MATHEMATICS AS GATEWAY

ACCESS TO SCIENCE, ENGINEERING, & TECHNOLOGY

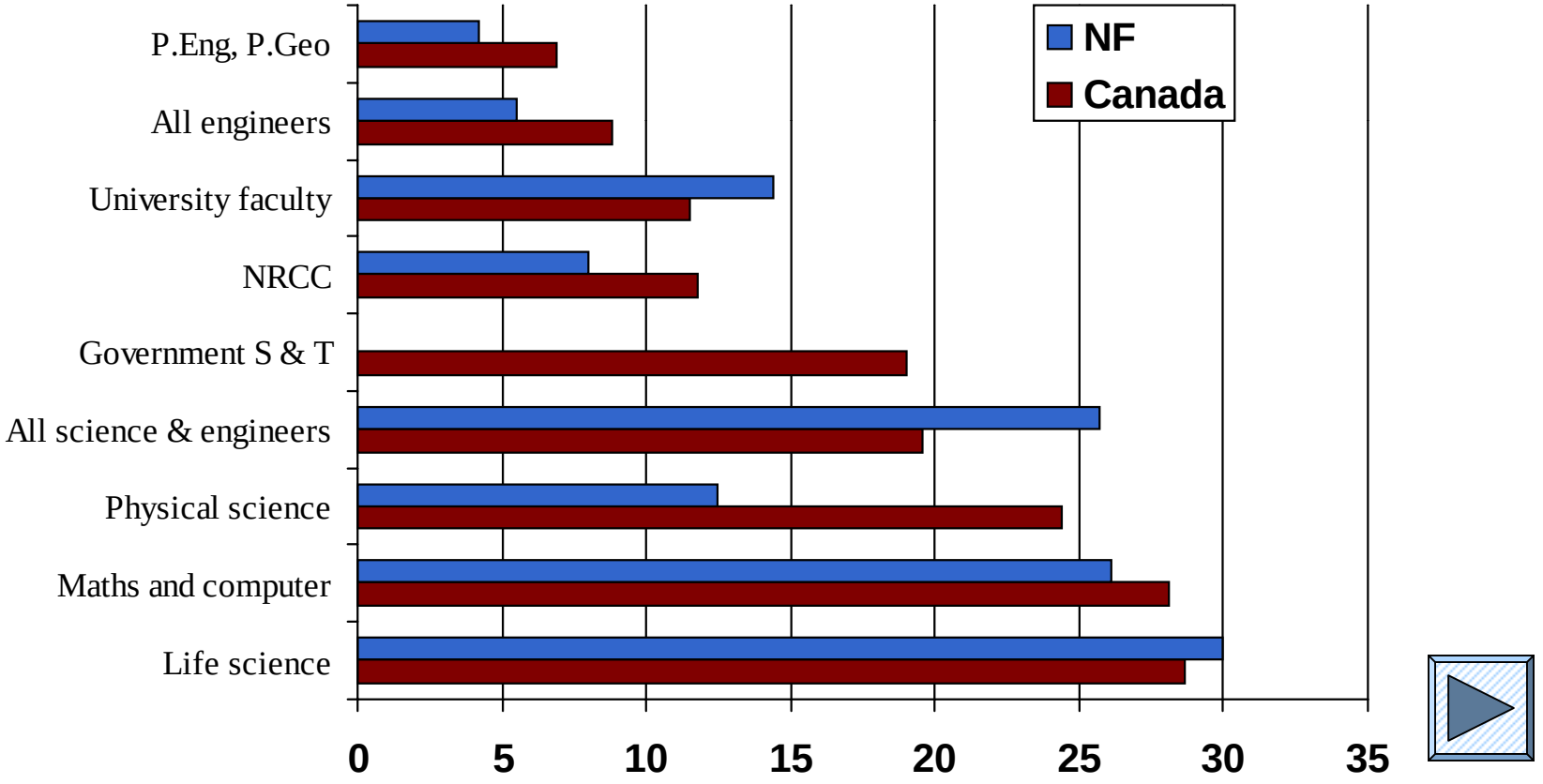
Memorial University of Newfoundland
NSERC/PETRO-CANADA CHAIR
Women In Science and Engineering

