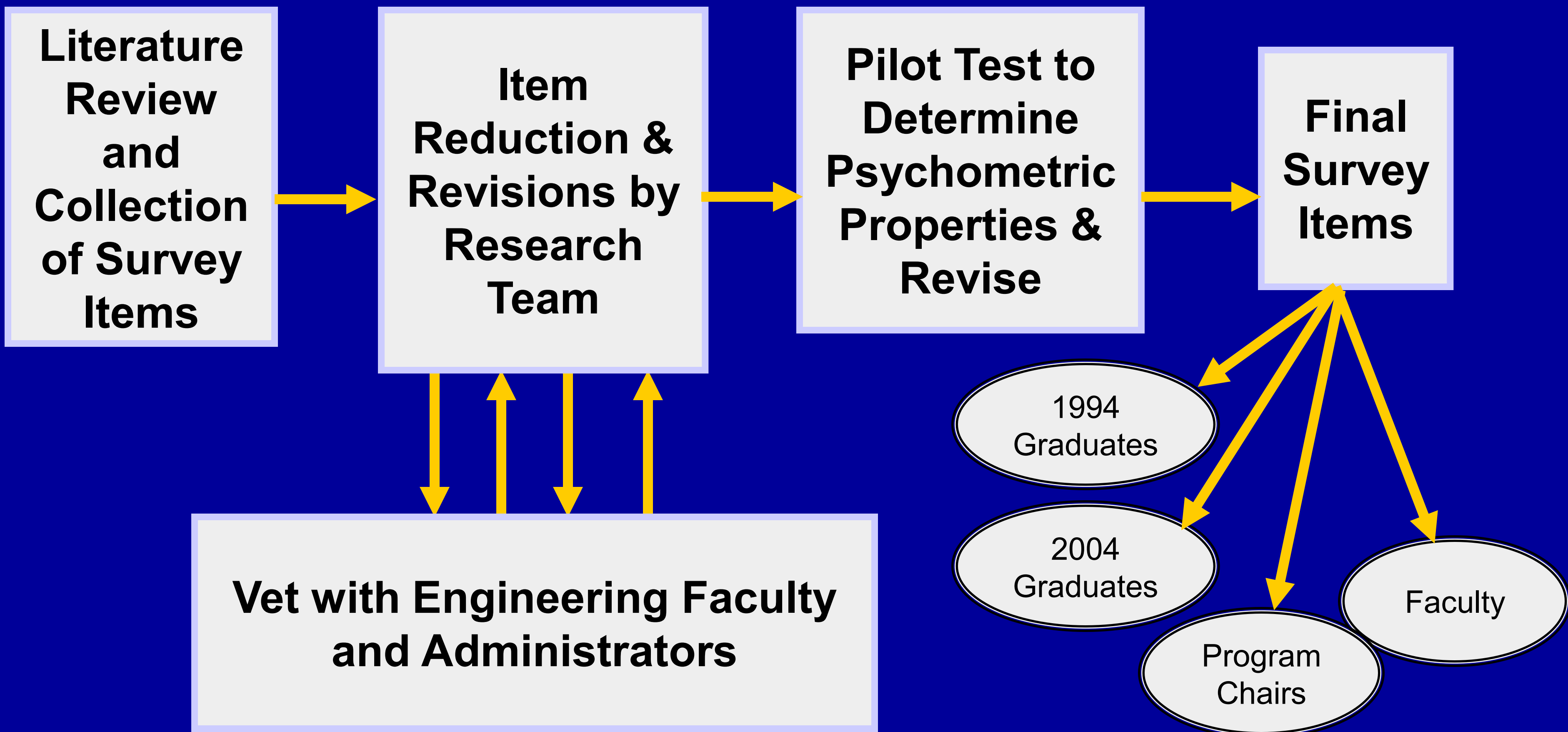
Significance of the *Engineering Change Study* for Engineering

- Establishes a pre-EC2000 benchmark (1994) for graduating seniors' preparation.
- Portrays post-EC2000 changes in curricula, instruction, faculty culture, and policies/practices.
- Provides the first post-EC2000 data point (2004) on graduating seniors' preparation.

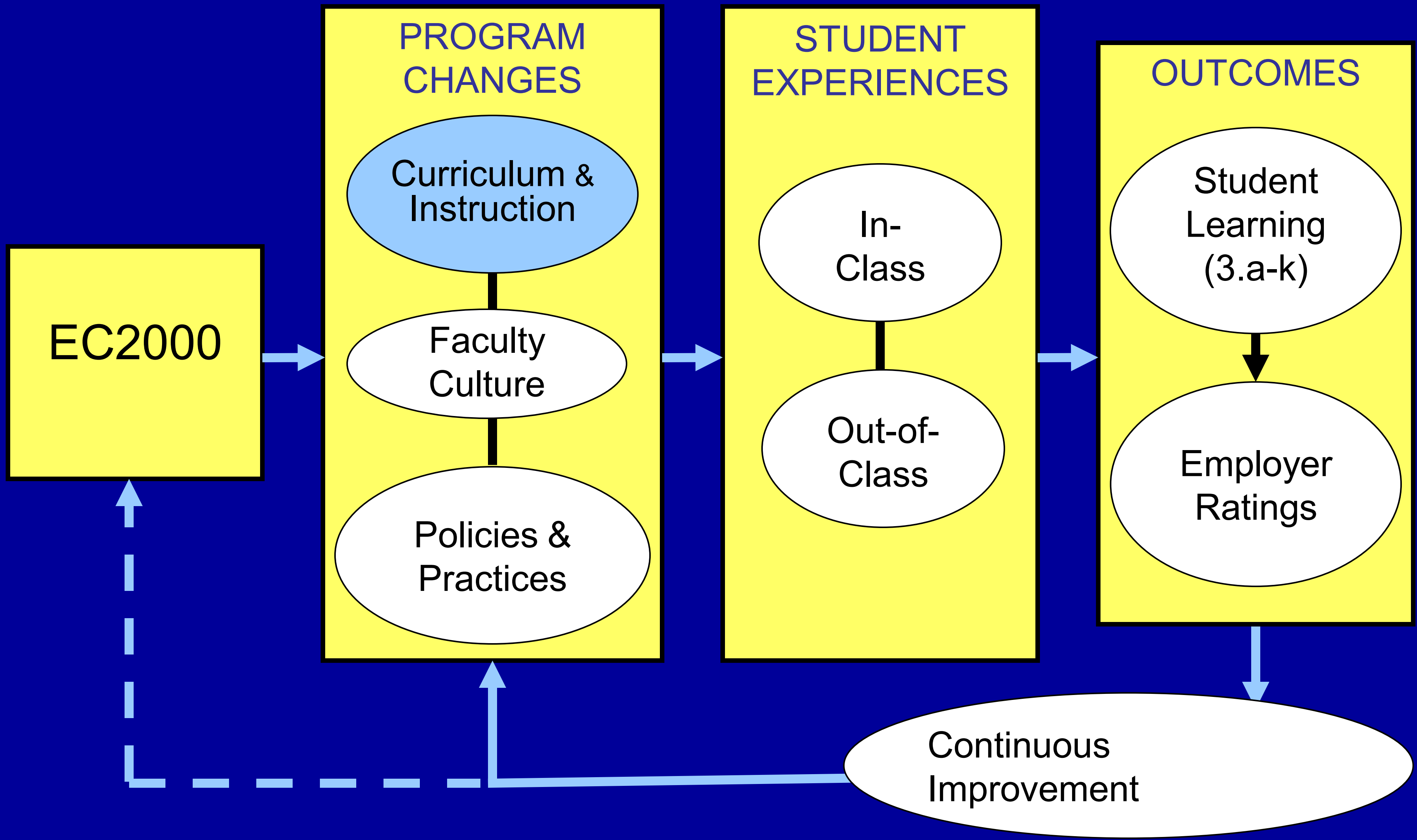
Engineering Change: Studying the Impact of EC2000



Development of Survey Instruments



Engineering Change: Studying the Impact of EC2000



Significant Findings: Curriculum and Instruction at Program Level

Program chairs report:

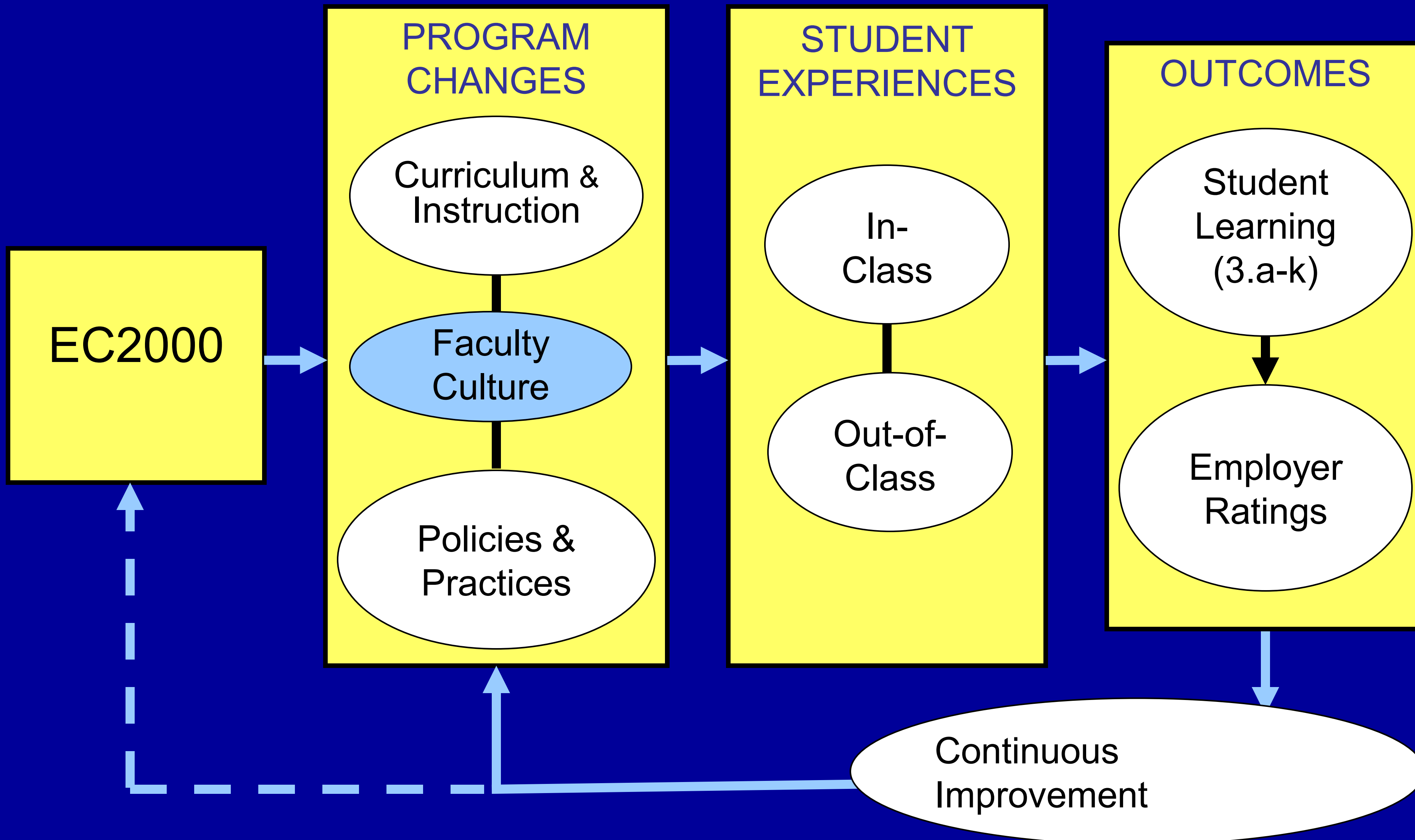
- Increased program emphasis in past decade on knowledge and skills central to EC2000.
- Greatest increases in emphasis on teamwork, communication skills, and use of engineering tools.
- Industry and ABET recognized as “moderate” to “strong” forces for curricular change.

Significant Findings: Curriculum and Instruction at Course Level

Faculty report:

- Increased emphasis on engineering tools, design, teamwork, and contemporary issues and contexts.
- Increased use of active learning methods.
- Faculty attribute changes primarily to their own initiative, but 20 - 25% view ABET and industry as influences on change.
- Faculty and chairs report little change in emphasis on basic math and science.

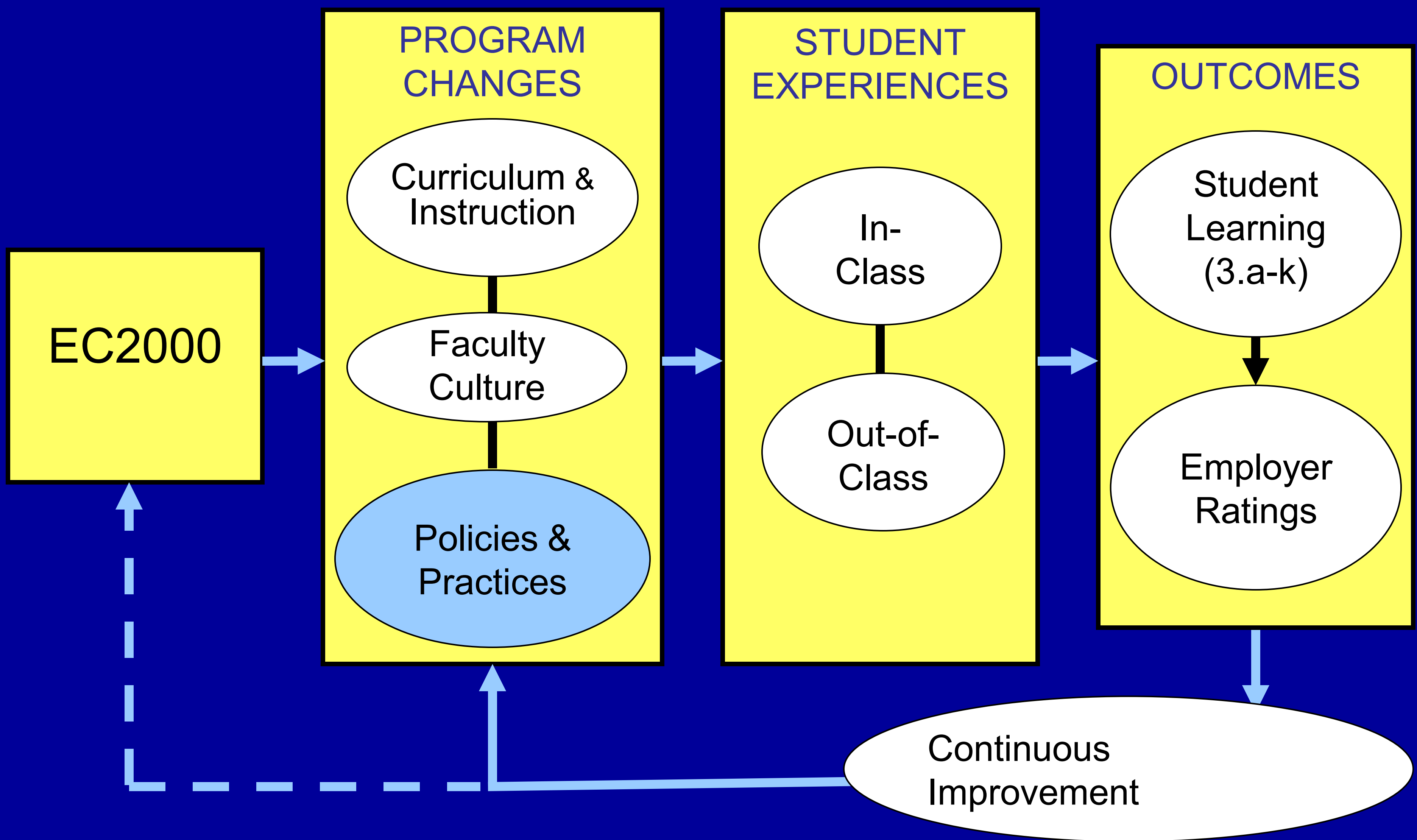
Engineering Change: Studying the Impact of EC2000



