EECS VI

Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science

# Expectations on and of our graduates

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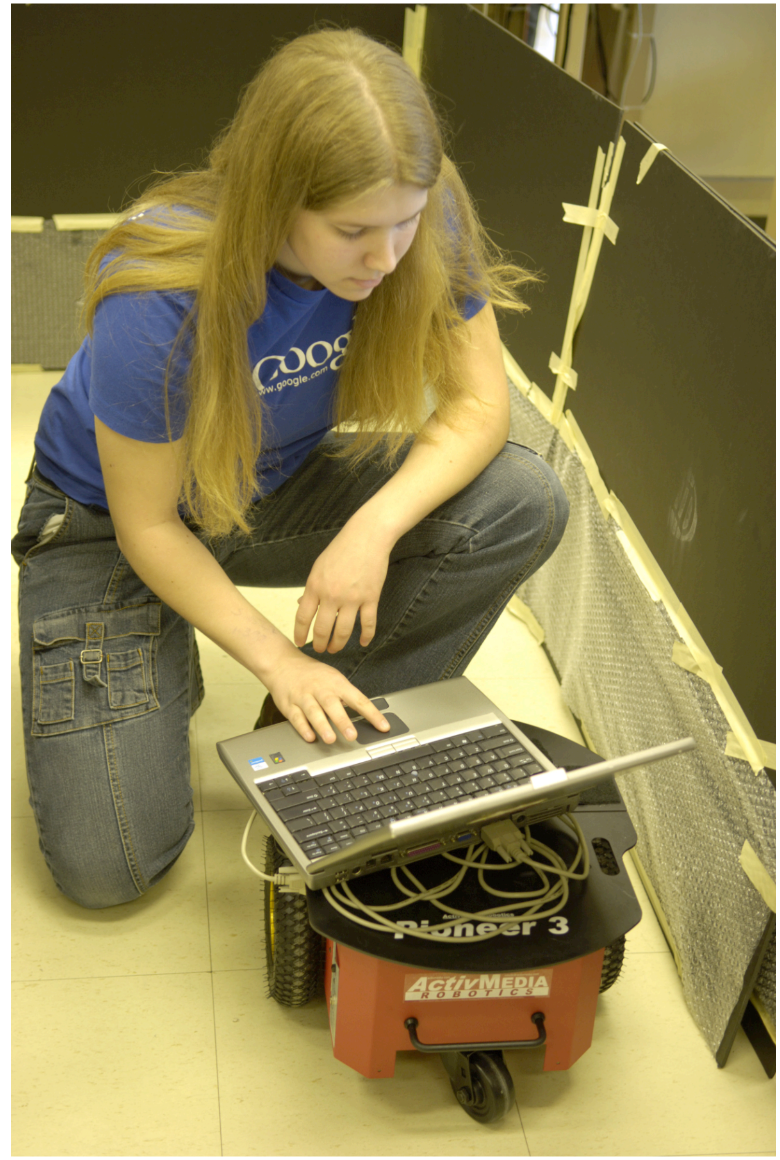
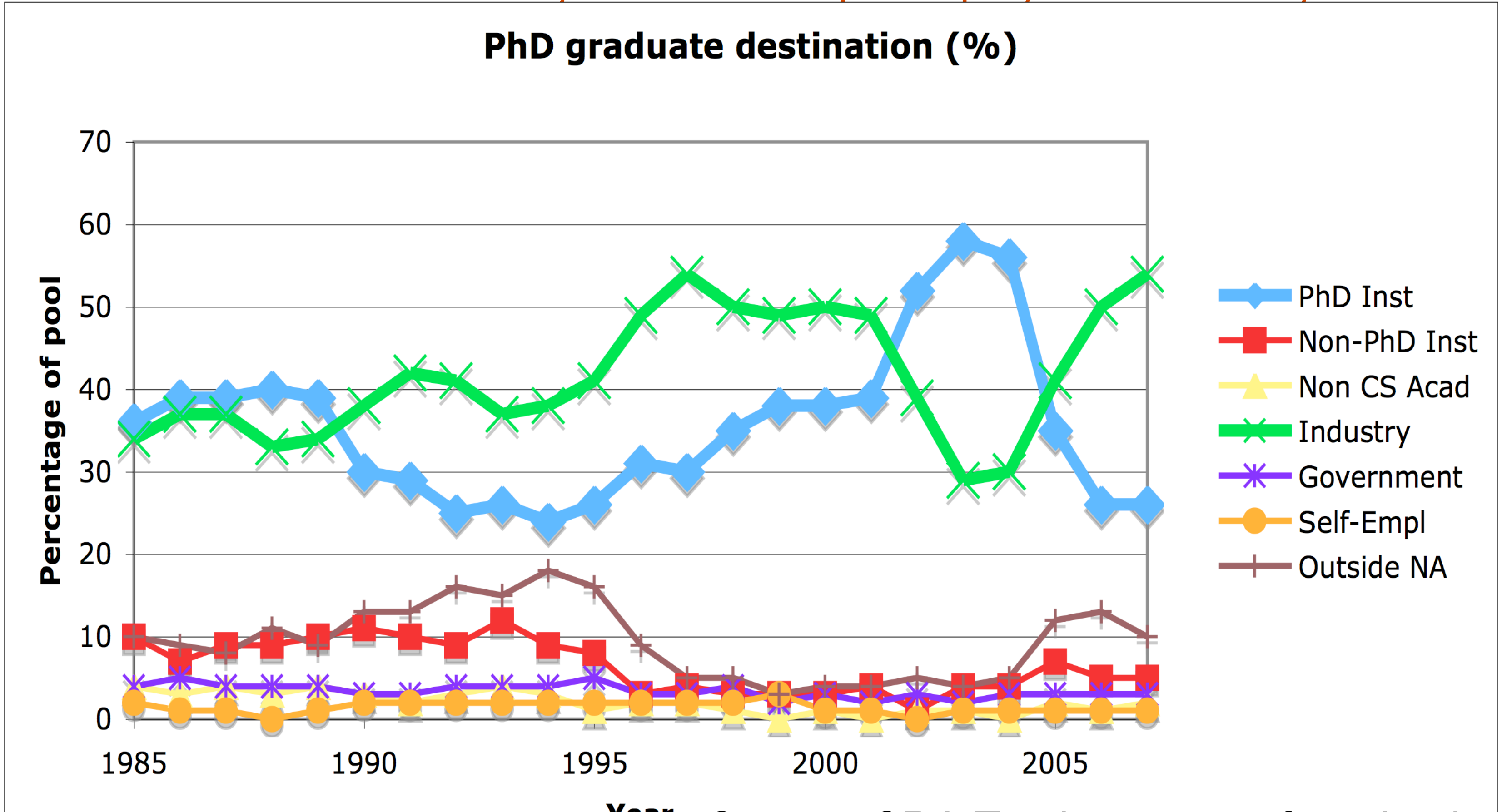
# Hypothesis: Expectations on our graduates is changing

