Teaching Computing in India – Are we doing Justice ?

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The Crisis in the Computer Science Pipeline

That there is currently a crisis in computing education is not in doubt.

- McGettrick et al., *SIGCSE 2007*

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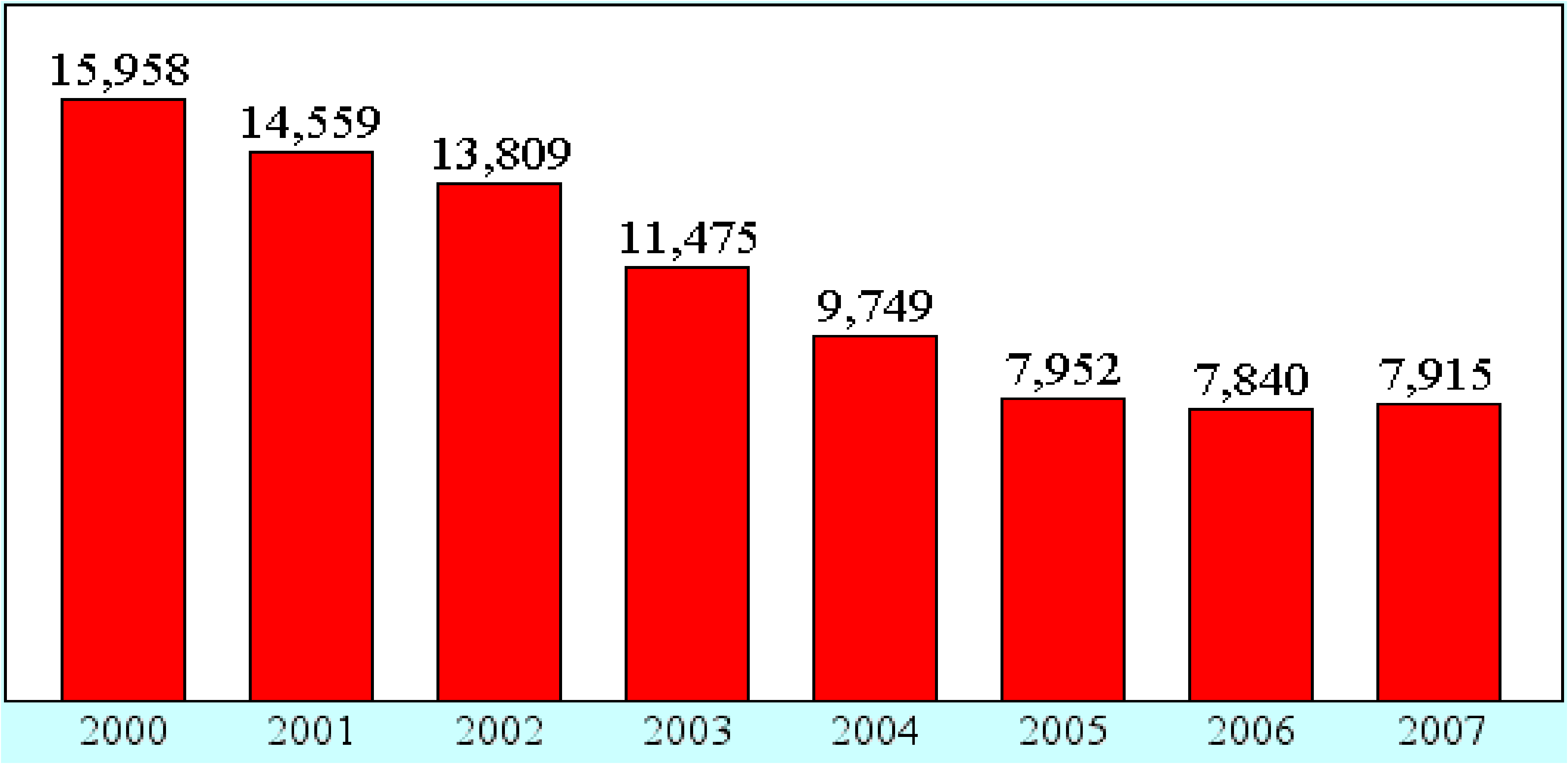
The Pipeline Problem in Computer Science

Although there are indications that the decline has bottomed out, the number of computer science majors at research universities has fallen by almost 50 percent since its peak in 2000.



Source: Computing Research Association, Taulbee Study, 2008

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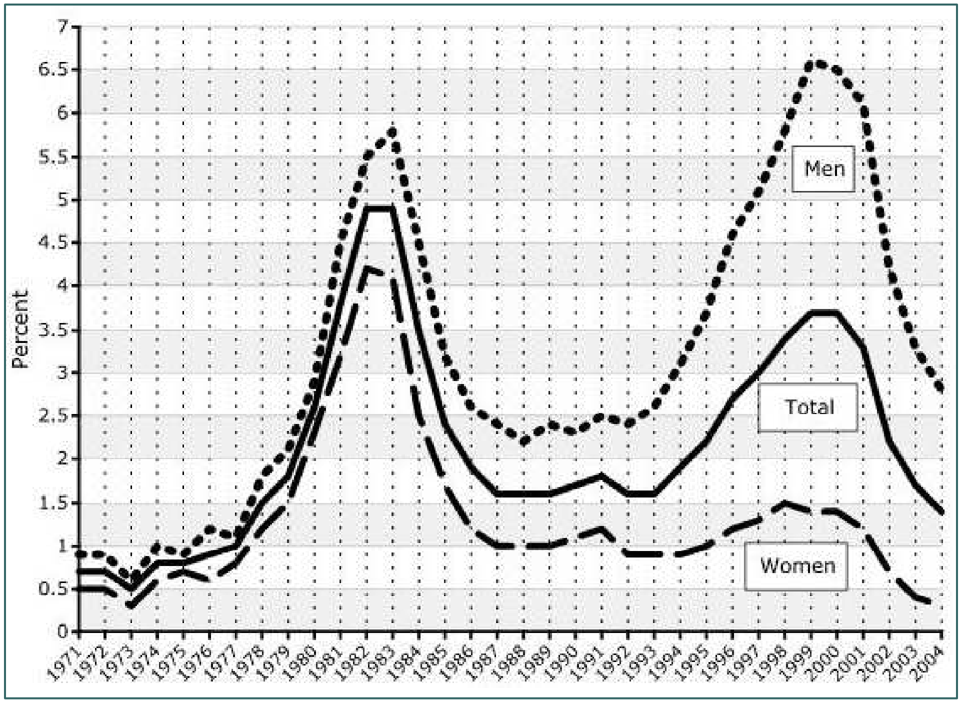
The Problem Starts Early

The UCLA HERI study shows that students have already made their decisions before they reach university.