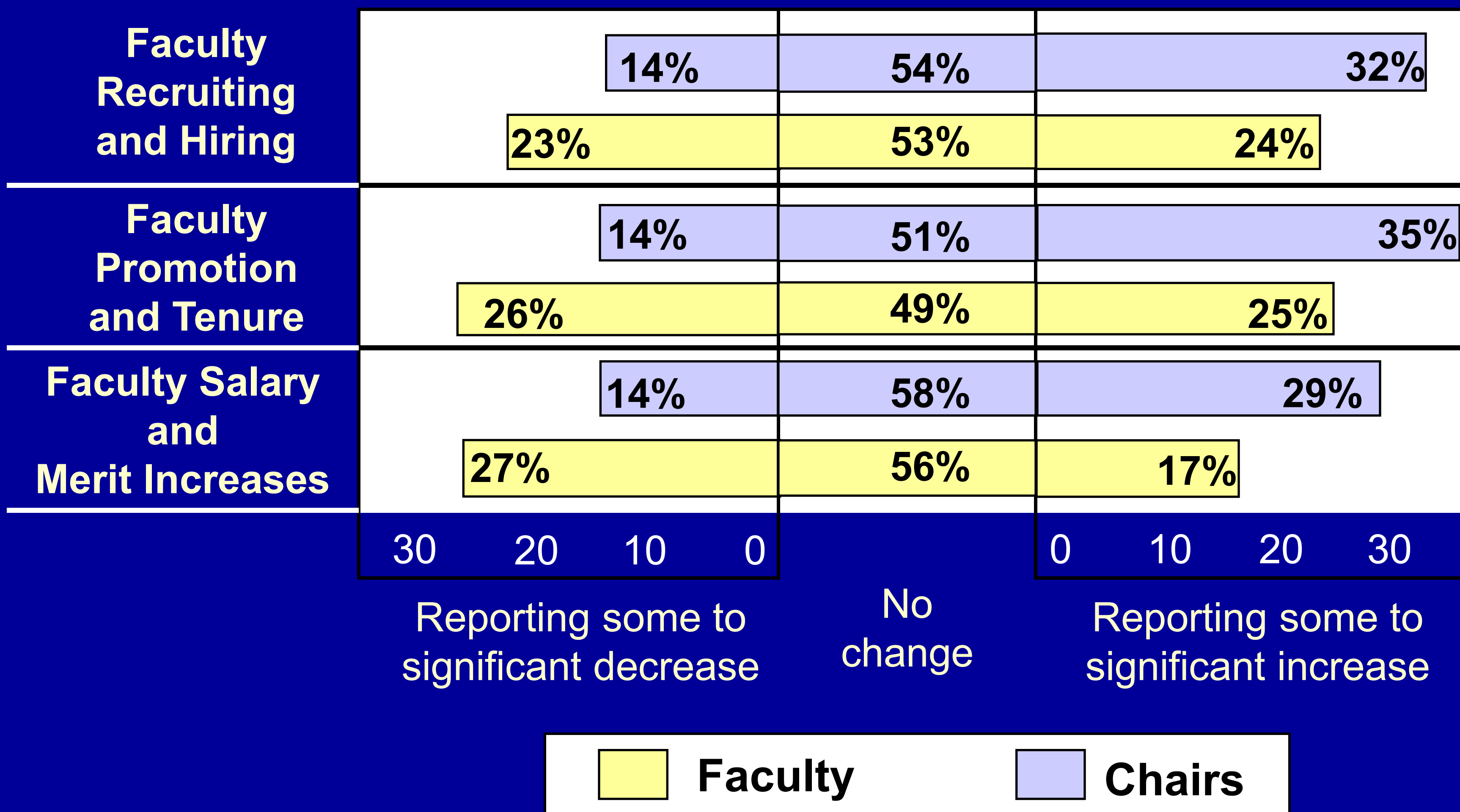
Significant Findings: Faculty Culture

- More than 70% of program chairs indicate high levels of faculty support for continuous improvement.
- 88% of faculty report at least some personal effort in program assessment.
- 68% of faculty consider their level of effort in assessment to be “about right.”
- 20 - 25% of faculty say they have increased their personal efforts to improve their courses.

Engineering Change:
Studying the Impact of EC2000

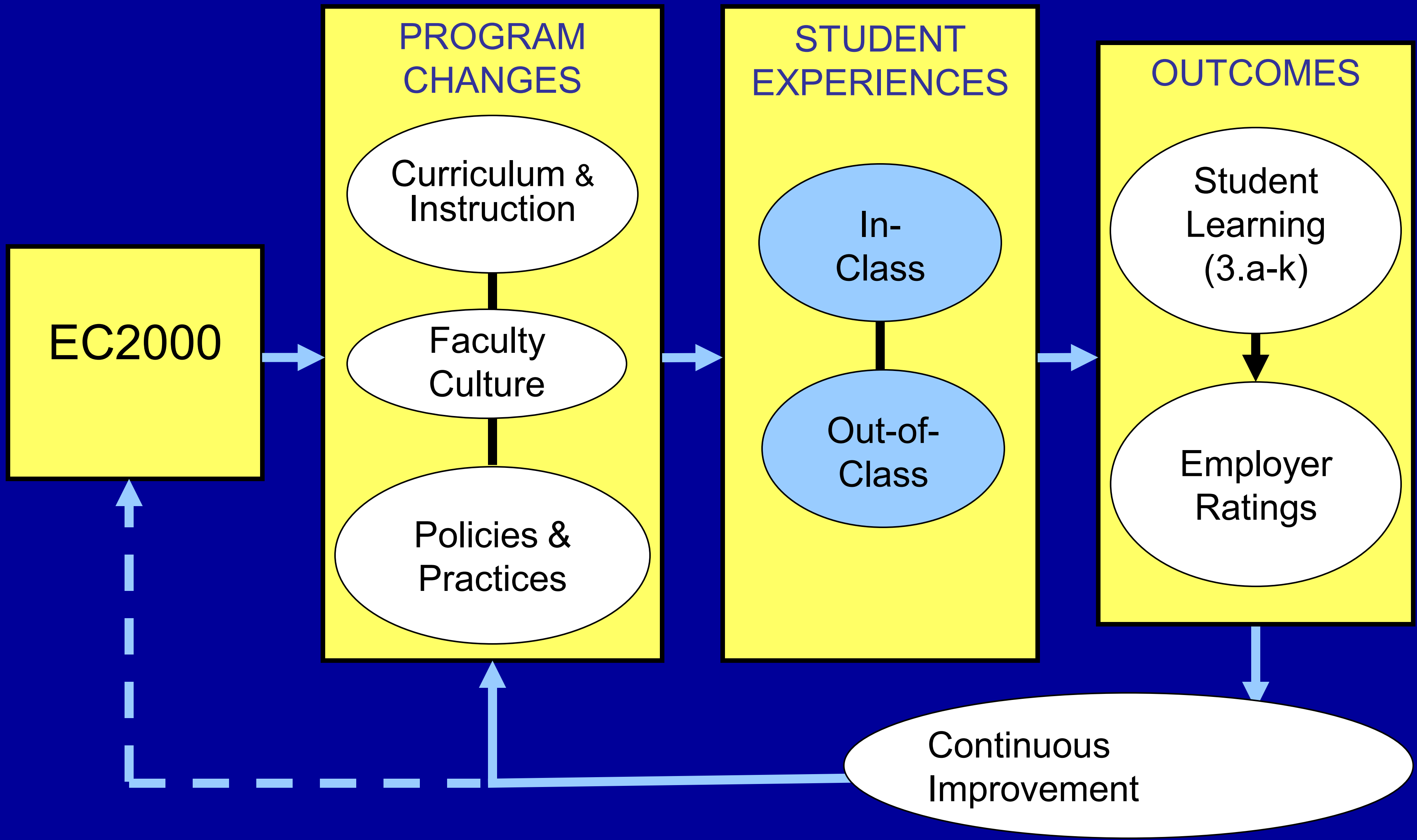


Change Over Past Decade in Emphasis on Teaching in…



5-point scale, where 1 = “Significant Decrease" and 5 = “Significant Increase"