- What is our product?
  - Our students
  - We do many other things -- new knowledge, new methods, new ideas, new devices and artifacts …
  - … but our multiplier is our students
    - They are the fuel for the innovation engine
- What are characteristics of a good product?
  - A function of the market -- where is the demand for our students?



# Who hires our PhD students (by percentage)?

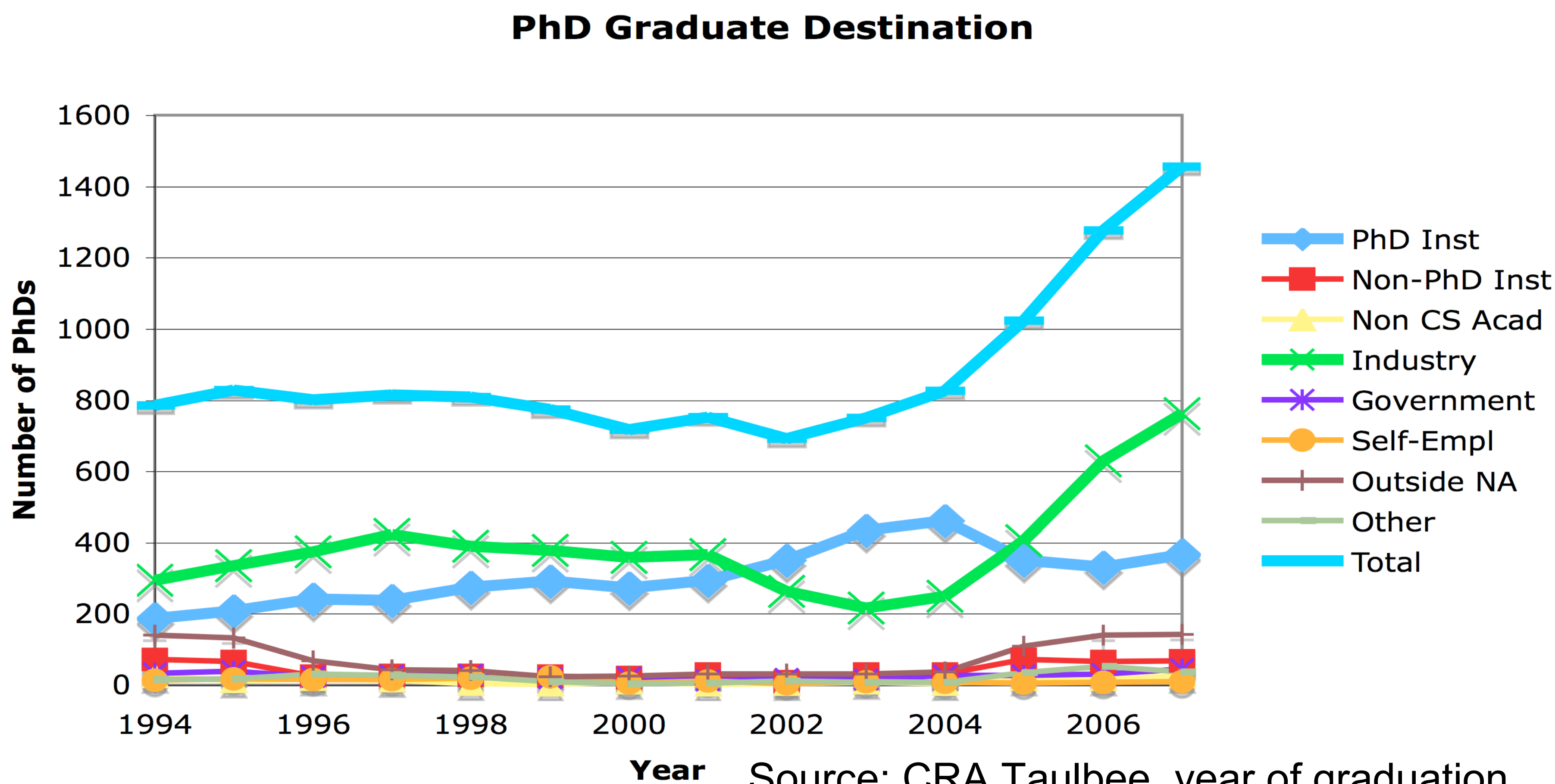
- Percentage of PhD's by sector
  - Note surge in academic positions, 2002-2004
  - Otherwise industry has been major employer for last 15 years