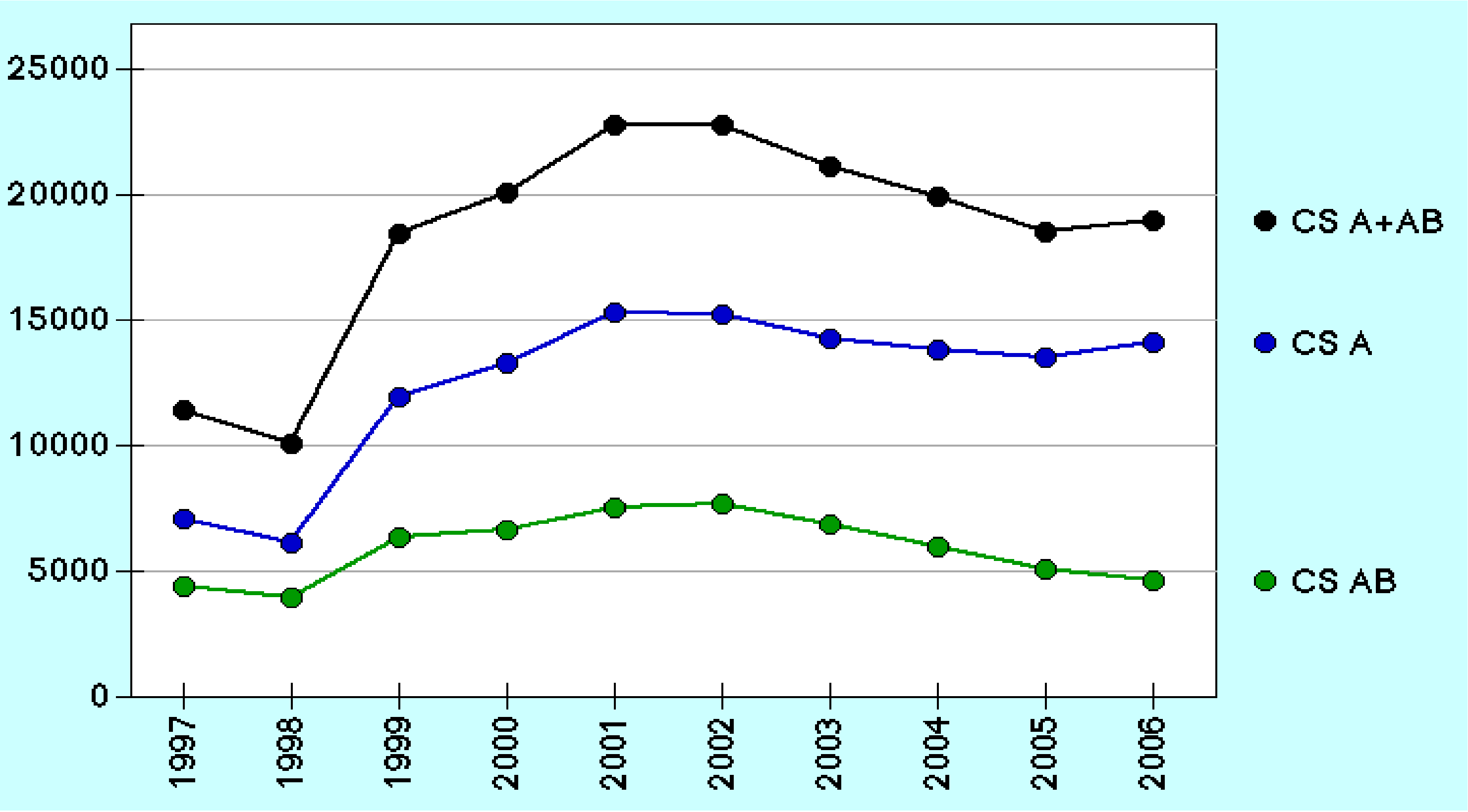
Source: Higher Education Research Institute at UCLA, 2005

By 1999, everyone and their dog wanted to major in CS

Graphic thanks to Andy Maag

CS is Losing Ground

- The Computer Science exam is the only Advanced Placement exam that has shown declining student numbers in recent years.



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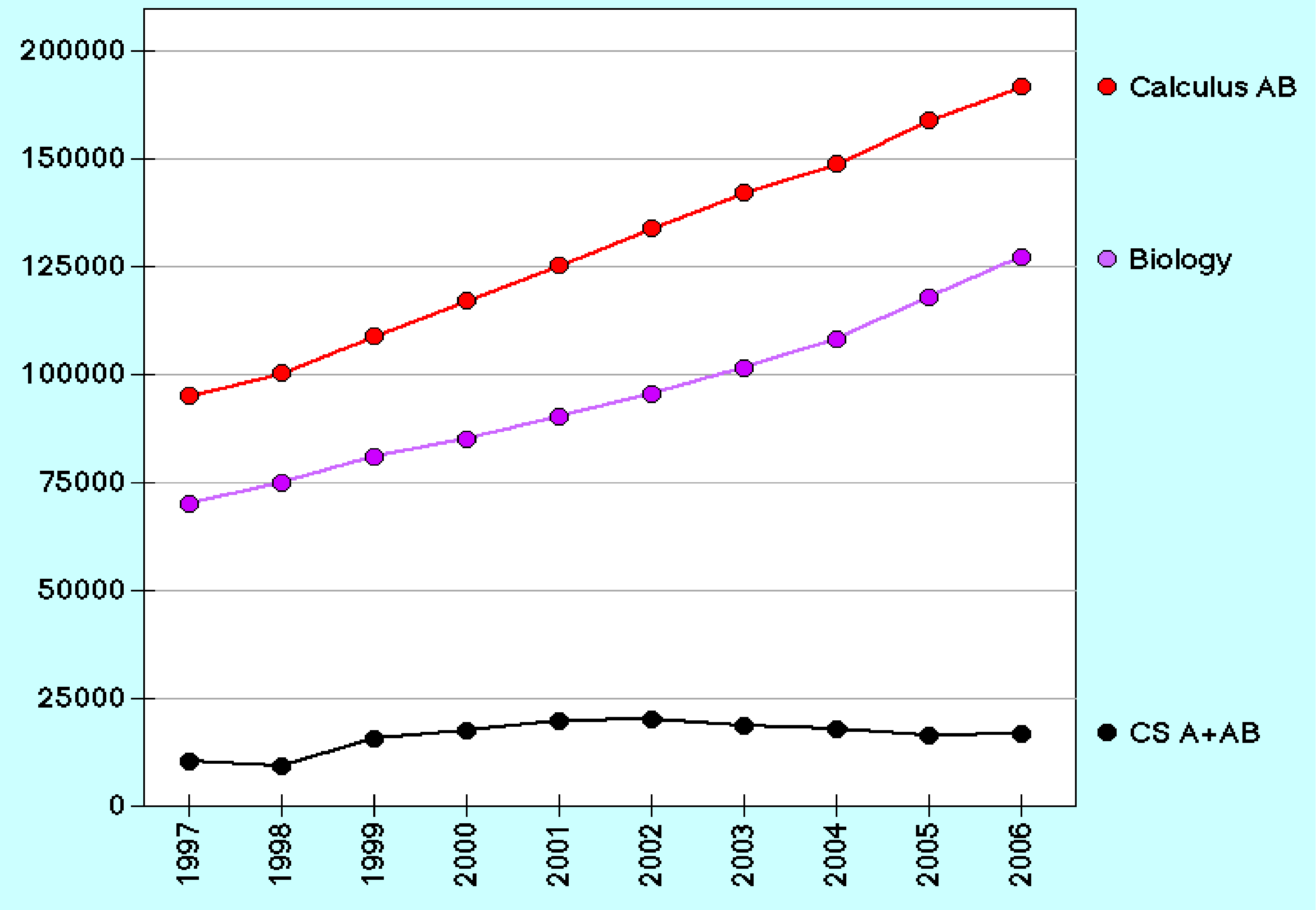
CS Is Tiny Compared with Other Sciences



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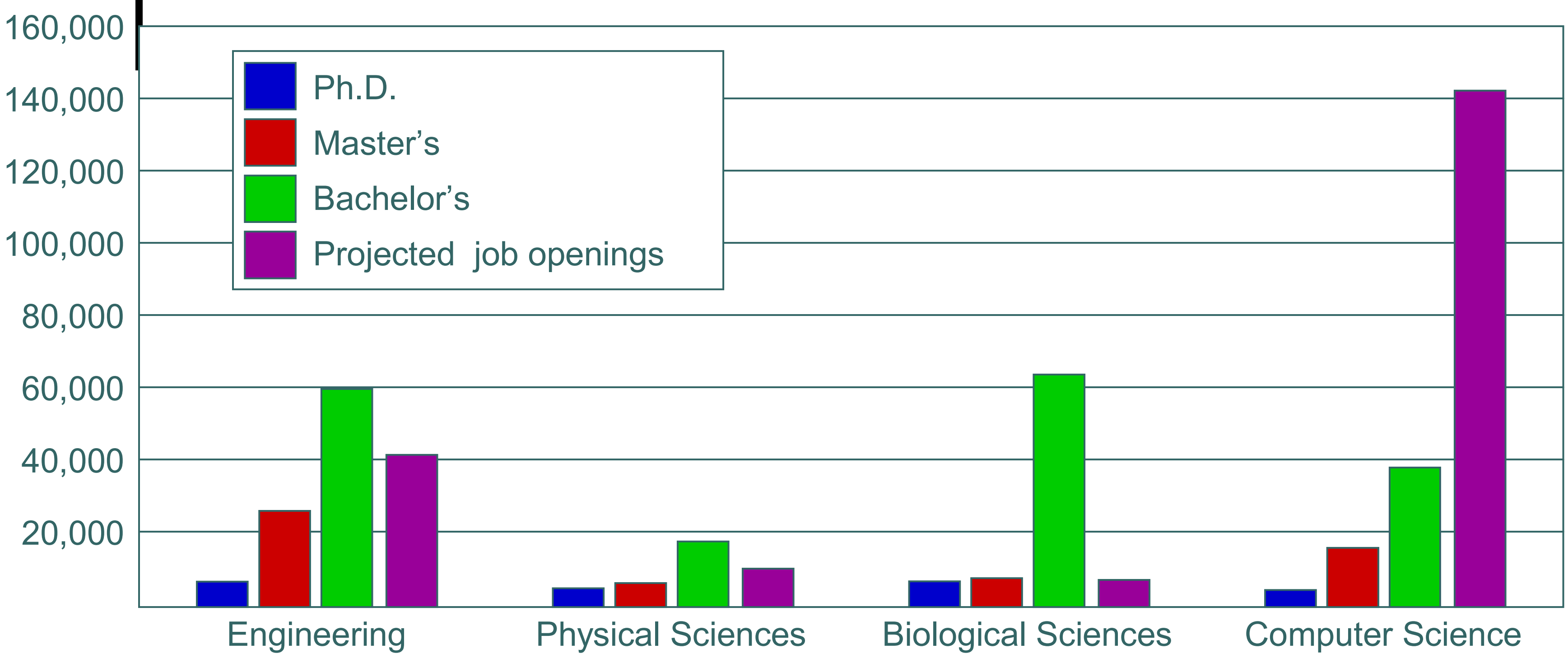
Degree Production *vs.* Job Openings