Engineering Change: Studying the Impact of EC2000

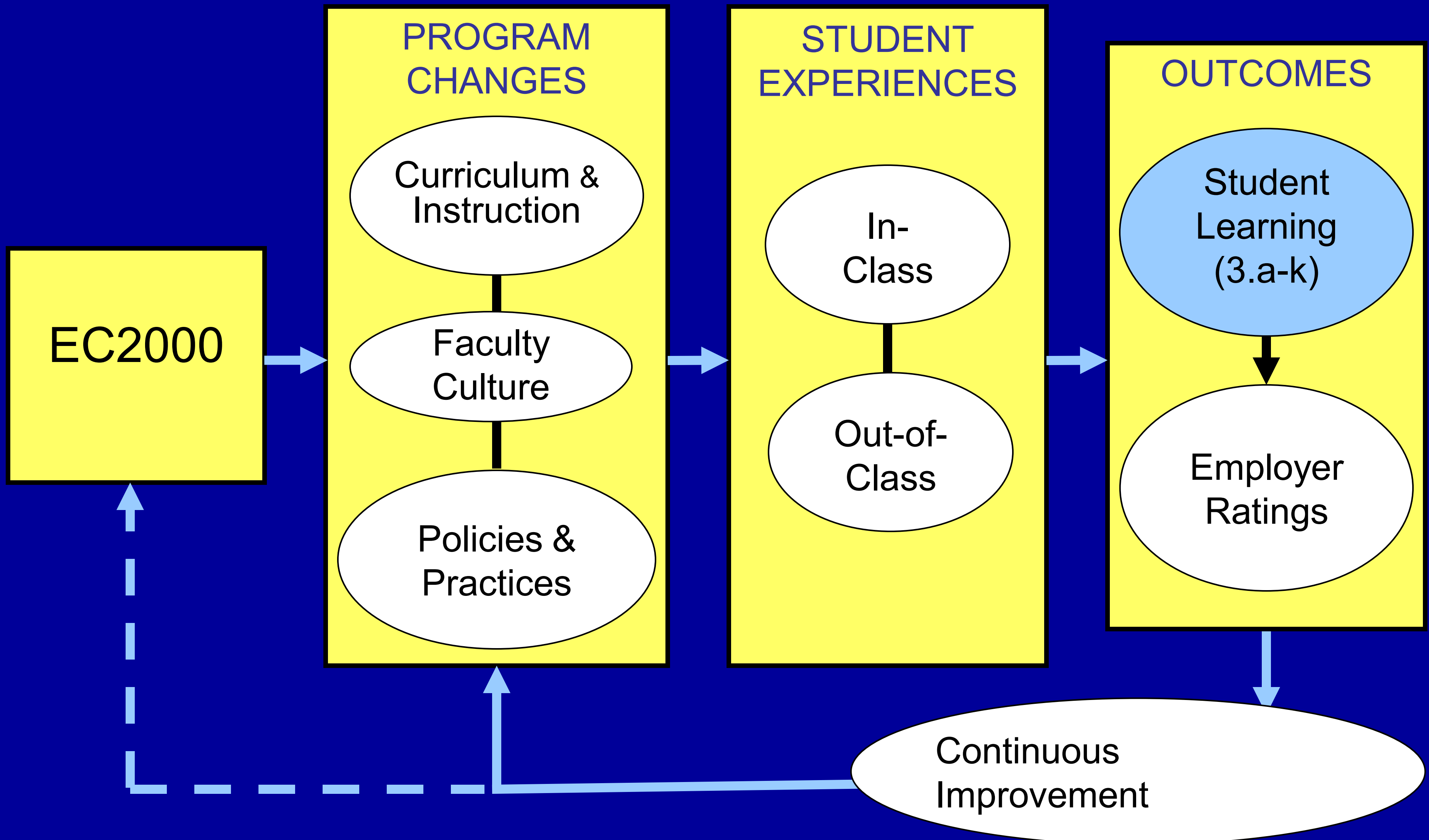


Significant Findings: Students' In- and Out-of-Class Experiences

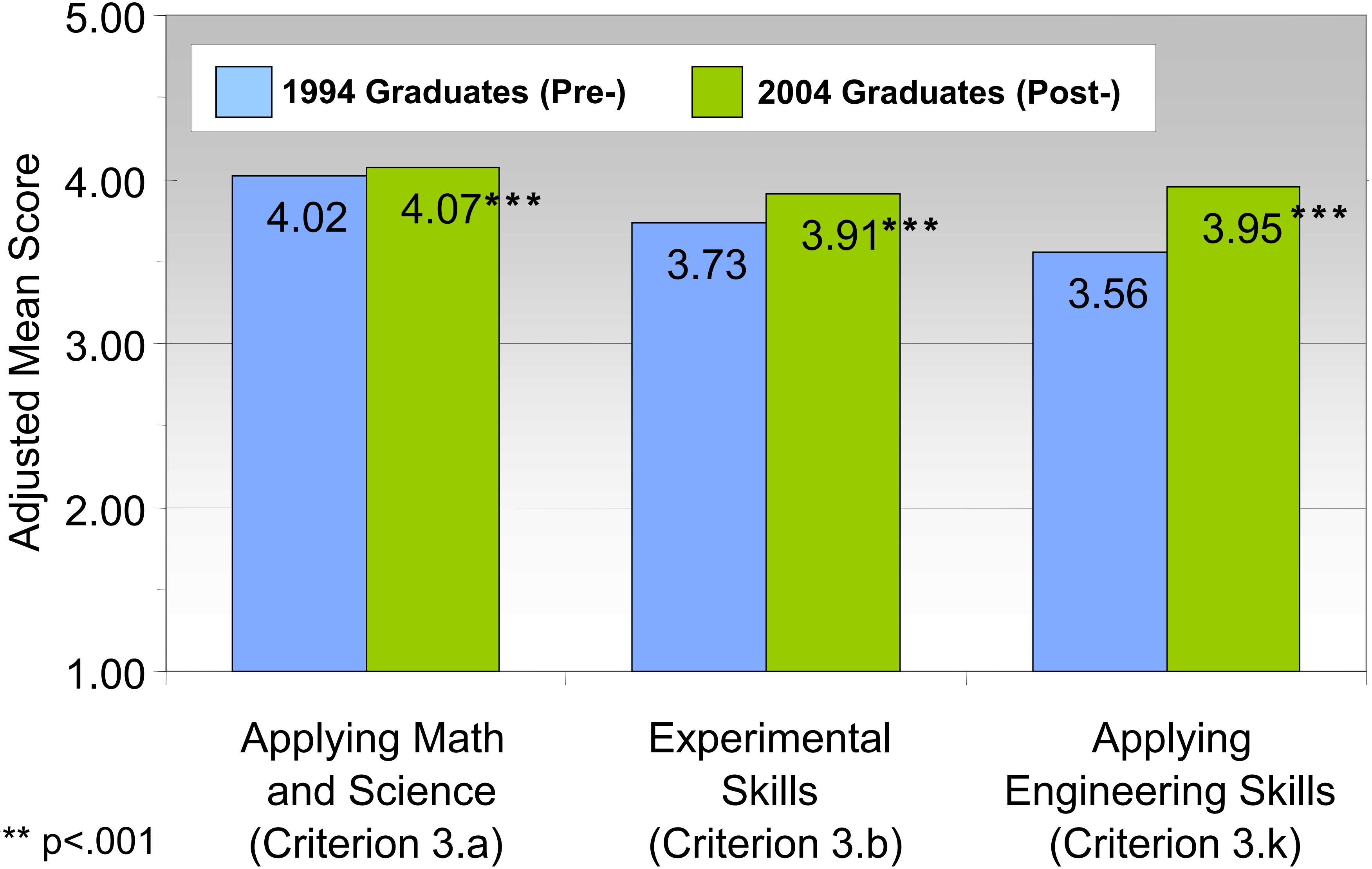
Compared to 1994 graduates, 2004 graduates reported:

- Greater active engagement in their own learning
- More interaction with instructors
- More feedback from instructors
- More time spent in cooperative or internship experiences
- More international travel
- More involvement in engineering design competitions
- Greater engineering program emphasis on openness to new ideas and people
- Some uncertainty about changes in diversity climate.