Source: CRA Taulbee, year of graduation

# Who hires our PhD students (by numbers)?

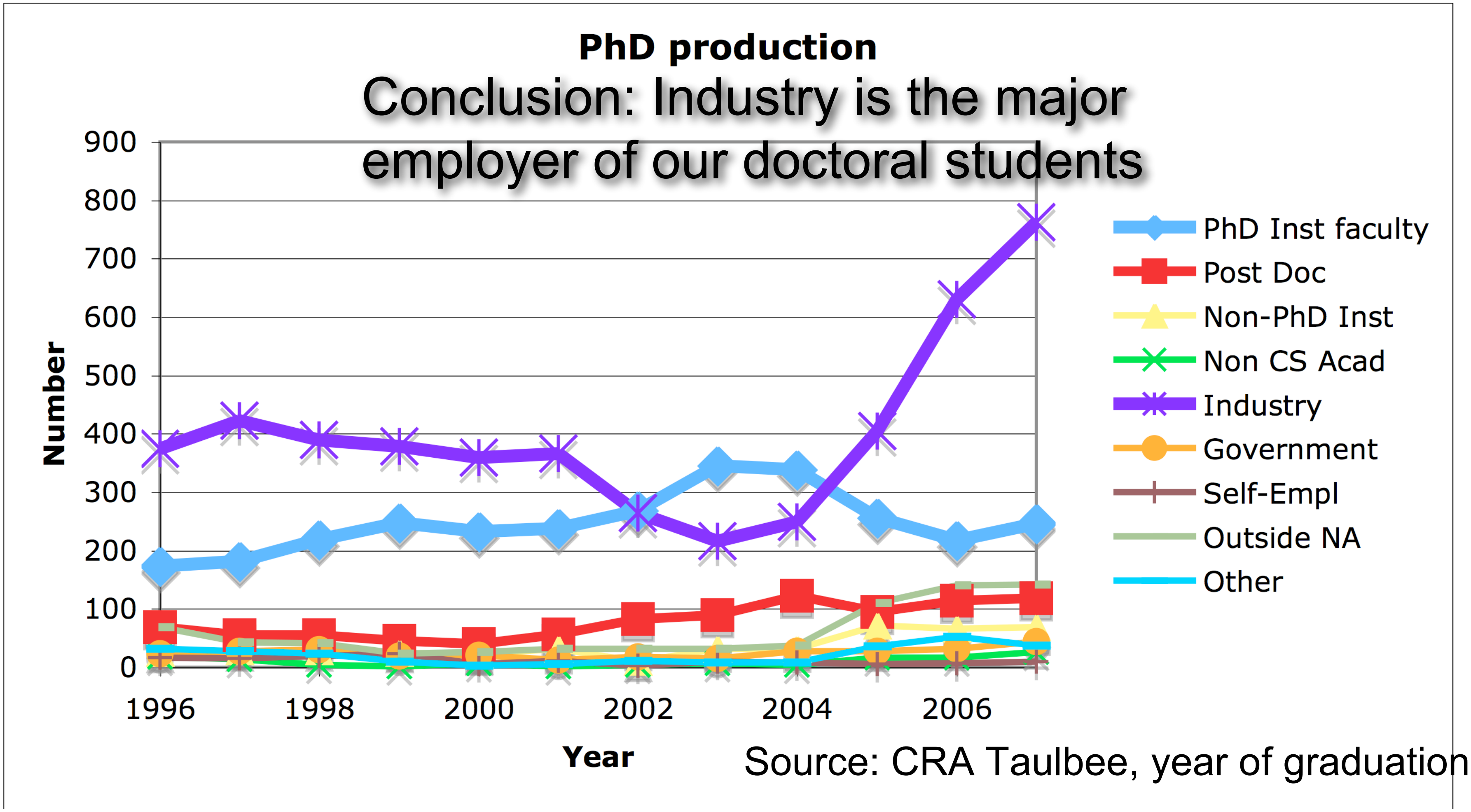
- Total output steady 94-99, slow decline to 02, then upturn, accelerating around 05
  - Note that by 07, industry hires outnumber academic hires at PhD schools 2:1




Source: CRA Taulbee, year of graduation

# Who hires our PhD students (by numbers)?

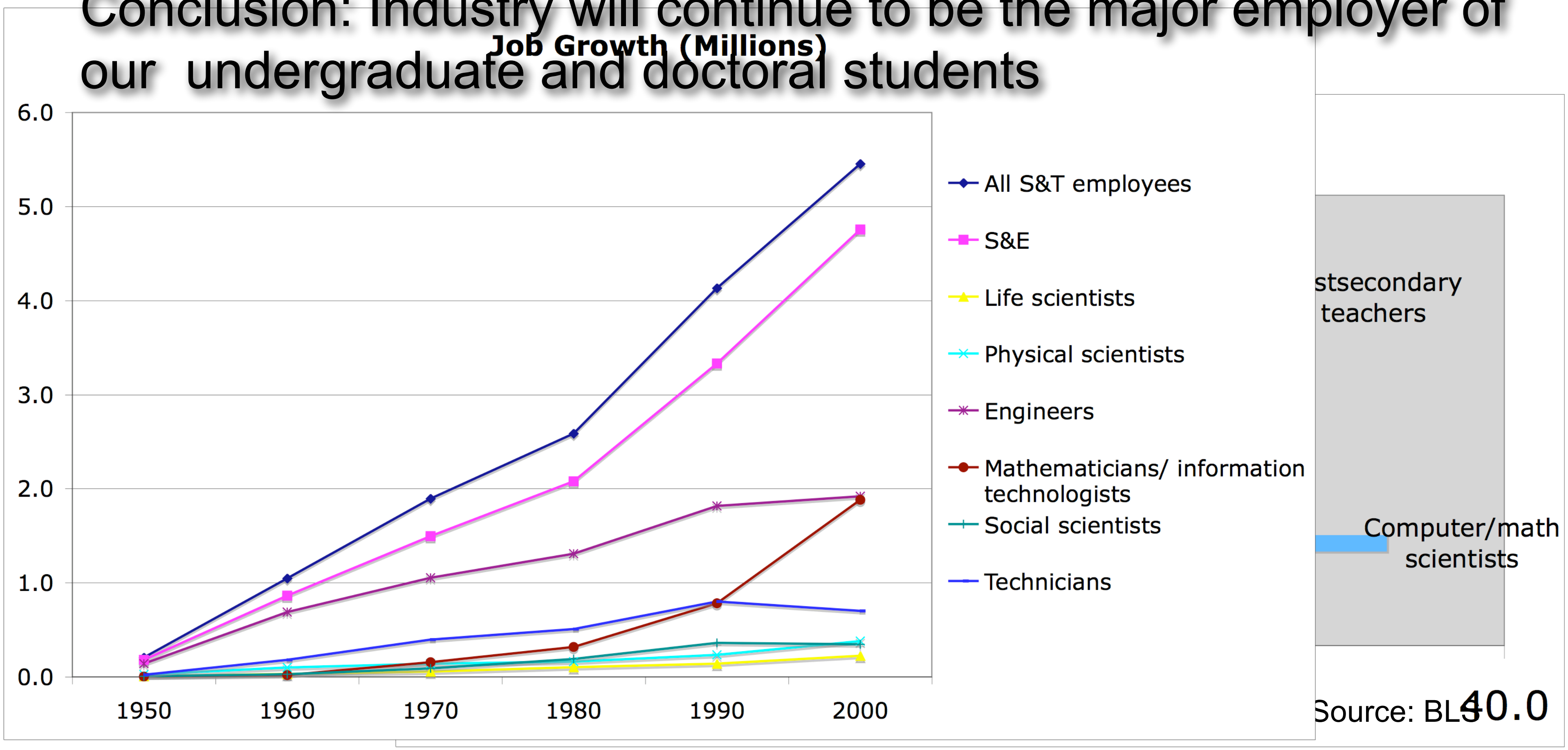
- If we separate post-docs from faculty positions, trend is more dramatic
  - Ratio of industry to tenure track faculty positions is then greater than 3:1
  - Note major growth in industry hires since 04