Sources: Adapted from a presentation by John Sargent, Senior Policy Analyst, Department of Commerce, at the CRA Computing Research Summit, February 23, 2004. Original sources listed as National Science Foundation/Division of Science Resources Statistics; degree data from Department of Education/National Center for Education Statistics: Integrated Postsecondary Education Data System Completions Survey; and NSF/SRS; Survey of Earned Doctorates; and Projected Annual Average Job Openings derived from Department of Commerce (Office of Technology Policy) analysis of Bureau of Labor Statistics 2002-2012 projections. See **http://www.cra.org/govaffairs/content.php?cid=22**.

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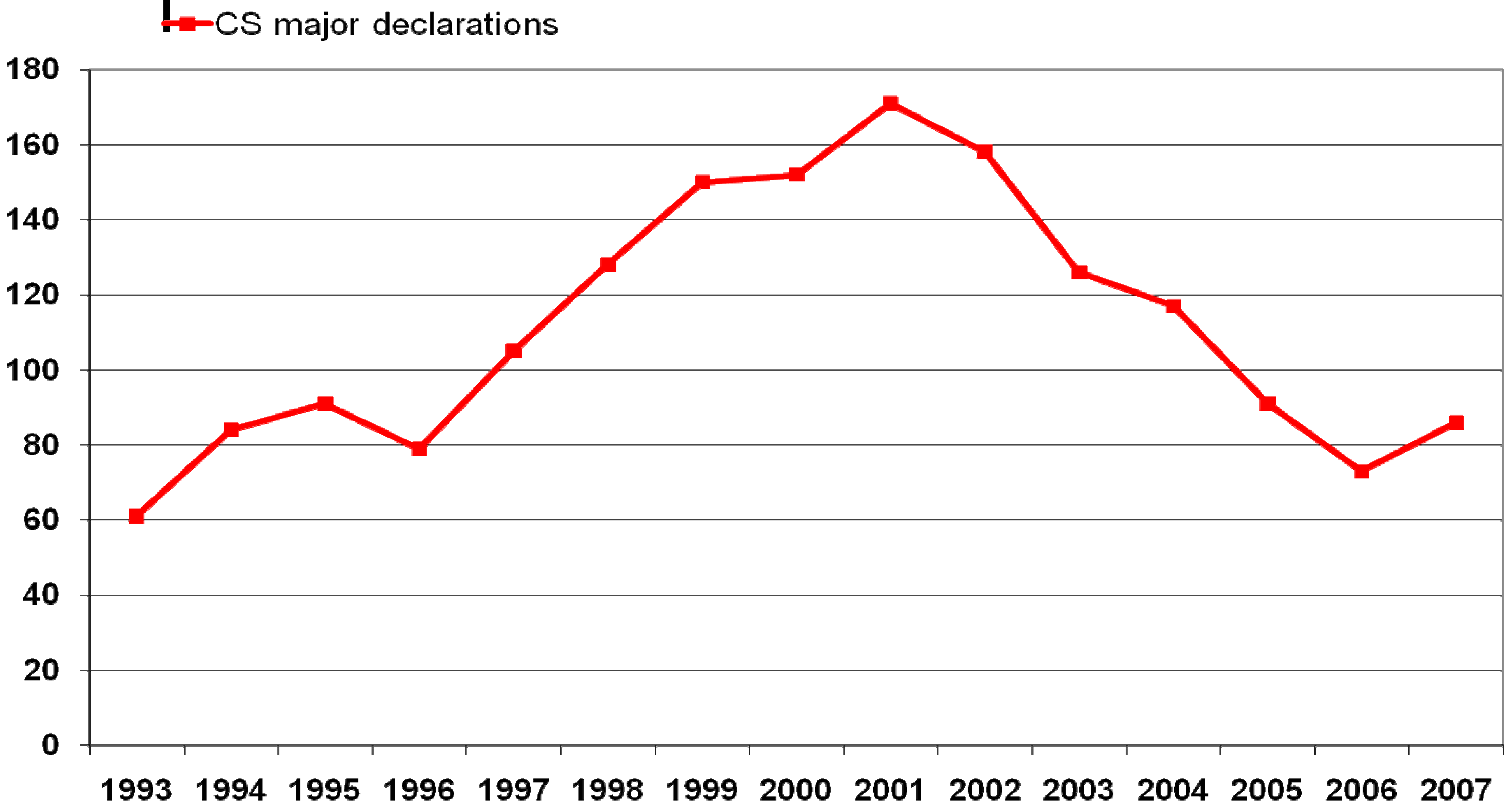
The Data From Stanford



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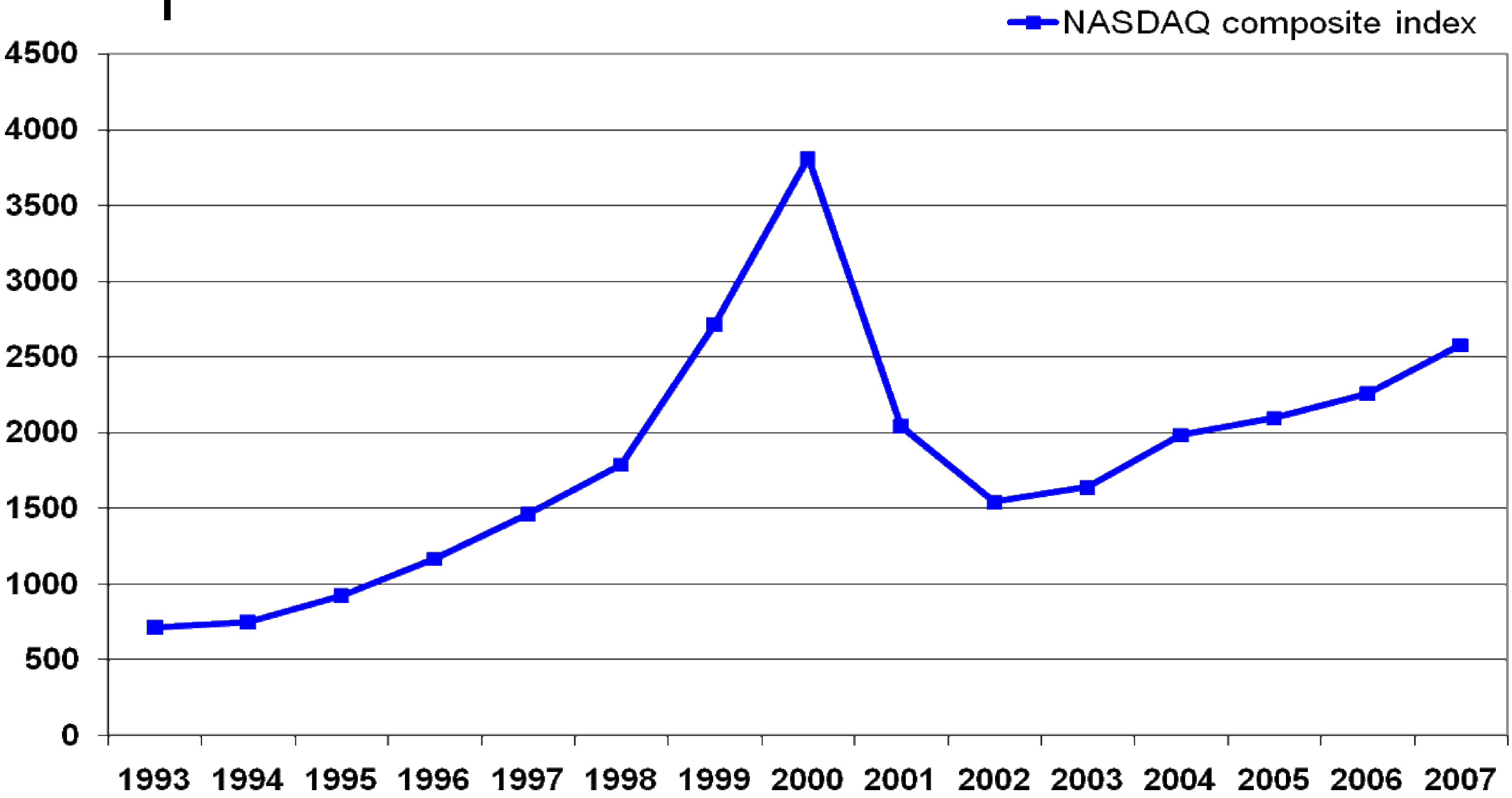
A Slightly More Well-Known Graph