Engineering Change: Studying the Impact of EC2000



Math, Science, and Engineering Skills Cluster



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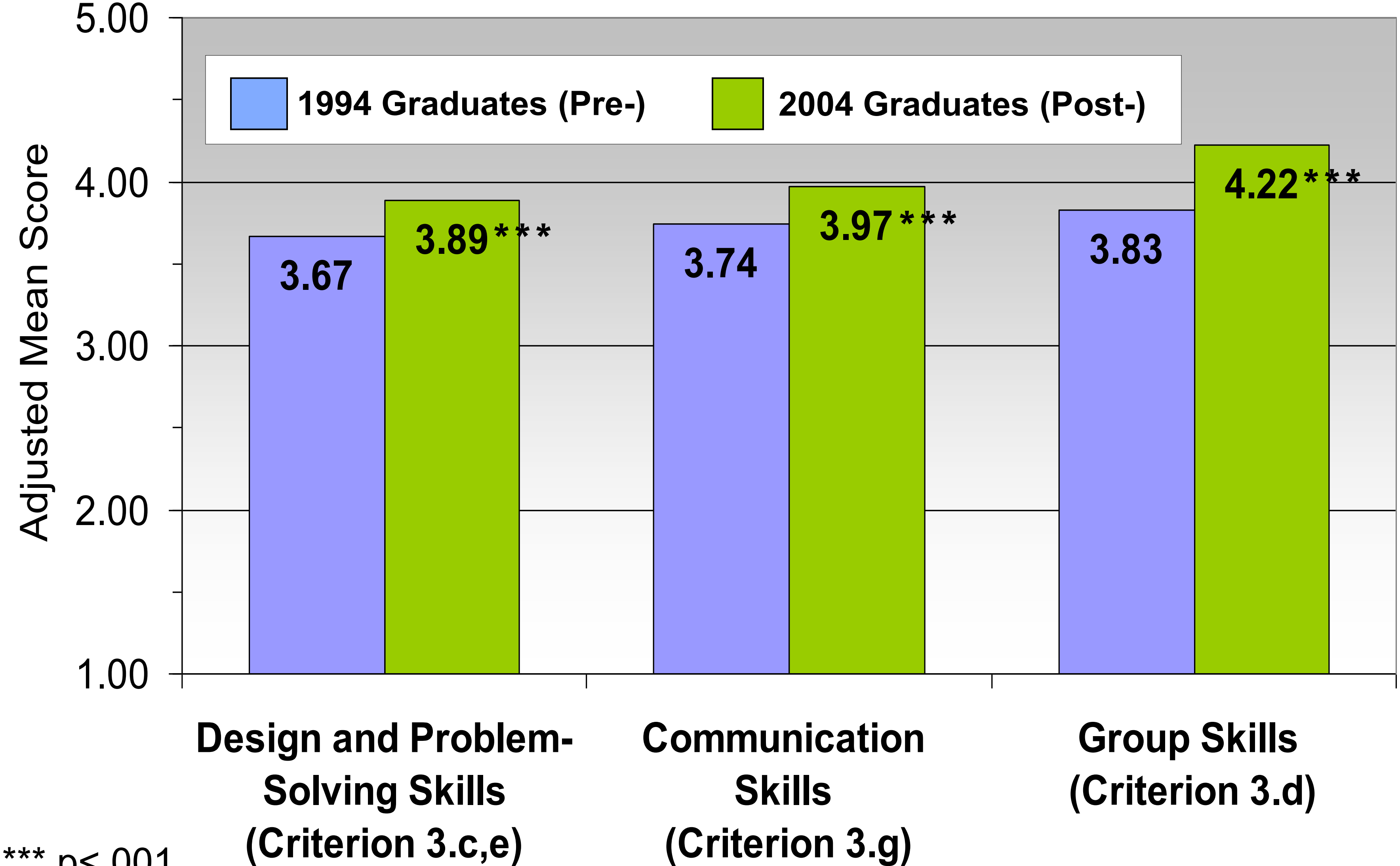
Project Skills Cluster



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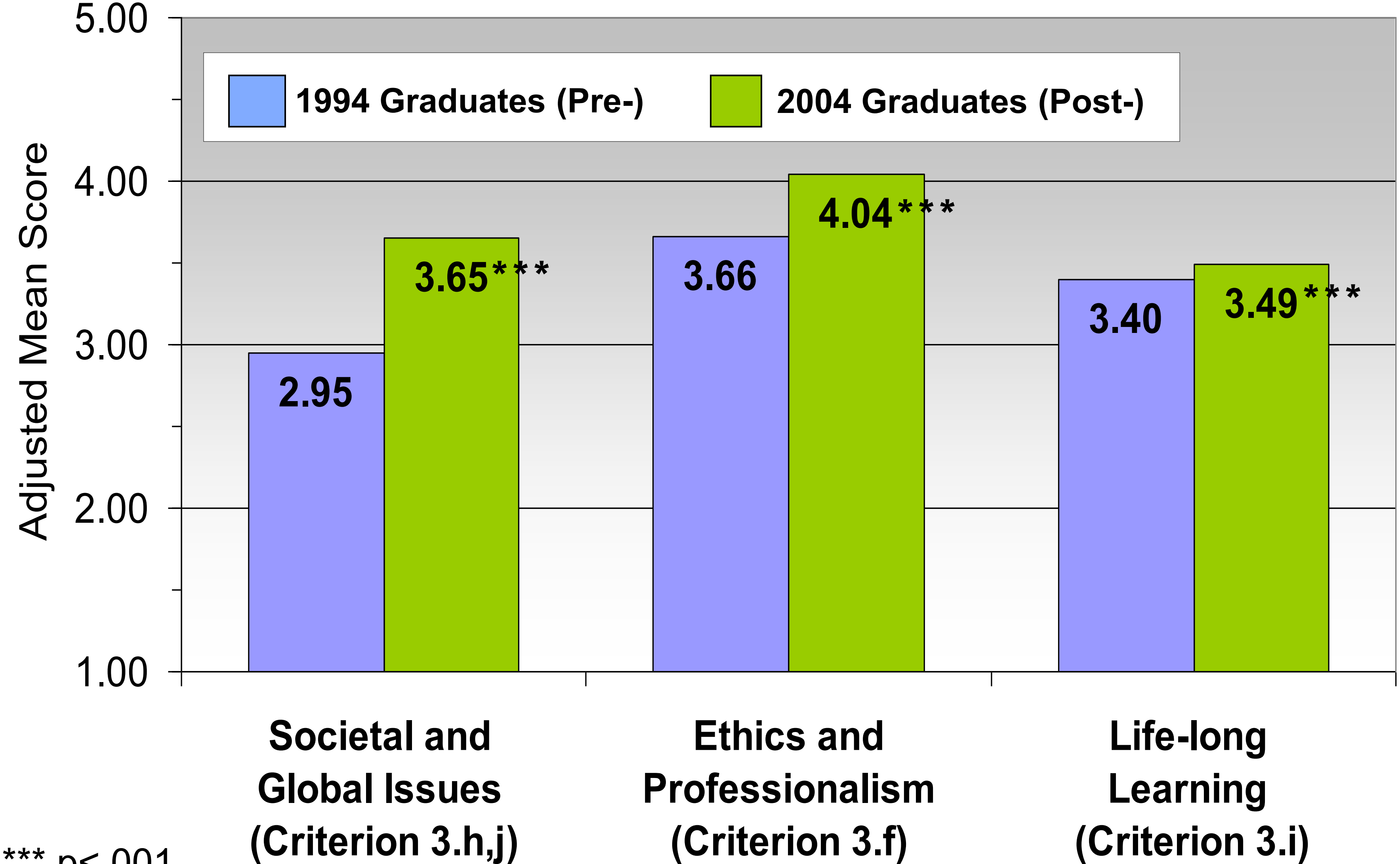
Contexts and Professionalism Cluster