# Where are the jobs in general?

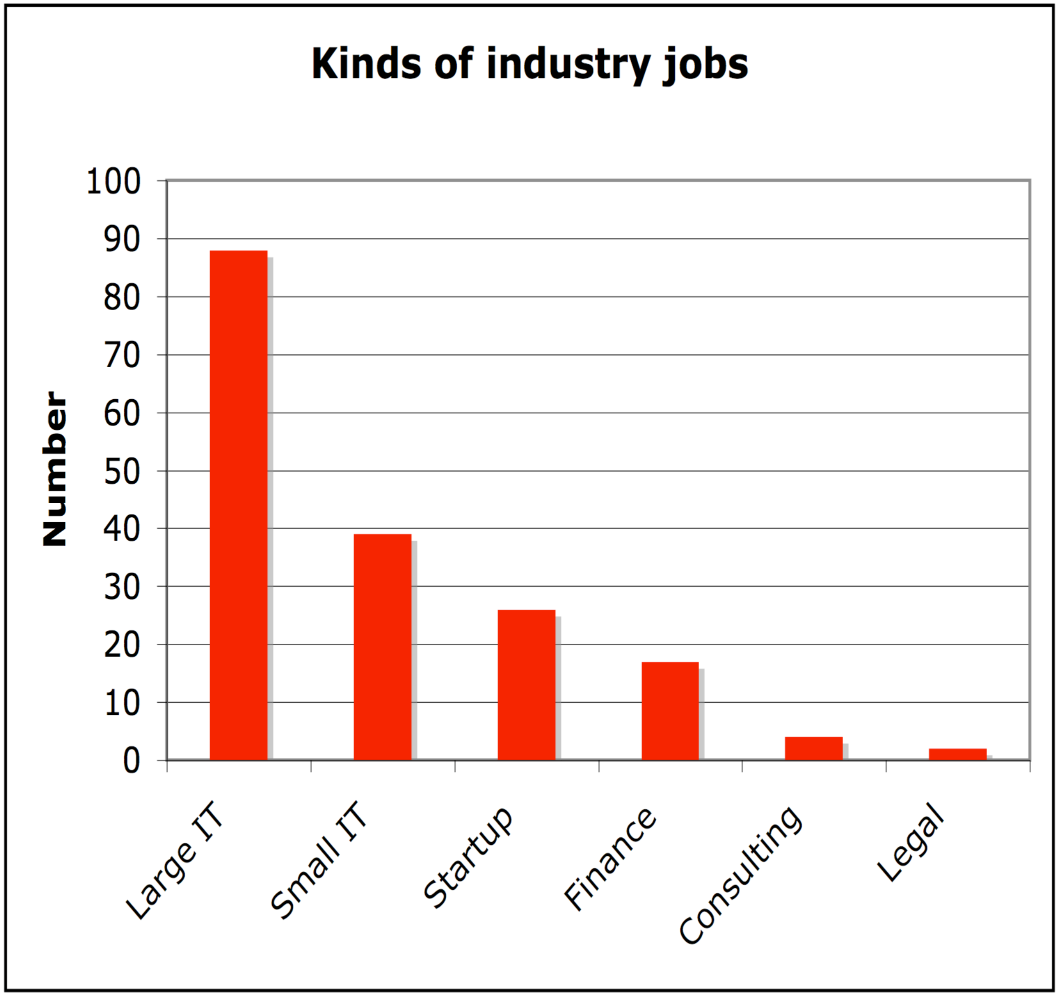
- Broadening to include BS as well as PhD positions
  - Significant growth over past 20 years
  - Major growth predicted for CS over next 10 years (3X all jobs)

Conclusion: Industry will continue to be the major employer of our undergraduate and doctoral students