Source: Yahoo! finance

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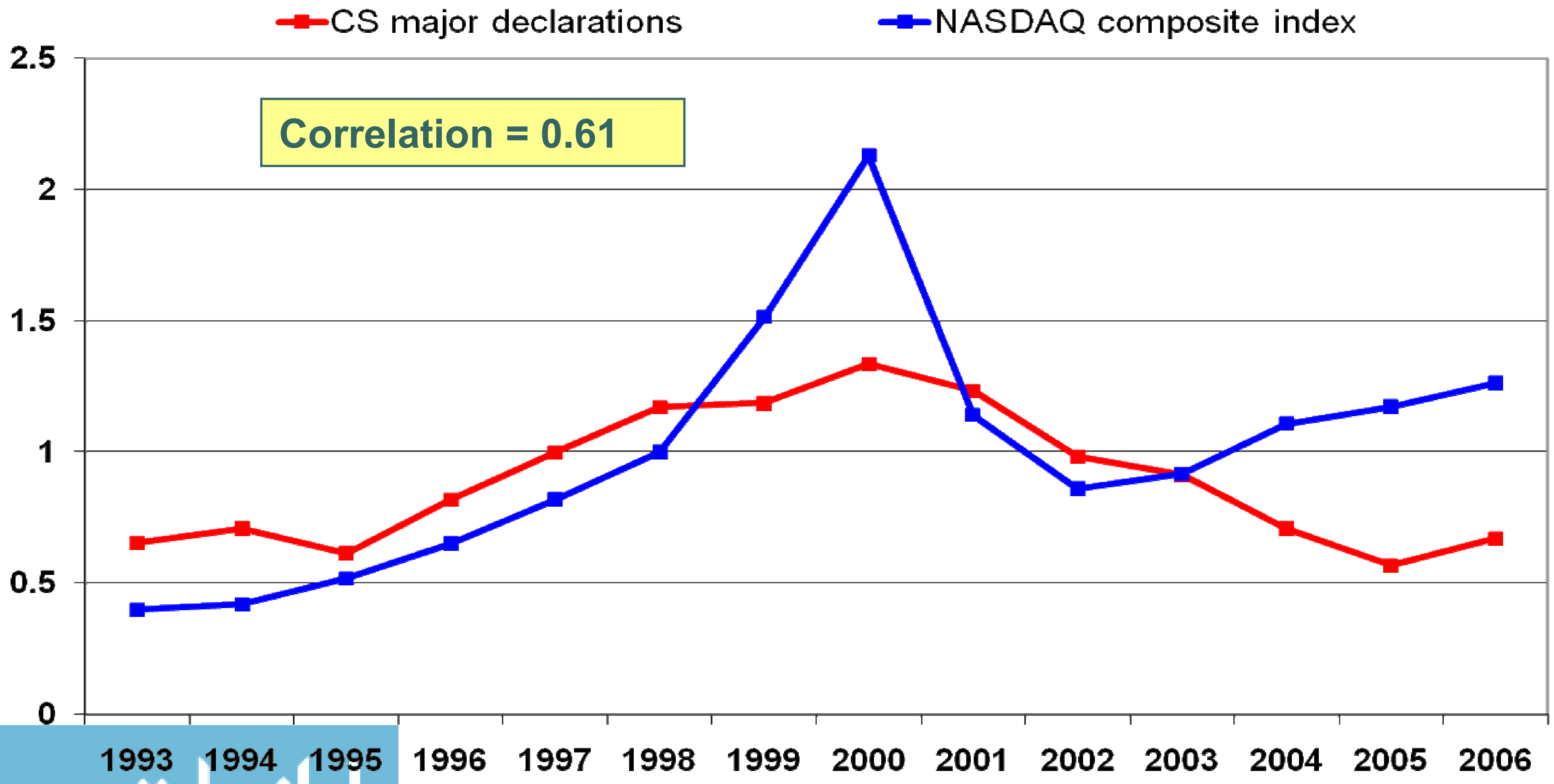
The Obvious Correlation

- Normalize both graphs by 1998 values
  - Adjust for a one year lag time in declarations



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Vital Question for India ?

Why are we increasing CS & IT Courses and Number of Students ?

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The Curriculum Cannot Be the Problem

- The computing curriculum as traditionally implemented has deficiencies and can always be improved.
- As an explanation for declining enrollments, however, the “curriculum is broken” theory has serious shortcomings:

1. It cannot explain why enrollments have varied so much over time.
2. It fails to account for the fact that institutions saw a similar loss of enrollment even when their curricula were different. Most of the proposed curriculum improvements were in place somewhere in 2000-01, but declines occurred everywhere. The resurgence of enrollment in the last year also seems independent of curriculum.
3. Students decide to avoid computing long before they have any idea what the university curriculum is.
4. Students who take our courses tend to like them but still shy away from the computer science major.

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The Reality Is Also a Problem

Typical concerns of the Students:

- Long hours with little chance for a balanced life
- A less pleasant social milieu than other occupations
- A sense that success in programming is possible only for those who are much brighter than they see themselves to be
- Work that is often repetitive and unchallenging, particularly when it involves maintaining legacy technology
- No chance for a lasting impact because of rapid obsolescence
- Fears that employment with an individual company is dicey even though opportunities are good in the industry as a whole
- Frustration at being managed by non-technical people who make more money but are not as bright (Dilbert’s boss)
- A perception that programmers are definitely on the labor side of the labor/capital divide

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The Vilification of Programming

- Those who argue most strongly for the broken curriculum theory often blame programming for the woes of the discipline, decrying the widely held view among students that

computer science = programming

This view is indeed too narrow.

- Unfortunately, however, some have started to argue for the far less defensible proposition that

programming ⊄ computer science

Adopting this position throws the baby out with the bathwater.

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Dangerous Trends

We have met the enemy and he is us.

— Walt Kelly

- As an illustration of this trend, consider the following post that appeared on SIGCSE-MEMBERS on August 14, 2006:

> I have an idea for a panel that I'd like to organize for SIGCSE'07. I'm asking for volunteers (or nominations of others) to serve on the panel. The panel I'd like to organize would have a title something like:
>
> “Alternative Models for a Programming-lite Computer Science Curriculum”
>
> The theme of the panel would be to share ideas and thoughts on how we might reduce (or eliminate) the emphasis on programming within a computer science curriculum. The basic idea is to cause discussion centered on the knowledge and skills students of tomorrow will need in the global economic workspace and the implications for the CS curriculum. As more and more aspects of software development of “offshored”, what kind of curriculum would allow a student to be successful in the IT field?

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Industry Is Not Amused

- Industry is horrified by the prospect of reducing the emphasis on programming in the undergraduate curriculum.
- At the ACM Education Council meeting in September, a panel of technical people from companies like Microsoft, Google, Amazon, and Boeing were united in their concern about the scarcity of competent software developers.
- Employers in developed countries with high-tech sectors are desperate for more people with programming talent. When Bill Gates visited Stanford, he reported that he was very happy with the students coming from Stanford; he only wished “Microsoft could hire three to four times as many.”

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Programming Remains Central

- As with many of the popular theories for declining enrollments, the call to “reduce or eliminate” programming from computing curricula arises from some undeniable assumptions:
  - There are more jobs in IT that don’t require programming.
  - Programming is not particularly popular with students today.
  - Offshoring of programming jobs has increased.