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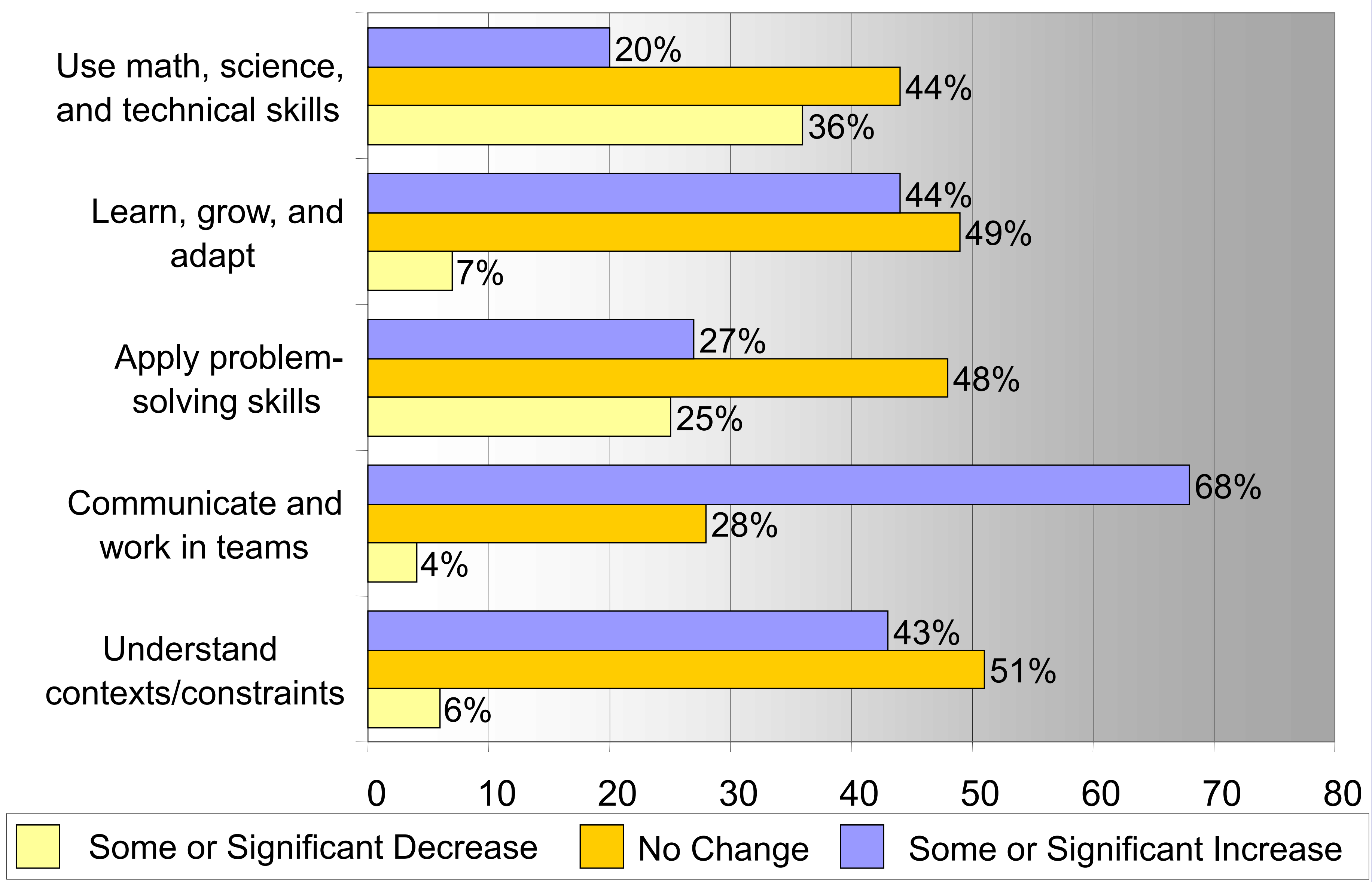
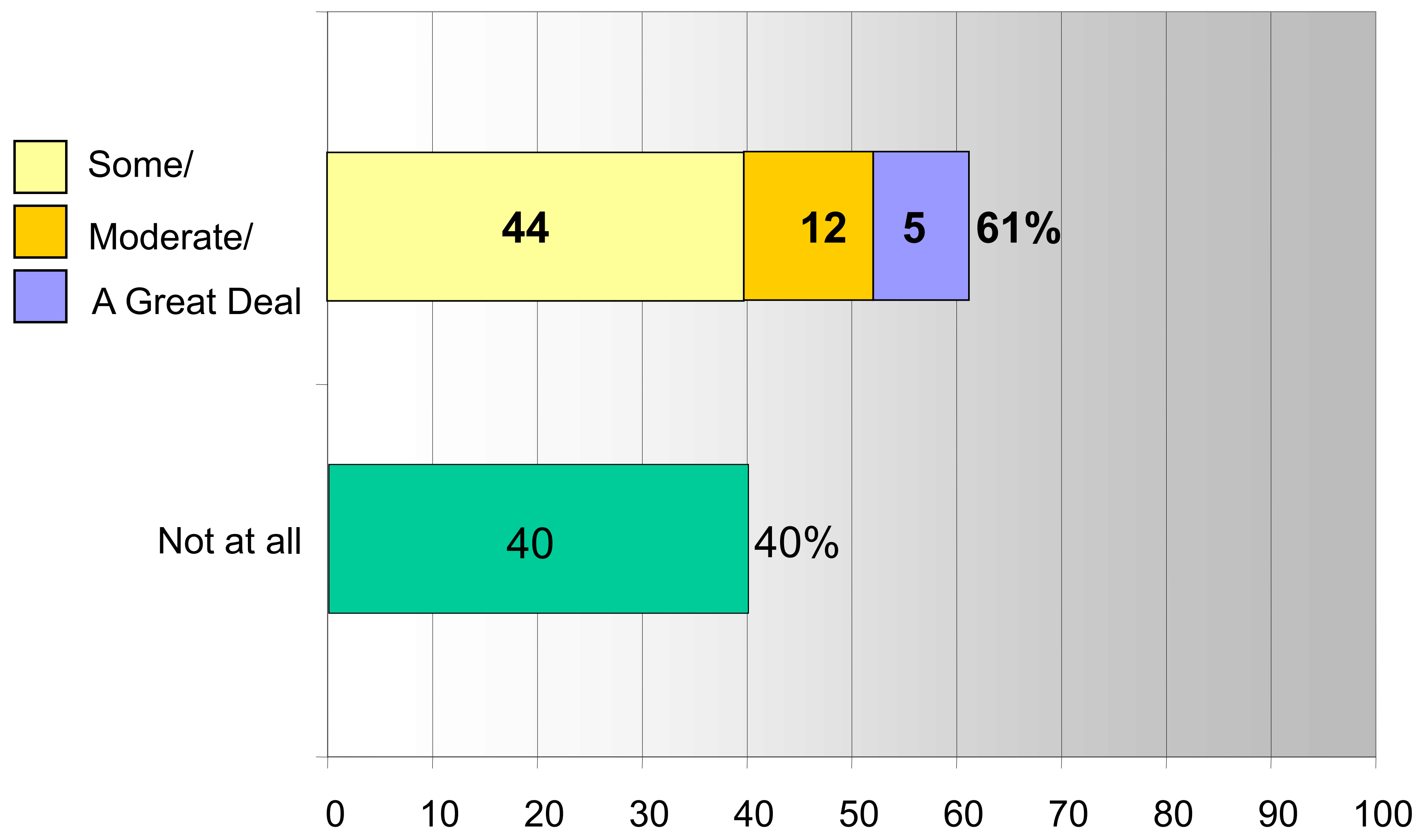
Faculty Reports of Students' Ability and Change in Ability Over Past Decade