# Industry needs our students, but do our students need industry?

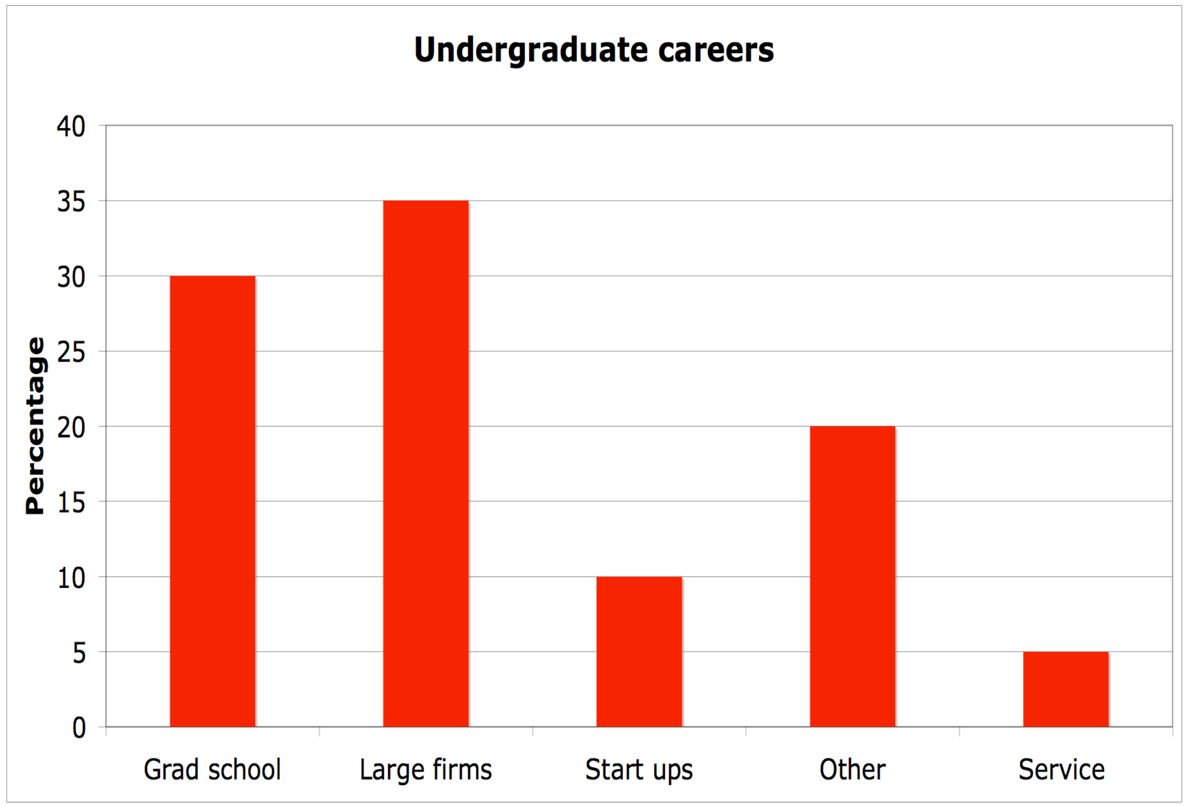
- Harder to find data
  - NRC data on MIT PhD Grads for past 5 years
  - Most students head to traditional industry sectors
    - List of major employers are what you would expect -- Google, Microsoft, IBM, Sun, Intel, Analog Devices, TI



# Industry needs our students, but do our students need industry?

- Where do our undergraduates go?
  - NSF data too generic
  - Example: Sampling of MIT data
    - Larger percentage of undergraduates take non-EECS jobs than do grad students
    - Other is primarily finance, consulting

**Conclusion: Range of industrial positions is broader than traditional CS industry of 20 years ago**

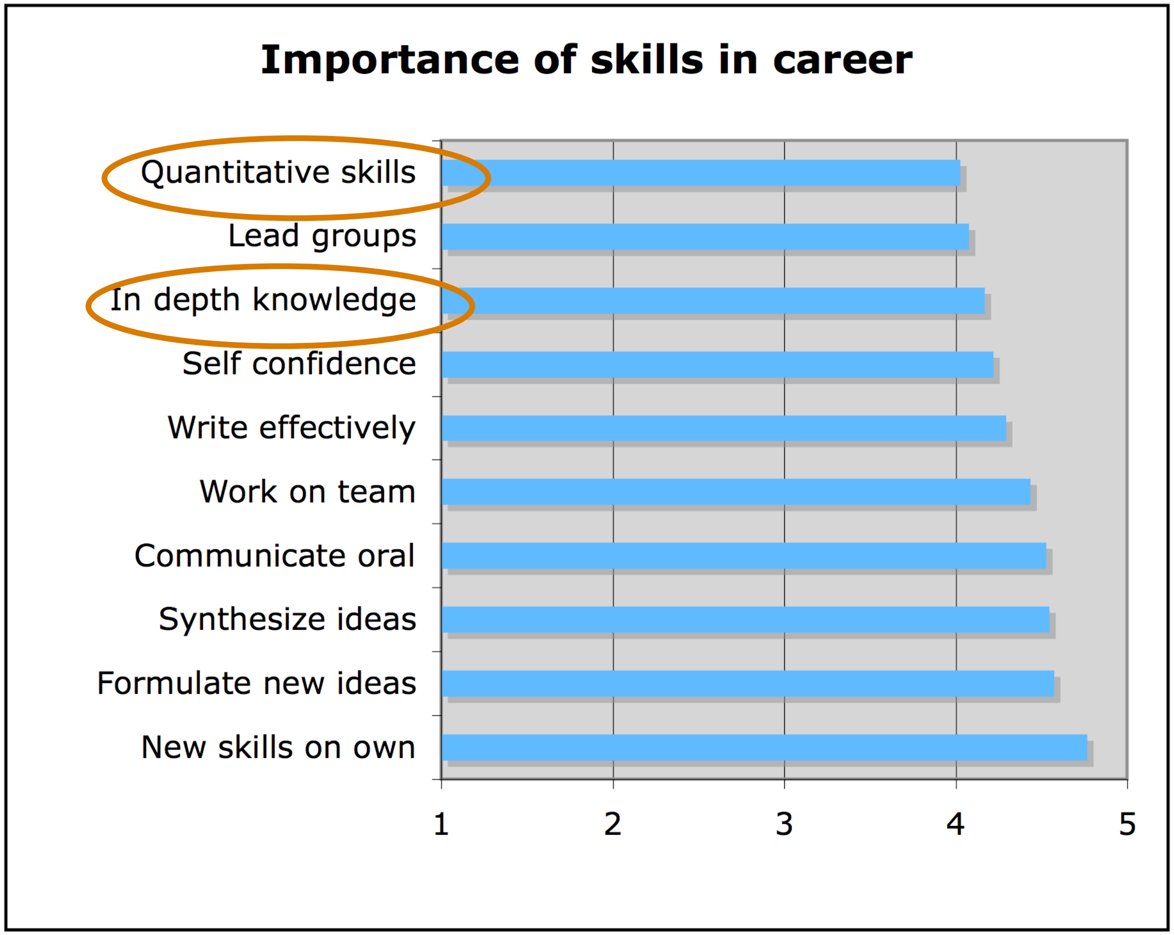


# So what does industry need?

- Transferable skills
  - Communications
    - oral and written
  - Analytic problem solving
  - Ability to work in a team
  - Leadership
  - Use of abstraction and modularity
  - Best practices
    - Documentation
    - Testing