- Unfortunately, this analysis ignores the following equally valid propositions:
  - There are more jobs in IT that *do* require programming.
  - Programming has historically been what attracts students the most.
  - Offshoring exists largely because of a shortfall of skilled employees.

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The Challenge of Teaching Computing

- E W Dijkstra, “On the Cruelty of Really Teaching Computing Science” [on teachers !!]
- Educating future software professionals in the industrialized world have a responsibility to teach them durable skills. It is not enough to present immediately applicable technology, for which a cheaper programmer will always be available elsewhere.
- Commoditization of IT makes the question what to teach a very difficult one to answer.
- The growing presence of software in non-computer-science endeavors is a serious concern for teachers.
- Not many good examples and high quality case studies.
- Creating an appreciation for Software Engineering Standards is another challenge.
- How to teach the real challenges of professional software development ?

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Revising the Undergraduate CS Curriculum

- Field has evolved more significantly than curriculum in last 20 years, and will continue to do so
- Students should be explicitly made aware of the options in Computer Science
  - Diversity of areas within computer science
  - Significant role of computing in inter-disciplinary work
  - Not just trying to “fix” the curriculum
- Provide context for computing
  - Programming is the *means*, not the *ends*
  - Still, should not discount the importance of rigorous software engineering skills
    - ***Don’t “water down” the curriculum to just attract more students!***

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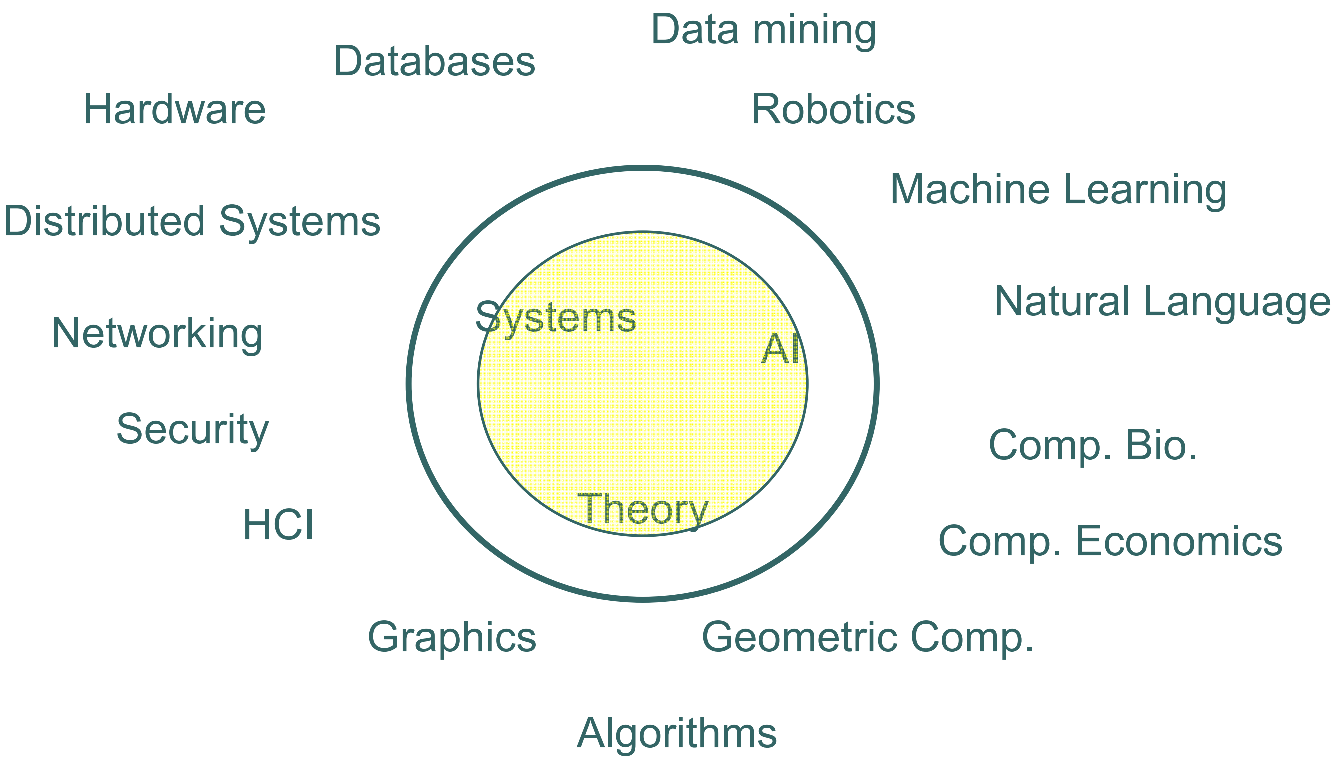
“Footprint” of CS Students See Today



Data mining

Databases

Hardware

Robotics

Machine Learning

Distributed Systems

Systems

AI

Natural Language

Networking

Security

Theory

Comp. Bio.

HCI

Comp. Economics

Graphics

Geometric Comp.

Algorithms

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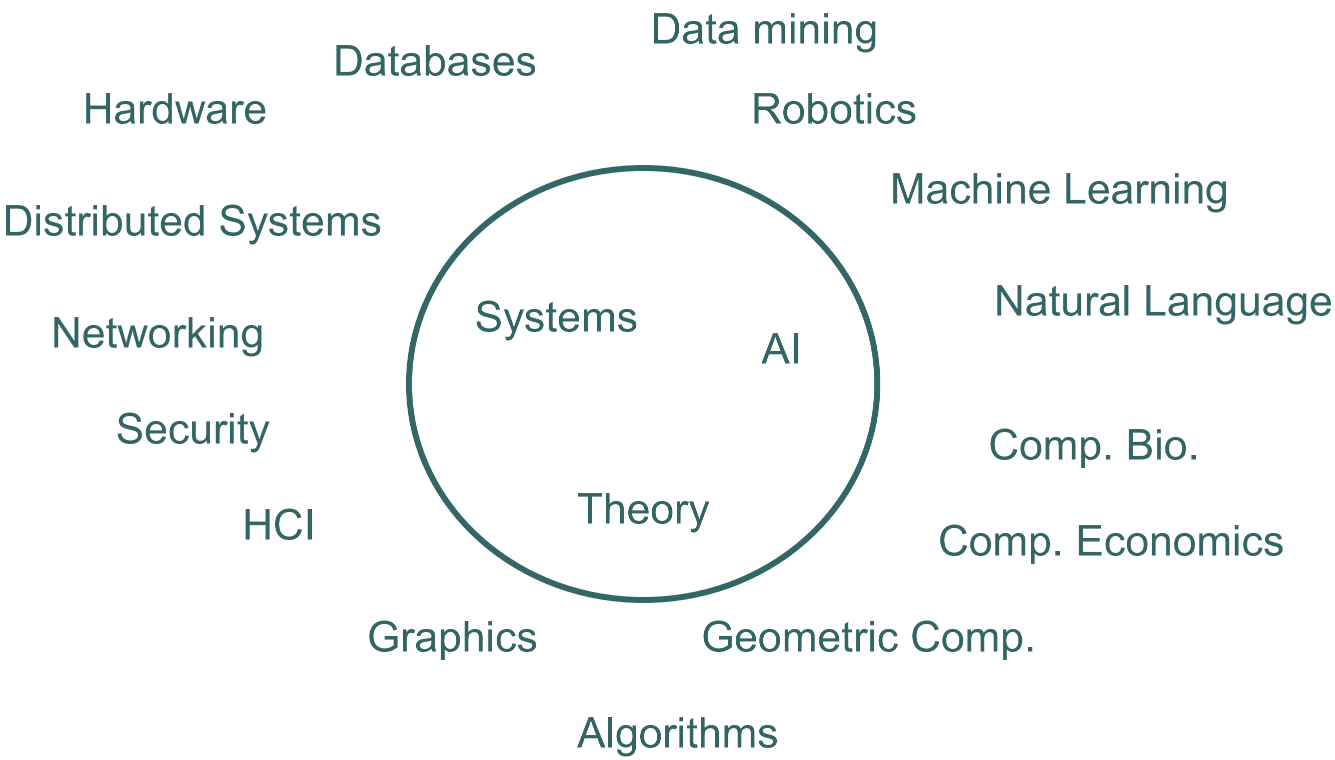
Increasing the "Footprint" of CS