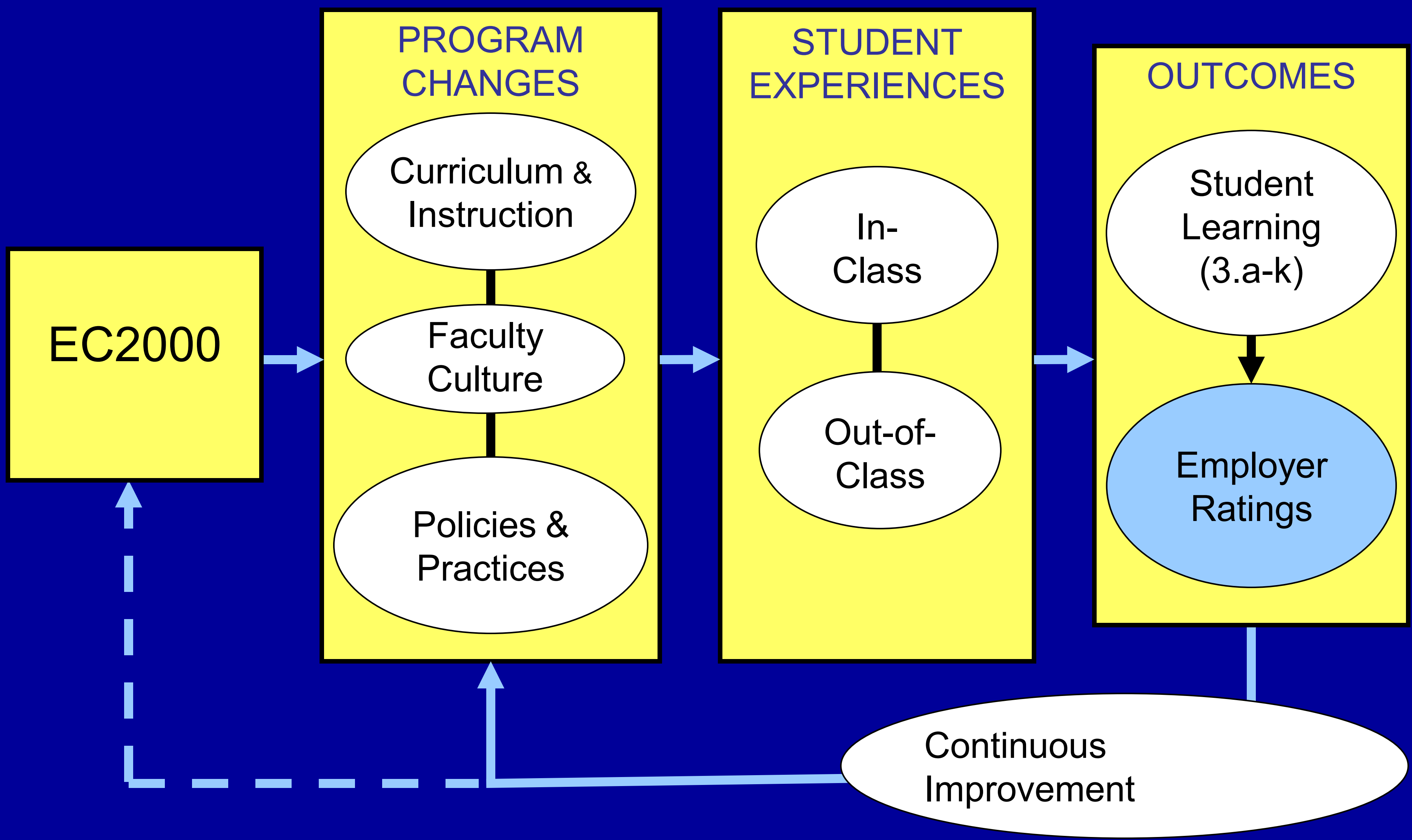
Faculty Reports of EC2000's Influence on Changes in Graduates' Preparation



Significant Findings: Changes in Student Preparation

- 2004 Graduates consistently report higher preparation than similar 1994 Graduates on all 9 measures of engineering skills.
- All 9 Post-EC2000 improvements are statistically significant, including Applying Math and Science Skills.
- With some exceptions, faculty report seeing similar increases in student skills.

Engineering Change: Studying the Impact of EC2000



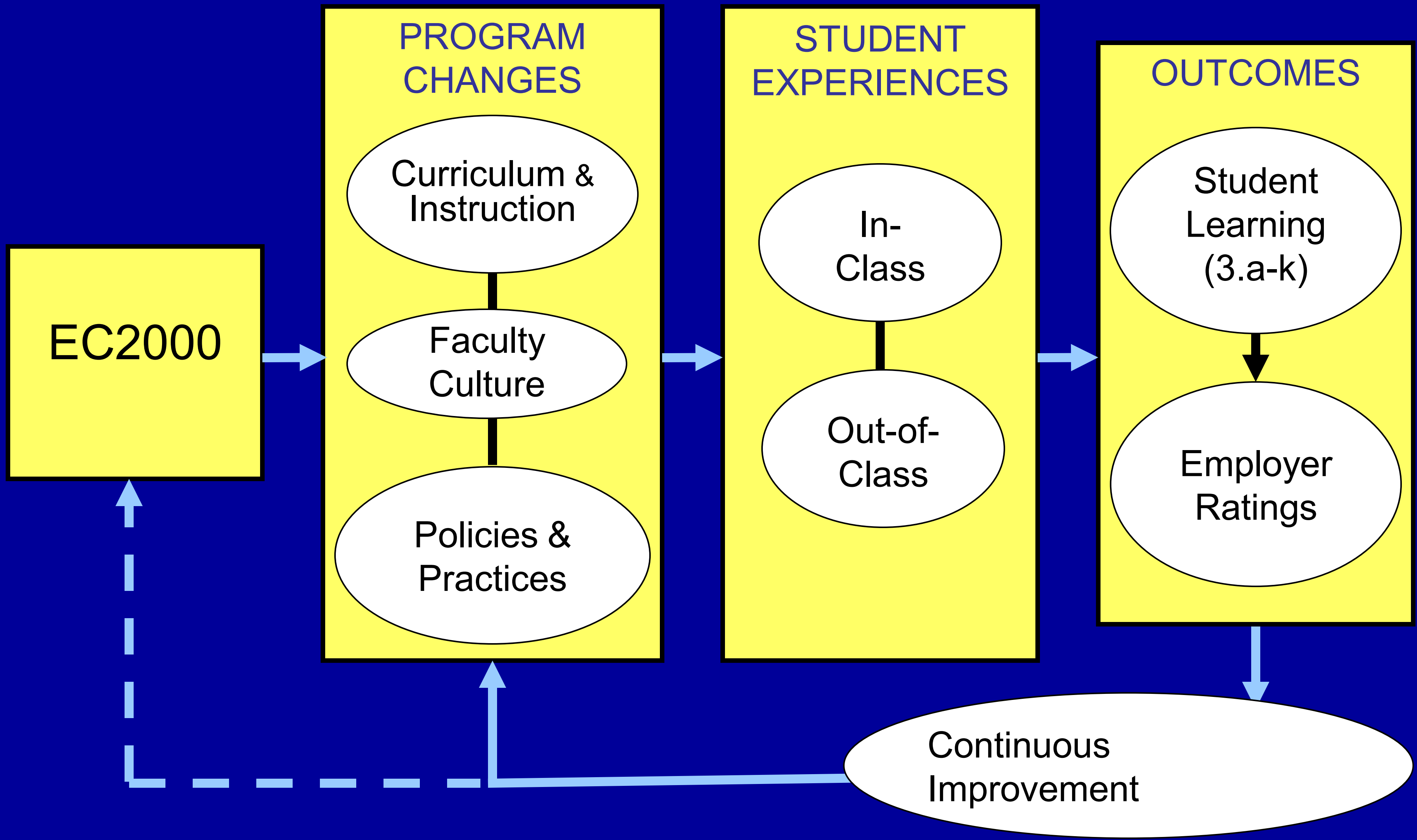
Significant Findings: Employers

- High agreement about the preparation of new engineers, even across:
  - engineering fields
  - organizational level
  - industry types
  - educational preparation
  - geographic regions
- More than 75% of employers rate new engineers as adequately prepared or well prepared in 4 of 5 knowledge and skill areas.
- More than half report no change in the abilities of new engineers over the past 7 to 10 years.