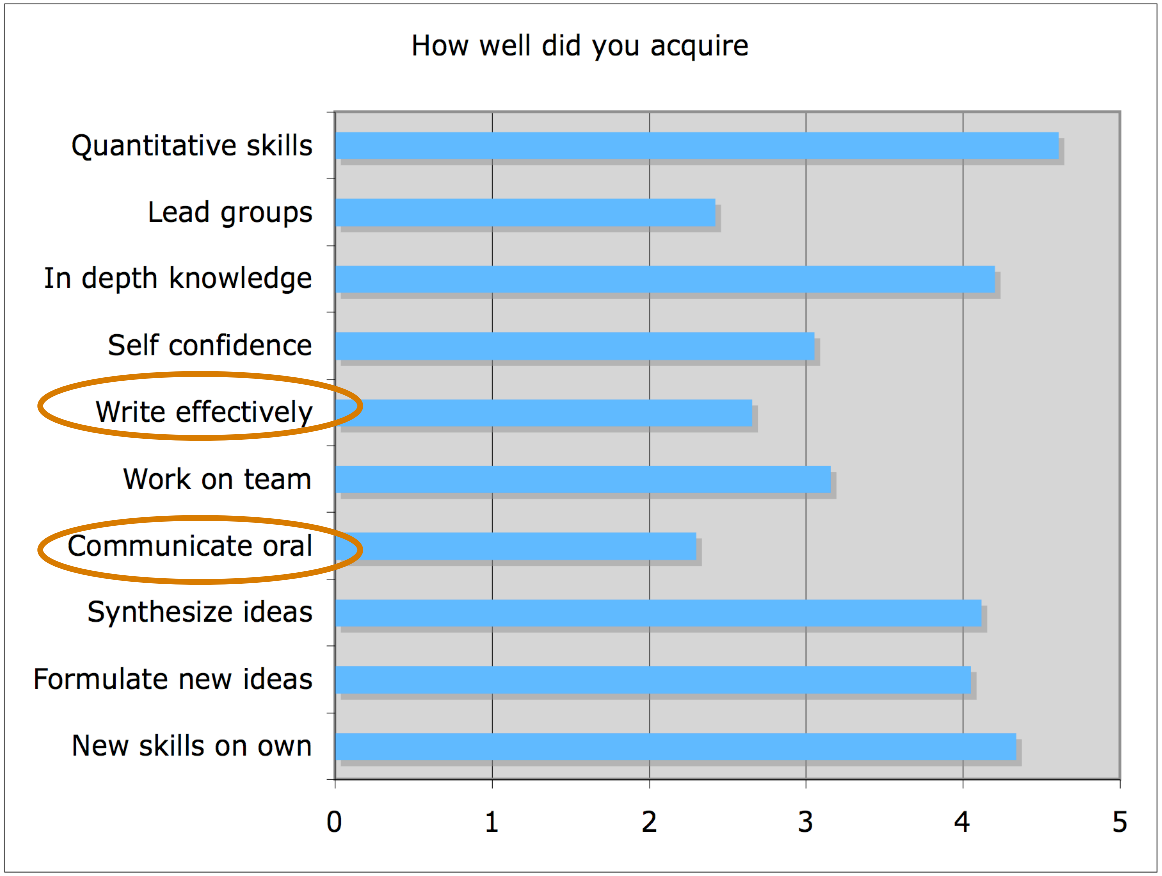
# What do our students think they need?

- Alumni survey from MIT
  - Classes of 1983, 1988, 1993, 1998, 2003
  - Surveyed in 2005
  - Rated importance of skills in their career since graduation
  - Note where “in depth knowledge” and “quantitative” fall



# How much do we contribute to our students growth?

- Alumni survey from MIT
  - Classes of 1983, 1988, 1993, 1998, 2003
  - Surveyed in 2005
  - Rated how well education experience contributed to growth in skills
  - Have worked on communication with new requirements
  - Teamwork issues still need attention