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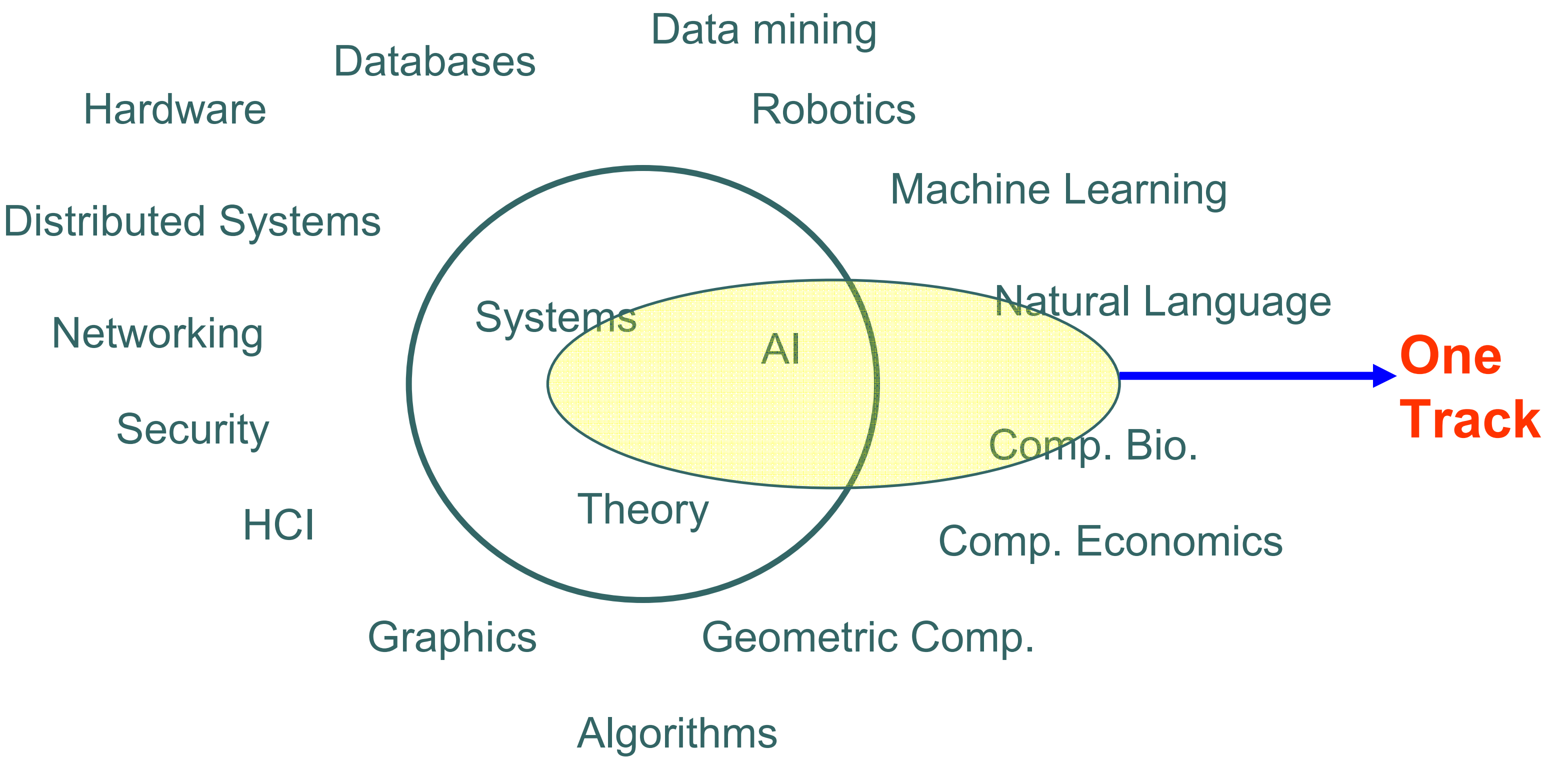
Tracks Allow More Depth...



Total amount of material covered must remain the same

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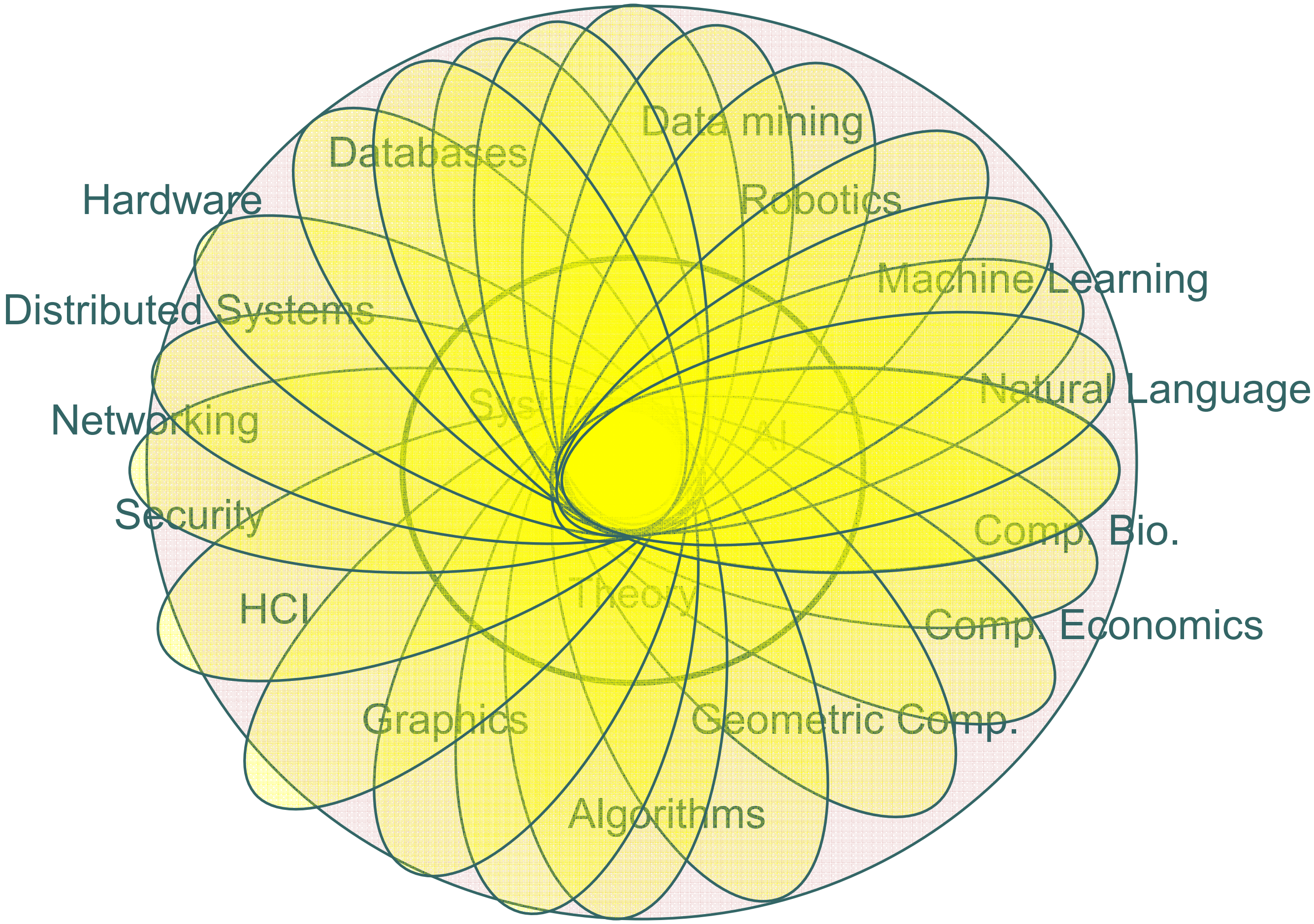
...in a More Diverse Set of Areas