Significant Findings: Employers

- Greatest increases seen in teamwork and communication skills and in life-long learning.
- About 1 of 4 employers report decreases in problem-solving skills and understanding of social and environmental contexts.
- Large national employers are more positive in their Pre- and Post-EC2000 ratings than are smaller local and regional employers.
- Majority of employers rate nearly all the a-k criteria as highly important or essential for new hires.

Engineering Change: Studying the Impact of EC2000



Conclusions and Implications

- America's engineers are measurably better prepared than their peers of a decade ago.
- In all nine outcome areas, 2004 graduates report higher levels of ability than 1994 graduates.
- Some differences are substantial:
    - Societal and Global Issues
    - Applying Engineering Skills
    - Group Skills
    - Ethics and Professionalism

Conclusions and Implications

- With a few exceptions, faculty concur with graduates' assessments of their abilities:

  40 – 60% of faculty report that recent graduates are better prepared than graduates of 7-10 years ago in

  - Communication skills
  - Understanding global and social contexts
  - Life long learning skills

- 25% of faculty report decreases in graduates' problem-solving abilities.
- About a 1/3 report decreases in graduates' abilities to apply math, science, and technical knowledge.

Conclusions and Implications

- 25% of the employers also report decreases in problem-solving skills.
- Fewer employers than faculty report decreases in abilities to apply math, science, and technical skills.
- 75% of employers report that graduates are adequately or well-prepared in problem-solving.
- More than 90% report recent graduates are adequately or well-prepared to apply math, science and technical skills.

Conclusions and Implications

- A complex array of changes in programs, faculty practices, and student experiences is linked statistically to improved learning outcomes.
- These changes are consistent with what one would expect to see if EC2000 was having an impact.
- Changes at the classroom level have been particularly effective in promoting the a-k learning outcomes.

Conclusions and Implications

- Students also learn engineering skills through out-of-class experiences, such as internships and design competitions.
- Changes in curricula, teaching methods, and administrative practices are also needed to promote desired student outcomes.
- Finally, a faculty culture that supports assessment and continuous improvement also appear to be important ingredients.

Conclusions and Implications

- Interviews with Deans of participating institutions resonated with many of our findings.
  - EC2000 credited with promoting good educational planning processes.
  - Consistent with deans' established priorities and directions for their colleges and schools.
  - EC2000 "enabled" change.
- Deans comments echo finding that ABET is one of several important influences on curriculum, teaching, and learning in engineering programs.

Topics

- Who is ABET?
- Development History – EC2000
- ***Future Challenges***

EAC of ABET student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Additional learning outcomes are under review … here are suggested additions from many sources (in an unstructured list):

Systems integration (synthesis)

Ability to realize products

Facility with intelligent technology to enhance creative opportunity

Ability to manage complexity and uncertainty

Teamwork (sensitivity in interpersonal relationships and global context) –(seems to add more than what is currently required)

Language and multicultural understanding

Ability to advocate and influence

Entrepreneurship and decision making

Knowledge integration, education, and mentoring

Creativity, innovation, and entrepreneurship

Ability to adapt to an increasingly diverse world

Ability not only to adapt to change but to actually drive change

Sustainable development: avoiding environmental harm; energy / materials efficiency

Life cycle / infrastructure creation and renewal

Micro / nanotechnology / micro-electromechanical systems

Mega systems

Smart systems

Multimedia and computer-communications

Living systems engineering

Management of technological innovation

Enterprise transformation

Knowledge of the fundamentals and dynamics of globalization, as well as opportunities to become immersed in study, work, or research abroad.

Understanding of public policy

Contemporary issues & Historical Perspectives (Application)

Materials Science (Analysis)

Experiments (Analysis)

Sustainability should be elevated rather than contained within a list

Risk and uncertainty

Communicates effectively in a variety of different ways, methods, and media (written, verbal/oral, graphic, listening, electronically, etc.)

Communicates effectively to both technical and non-technical audiences

International/global perspective

Understanding of the ethical and business norms and applies norms effectively in a given context (organization, industry, country, etc.)

Applies personal and professional judgment in effectively making decisions and managing risks

Mentors or helps others accomplish goals/tasks

Shows initiative and demonstrates a willingness to learn

- Professional and ethical responsibility – elevate from understanding to a higher level – perhaps synthesis
- Sustainability
- Understanding of political, social, and economic perspectives
- Understanding of information technology, digital competency, and information literacy
- Understanding of stages/phases of product lifecycle (design, prototyping, testing, production, distribution channels, supplier management, etc.)
- Understanding of project planning, management, and the impacts of projects on various stakeholder groups (project team members, project sponsor, project client, end-users, etc.)

Possesses fluency in at least two languages

Ability to think both critically and creatively

Ability to think both individually and cooperatively

Functions effectively on a team (understands team goals, contributes effectively to team work, supports team decisions, respects team members, etc.)

Maintains a positive self-image and possesses positive self-confidence

Maintains a high-level of professional competence

Embraces a commitment to quality principles/standards and continuous improvement

Embraces an interdisciplinary/multidisciplinary perspective

Skills spanning engineering discipline boundaries.

Communications skills to span organizational, cultural, and other boundaries.

Graduates need stronger professional skills, e.g., interpersonal skills, negotiating, conflict management, innovation, oral and written communication, and inter-disciplinary teamwork.

Developing student creativity and innovation skills, through explicit curricular components that emphasize active, discovery-based learning

Practical experience in how devices are made or work, a familiarity with industry codes and standards, and development of a systems perspective

Strong analytical skills

Practical ingenuity

- Creativity
- Communication skills
- Business and management
- High ethical standards
- Professionalism
- Dynamism, agility, resilience, flexibility
- Lifelong learners
- Skills spanning engineering discipline boundaries
- Communications skills to span organizational, cultural, and other boundaries.
- Leadership
- Risk and Uncertainty

Explain business concepts applicable to engineering practice

Apply principles of sustainability to the design and evaluation of engineering systems

Young engineers now have to move up to design leader and managerial positions much faster.

Good candidates need to have global references and experience on projects and assignments around the world.

Need a basic understanding that our culture is not the only one around.

Analyze problems, situations, ramifications, upside and downside, near-term and long-term effects.

Ability to communicate with a broad range of audiences through numerous media

Project Management

Public Policy

Overview

Into the third six-year cycle after EC2000 introduced by EAC

- EAC remains aware of questions and concerns raised regarding Criteria 2, 3 and 4 and is in the process of considering different paths of resolution

- We reflect upon our experience of the past 10-15 years … pause and remember:
  - not only how we got to where we are
  - the positive results that have been realized during this time

Overview

Into the third six-year cycle after EC2000 introduced by EAC

- EC2000 was a response to demands from industry that our engineering accreditation criteria be changed to assure graduates are better prepared for practice, e.g.
  - to have good communication skills
  - demonstrate ability to work on teams
  - be more aware of industry standards and regulatory requirements
  - become generally more aware of good design processes and practices

Overview

Into the third six-year cycle after EC2000 introduced by EAC

- EC2000 was also a response to engineering deans and faculty demands to:
  - allow programs greater flexibility in curriculum design
  - remove highly prescriptive curriculum requirements

Overview

Into the third six-year cycle after EC2000 introduced by EAC

- EC2000 responded to these demands by requiring each program faculty to:
  - develop relationships directly with employers, alumni, and others who could "educate" the faculty about what program graduates are expected to do after graduation via Criterion 2

Overview

Into the third six-year cycle after EC2000 introduced by EAC

- Today all engineering programs have such relationships and we see the results in many ways including the quality of design projects, with many being closely tied to industry.

- Before EC2000 most industry advisory groups operated at the dean's level and were viewed as fund raising tools

Overview

Into the third six-year cycle after EC2000 introduced by EAC

- ABET member societies have taken the lead in the introduction of "outcomes based assessment" of technology programs

- This has become the preferred approach by program accreditors in most disciplines here in the U.S. and abroad

DON’T HESITATE TO REACH OUT

jsussman@abet.org

THANK YOU!

Assuring Quality • Stimulating Innovation