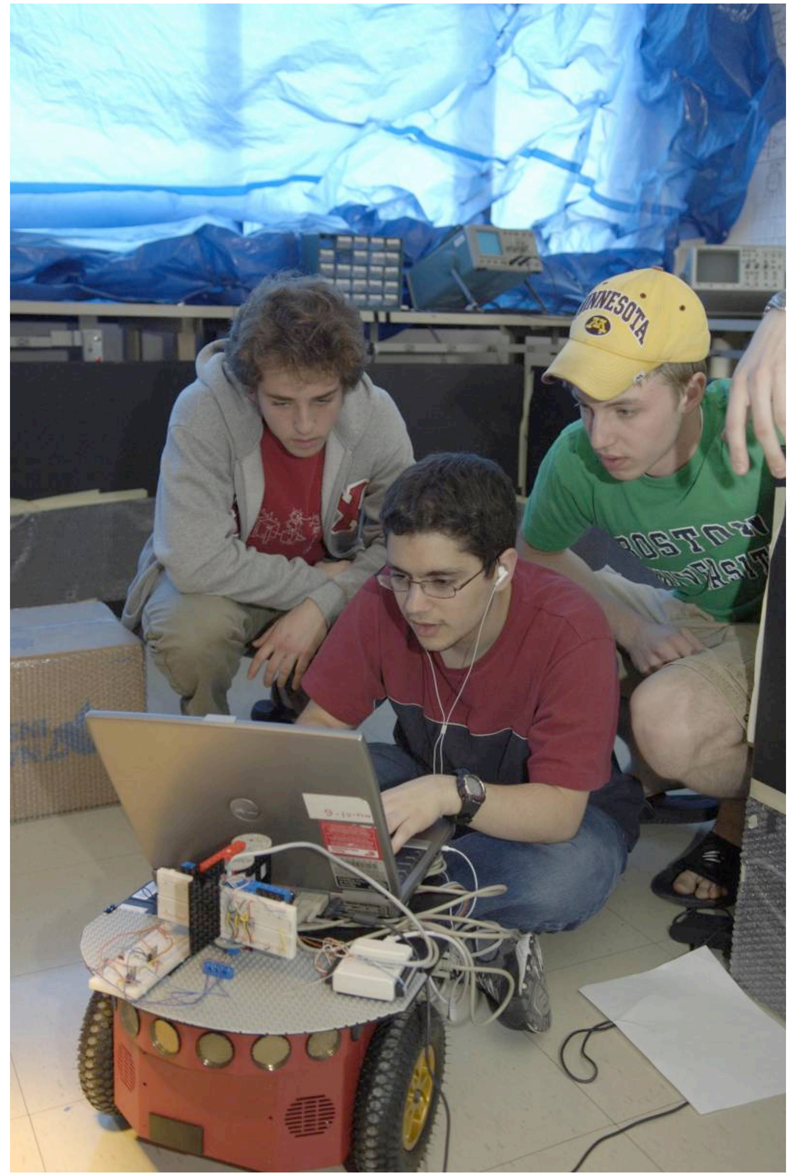
# So what else does industry need?

- Technical skills
  - Operating systems
  - Security
  - Search/learning
  - Database systems
  - Interactive digital media
  - Human-Computer interfaces
  - Informatics
  - Social computing
  - Computational life sciences

Conclusion: There is a wide range of industrial needs and a wide range of required skills -- too much to expect of any single student

# Hypothesis: Not possible, or even preferable, to teach “everything”

- Too much material to stuff into a four year curriculum
  - A lot is expected in knowledge and experience even in traditional areas
  - Problem is exacerbated  when you factor in need to include experience in related fields depending on area of application or interest
    - Computational biology
    - Social networks
    - Environment and energy issues
    - Interactive media
    - Finance



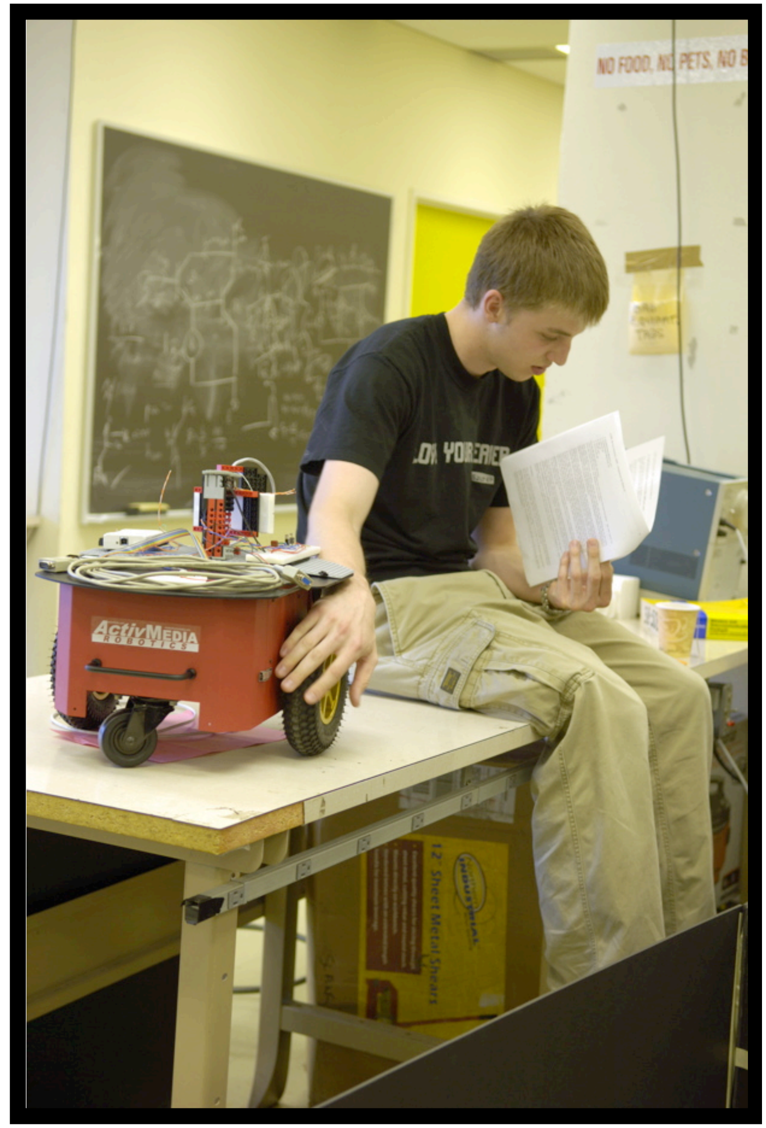
Conclusion: We may need to consider new models of curricular delivery

# Some possible options for handling explosion of knowledge

- Move to a professional degree
  - MEng as first professional degree
- Maintain current curricular structure
  - But change examples and scenarios for different student groups
- Change curricular structure
  - Allow student choice
  - Tradeoff of some areas with ancillary areas

# Move to a professional degree

- 5 Year MEng program
  - Greater breadth and depth
  - Capstone experience in large scale project
  - Additional cost burden
  - Not the right path for every student, so need 4 year “bailout”