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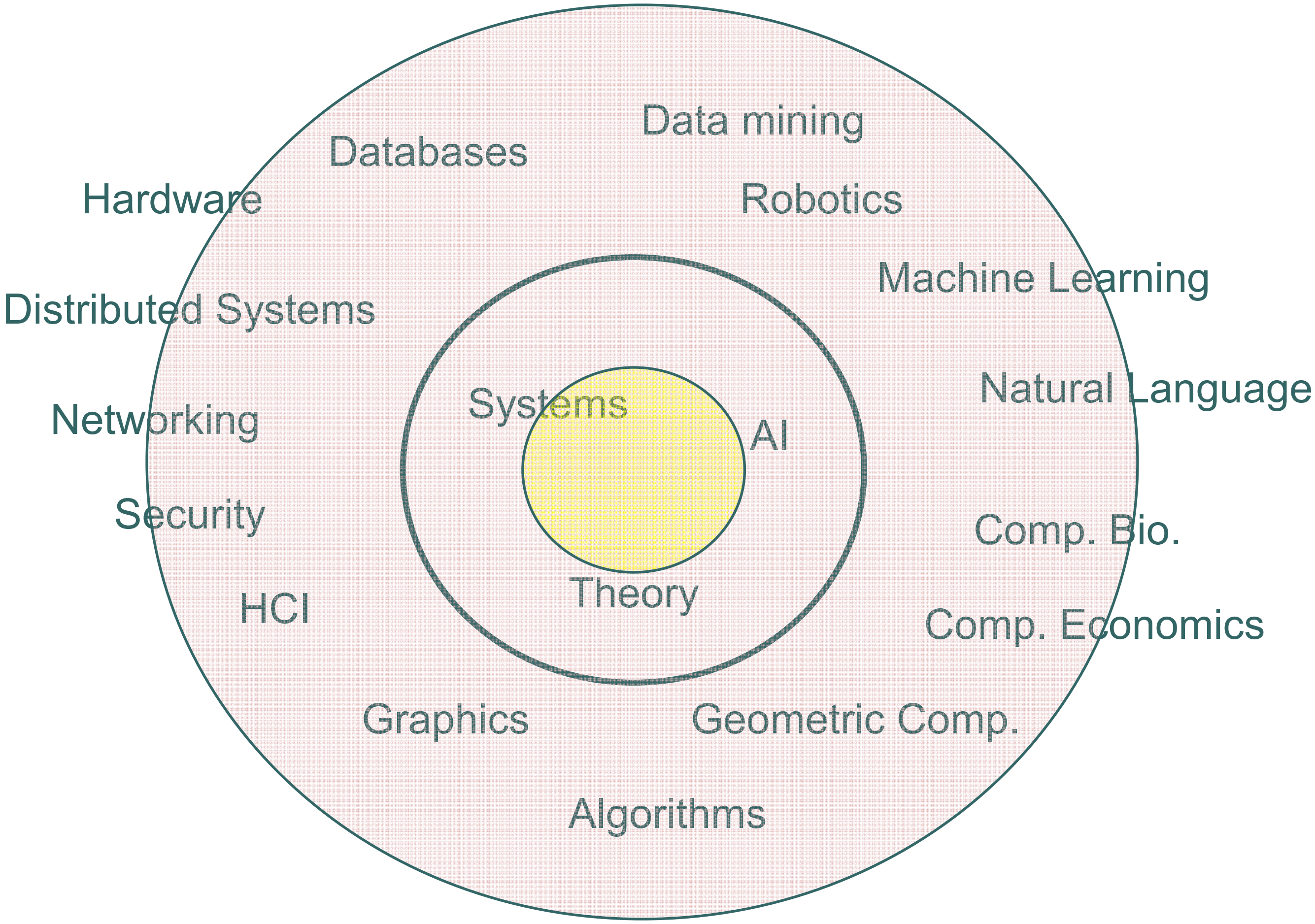
Total Potential "Footprint" is Larger



Core material everyone sees is streamlined to accommodate

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Why Tracks?

- Explicitly shows available options
  - Broad picture from awareness raising matches curriculum
  - Allows students to focus on areas in which they have the greatest interest, thus increasing appeal of program
- Helps eliminate image of CS as “just programming”
  - Shows diversity of themes in computer science
  - Provides more context for what is possible with CS degree
  - Still provides significant programming education
- Provides organizational infrastructure
  - Easier to evolve major as the field evolves
  - E.g., add/drop/modify tracks (or programs in them)

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Initial Set of Track Areas

- Software Engineering
- Systems
- Human-Computer Interaction
- Graphics & Multimedia
- Business Analytics
- Biocomputation
- e-Governance
- e-Commerce
- Digital Rights Management
- *Individually Designed*

Developing a Body of Knowledge in each track which is tailored to Indian context is a big opportunity.

Establishing a recognized certification process is a big challenge.

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Computing Curricula

The Association for Computing (ACM)

The Association for Information Systems (AIS)

The Computer Society (IEEE-CS)

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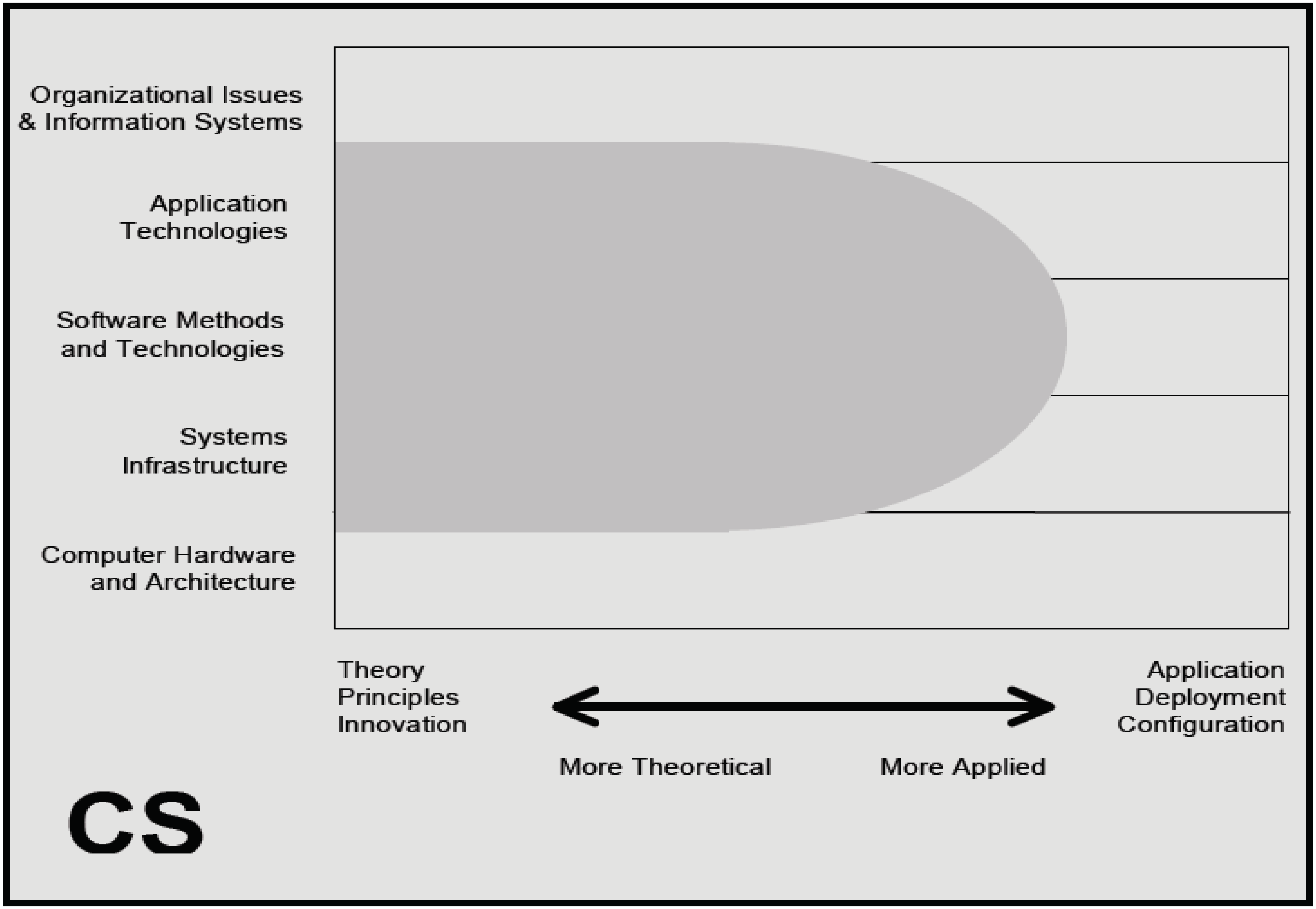