FOCUS ON MATH

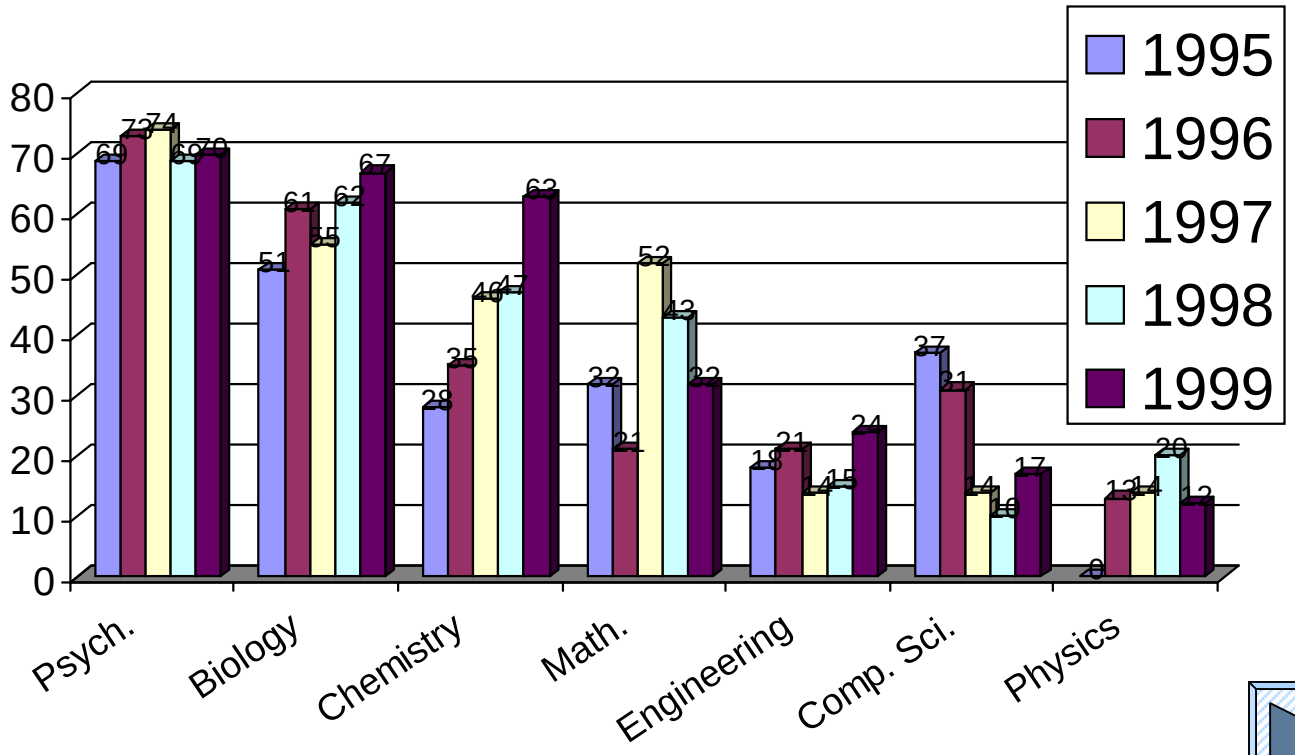
- Identifiable
- Pervasive
- Critical
- Evocative
- Personal

CWSE

Women as % total employment



% Female Undergraduate Degrees 1995-1999



Factors in girls' career selection

- Marks and self-evaluated ability
- Advice of parents & teachers
- Job opportunity
- Desire for career flexibility, balance career & family
- Desire to make the world a better place

Factors in boys' career selection

- Salary
- Job image
- Prestige or status

(Marini, Fan et al. 1996)

What is "WRONG" with Math?