# Preserve the current curriculum

- Keep the core subdisciplines in curriculum
  - Allow variations in each subarea specialized to student interest
    - Algorithms based on biological examples, or on information management, or …
    - Machine learning applied to biology, or to information management, or …
    - Distributed systems for environmental sensing, for information management, for …

# Move to different degrees

- Acknowledge that not every student can or wants to know everything
  - Single degree option
    - Provide set of choices of major subareas
    - Allow students some choice
  - Multiple degree option
    - Create specific degrees for different areas
      - Computer science
      - Computational science and engineering
      - Information science

# An example: MIT

- 2 introductory courses
- Select 4 of 7 foundation courses
  - 3 specific for CS, 3 specific for EE, 4 of 7 for EECS
- Select 3 header courses, followed by 2 advanced courses
  - Depth structure enforced
  - Choices largely based on idea of streams
    - Software engineering, security, information sciences, HCI, learning, systems, networks, …
- Exploring idea of new degrees
  - Computational biology
    - Replace one of 3 streams in CS degree with a biology stream
  - Information sciences
    - Replace one of 3 streams in CS degree with information management stream

# An example: Cornell

- Computer Science Degree
  - Balances traditional curriculum (8 course core) in languages, systems, data structures, algorithms, theory, scientific computing together with set of electives and specializations
  - Specialization (3 course sequence) in one of 24 fields covering broad range of areas, many outside of traditional CS
  - Minor in Games, double majors with other fields as variations
- Information Sciences Degree
  - Select a primary and secondary track from following three options
    - Information systems
      - CS, OR
    - Human Computer Interaction
      - Communication, Psychology, Cognitive Studies
    - Social Studies of Computing
      - Science & Technology, Law, Economics, others

# An example: Georgia Tech

- Threads™ (specific paths through curriculum)
    - Modeling & simulation
    - Devices
    - Theory
    - Information Internetworks
    - Intelligence
    - Media
    - People
    - Platforms
- Roles (fine tuning of threads based on desired goals of student)
    - Master practitioner
    - Entrepreneur
    - Innovator
    - Communicator
    - Policy maker
- Additional degree programs in Interactive Computing and in Computational Science and Engineering

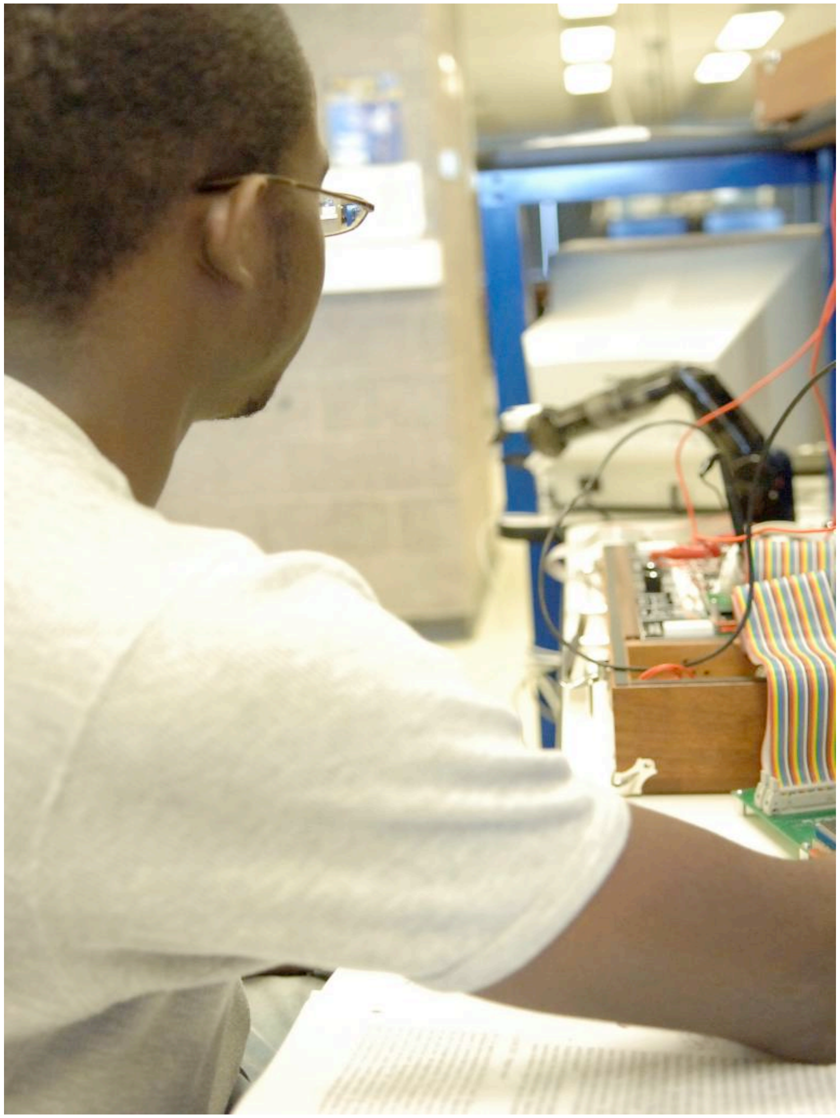
# What about the expectations of our students?

- Current students have much broader interests than their predecessors
  - Games and other interactive media
  - Social computing
  - Life science applications
  - Information sciences
- They may not be interested in or need all of the traditional areas of CS
- We need to adapt to those needs
- We may also benefit by an increased interest in the field and an increasingly diversified student body

Suggestion: We should pay attention to changing interests and needs of our students

# Adding elements to existing curricula to meet emerging needs

- As industry changes, do the requirements on curriculum need to change to meet those needs?
  - Multi-core
  - Cloud computing
  - User interfaces for mobile devices
  - Low power devices, low power computation



# Challenges to academia

- Balance teaching fundamentals with needs of specific fields
- Balance teaching foundations of field with changing interests of students
- Ensure that CS is more than a service to related fields
  - Contribute to modes of thought of other fields -- biology, medicine, social sciences, interactive media

Conclusion: Our students are changing and the requirements on our students are changing. We need to adapt to meet these changes.