Organizational Issues & Information Systems

Application Technologies

Software Methods and Technologies

Systems Infrastructure

Computer Hardware and Architecture

Theory
Principles
Innovation

Application
Deployment
Configuration

More Theoretical

More Applied

CS

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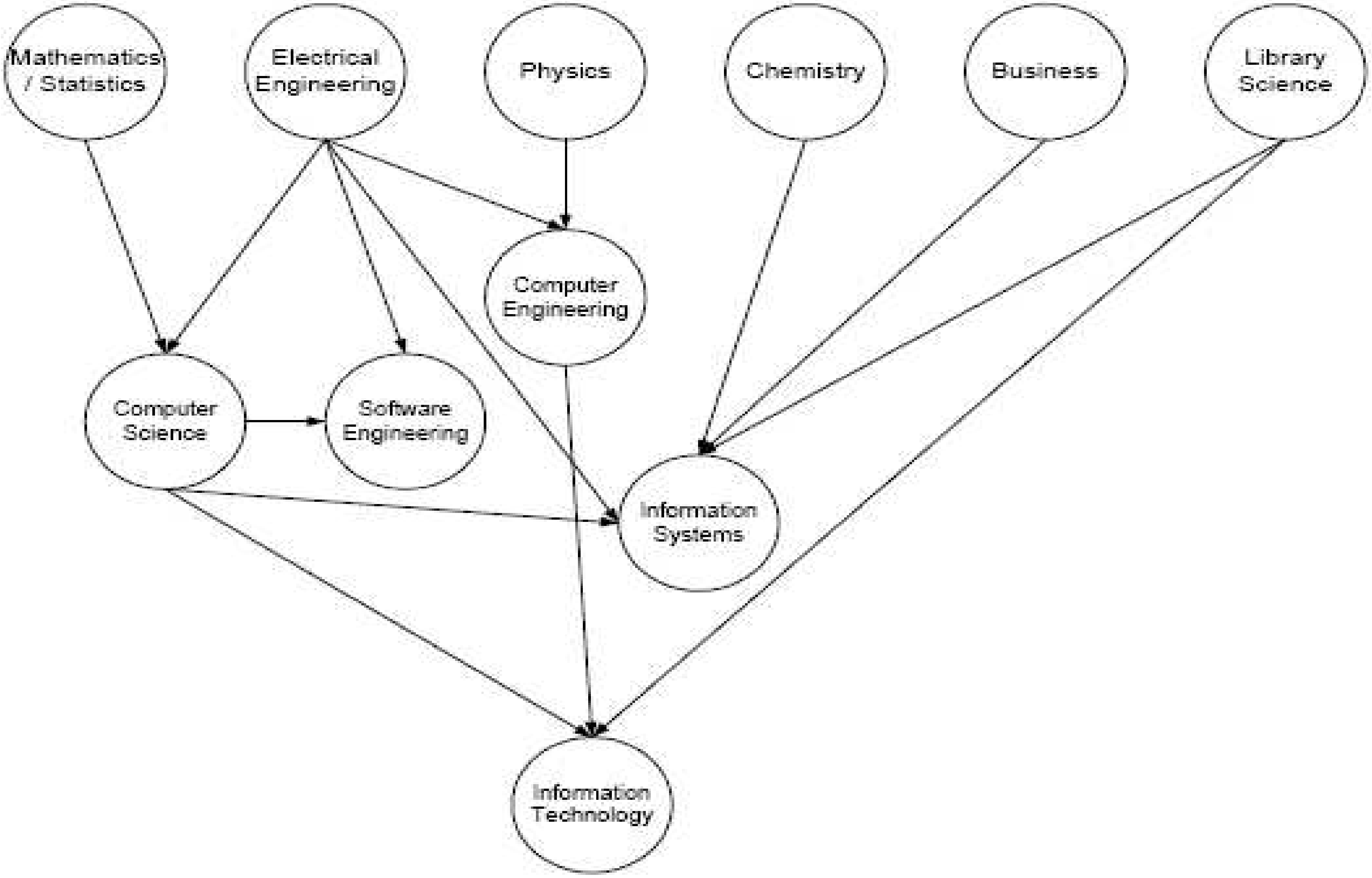
Evolution of Computing Programmes



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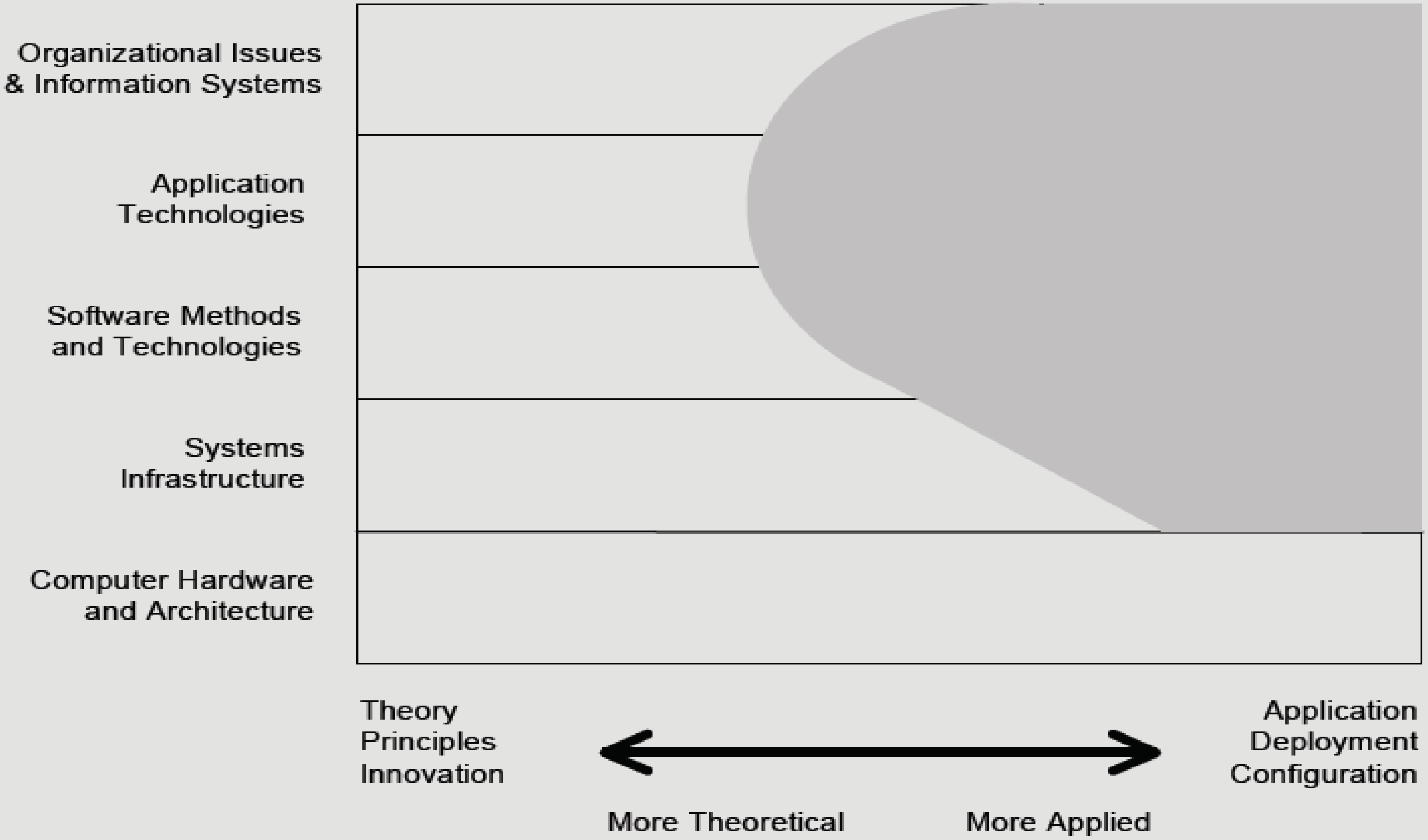

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Transferable Skills

- Intellectual skills
- Communication skills
- Organizational skills
- Interpersonal skills
- Research skills
- Numeracy [Making Numbers Speak]

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Some Ground Truths

- The Accreditation Bodies in India function autonomously.
- CSI and NASSCOM do not really impact them as of now.
- Some institutions are warming up to using courseware from NPTEL, NKN, C-DAC and Microsoft.
- India is not yet “learner – centric” in matters pertaining to pedagogy.

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What We Need To Do

- Recognize that the problems extend well beyond the university.
- Press government and industry to improve computing education at the K-12 level.
- Take creative steps to bolster both the image and the reality of work in the profession.
- Emphasize the fact that programming remains essential to much of the work in the field.
- Encourage research into new software paradigms that can bring back the **"passion, beauty, joy, and awe"** that can make programming fun again.

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- Don Sheridan and David White, **Representing a Body of Knowledge for Teaching, Learning and Assessment.**

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