- Difficult
- Abstract
- Useless
- Not relevant
- Anything else?

Difficulty

- Compared with … Music? Medicine?
- Aspects: skills, reasoning, creativity
- Timing: some students ‘get it’ later
- Culture: Japanese students do better than American
- Counterexamples: A. Einstein


CECI N'EST PAS UNE PIPE
Magritte

Common Abstractions

- Art - many styles
- Real numbers and arithmetic
- Jargon and buzzwords
- Physical model tests
- PowerPoint presentations

G. H. Hardy (1940):

Mathematics is useless, harmless, and timeless.

“The ‘real’ mathematics of the ‘real’ mathematicians … is almost wholly ‘useless’.”

“Real mathematics has no effect on war. No one has yet discovered any warlike purpose to be served by the theory of numbers or relativity, and it seems very unlikely that anyone will do so for many years.”

“Greek mathematics is the real thing.”

Relevance

- Applications in science & technology
- Scientific literacy
- Infographics
- ==========
- Not required

Academic Mathematics

- Thales (~ 600 BC) formal proofs of theorems
- Pythagoreans (~540 BC) “all is number”
- Archytas: mathematical quadrivium essential to education
- Hilbert (1898) Grundlagen der Geometrie put geometry on a *strictly* axiomatic basis
- axiomatic tradition permeates modern Mathematics writing and teaching

Formalism's limits

- Gödel's theorem (1931)
- Brouwer and intuitionism (1924)
- Penrose: Truth, proof, and insight
- Computability, complexity theory, neural networks, stochastic processes, etc.

Axiomatic Tradition

- Legacy of the Greek schools
- Legitimacy through argument & proof
- Concept is primary; application is secondary
- Progression is hierarchical

Relational Learning

- Characteristic of the arts
- Legitimacy through observation & experience
- Relationships are primary; logic follows
- Validation & extension are continuous

Relational Learners in Axiomatic Environment

- Question legitimacy
- Question motivation & relevance
- Anxiety due to missing validation
- Miss steps in progression

  or are slower initially

(Booth and Brooks 1985)

Separate studies

- Most women are relational learners (Brooks 1986) showed 93%
- Most men are relational learners (Booth and Brooks 1985) ->> 77%
- Among hierarchical learners, 80% are men (calculated, sample groups)

Your Students

- ~ 85% first year university students tend to be relational learners (spectrum).
- Motivated students will develop the other thinking style:
  - Relational thinkers learn axiomatic
  - Axiomatic thinkers learn relational
- Motivation may follow discipline switch

Some Relational Thinkers

"The way the two triple sets of axioms are contrasted in (the book) is not at all the way things happened in the process of actual thinking. This was merely a later formulation of the subject matter." - Albert Einstein

" … it was necessary to continue the development of the picture as the method, before the mathematics could really be done." - Richard Feynman

Thinking Spectra

- Axiomatic
- Rigour
- Pure math
- Structured programs
- Highly specialized

- Relational
- Intuition
- Applied Math
- Bricolage *
- Interdisciplinary

*Levi-Strauss, *The Savage Mind*

Thinking (Learning) Styles

- Trainable
- Evidence of cultural influence
- Language influence
- Brain maps (Wilder Penfield)
- Thinking paths are neural networks

Relational Technologies

- Fuzzy logic and Neural networks
- Automation and control
- DNA - and genetic engineering
- World wide web
- Climate modeling - and study of global warming

Dumbing Down Mathematics?

Students need:

- skills
- confidence
- creativity
- understanding

Upgrade of Mathematics required

Open Mathematics Teaching

- Order of topics
- Learning assumptions
- Diversity
  - student learning styles
  - evaluation methods
  - research approach

Challenge: Open Mathematics

- Research topics
- Research evaluation
- Communication
  - of research
  - about Mathematics
- Multi-discipline subjects