Educating Kids for the Information Age

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June 2003
This morning

- The future of information technology
- Education for the “innovation economy”
- Implications for K-12
  - Fluency with Information Technology
  - Educational Technology
- Washington State
  - K-20 Network
  - Digital Learning Commons
- What about women?
The future of information technology

May 16, 2003, Friday

BUSINESS/FINANCIAL DESK

TECHNOLOGY; Has Technology Lost Its 'Special' Status?

By STEVE LOHR (News Analysis) 1197 words

Searching for the elusive recovery in technology spending has resembled walking toward a horizon that just keeps receding. Improvement lies just over the next hill, most technology executives keep saying, but the present looks pretty murky.

But with signs emerging that some sort of technology recovery may be under way, Craig R. Barrett, chief executive of Intel, the world's largest computer chip maker, was still echoing the prevailing wisdom yesterday. "We continue to be optimistic about the future, but cautious about tomorrow," he said.

CIRCUITS

Computing's Lost Allure

By KATIE HAFNER (N.Y.T) 1968 words

BERKELEY, Calif. -- ON a sunny May afternoon, Berkeley's Computing's Lost Allure class at the University of California convened for the first time. Harvey was full tilt into his lecture, reviewing recursive cavernous hall was lightly peppered with about 100 seats slammed over the backs of empty seats.

Sparse attendance is, of course, an end-of-semester in a Webcast, if at all. But more significantly, just 350 students striking contrast to enrollment in the fall of 2000, when start of the semester with 700 students sitting and standing.

letters to the Editor

Does IT Matter?
An HBR Debate

1. Introduction by Thomas A. Stewart

Letters from:
2. John Seely Brown and John Hagel III
4. Paul A. Strassmann
5. Other readers
6. Reply from Nicholas G. Carr

Order the article, "IT Doesn't Matter"
E-mail us at hbr_letters@hbs.harvard.edu
A few examples
CTSS, Multics, BSD
Unit
SDS 940, 360/67, VMS

Sketchpad, Utah
CM/IBM, LucasFilm
E&S, SGI.

Arpanet, Internet
Ethernet, Pup, Dataport
DECnet, LANs, TCP/IP

Lisp machine, Stanford
Xerox Alto
Apollo, SUN

Engelbart, Rochester
Alto, Smalltalk
Star, Mac, Microsoft

Berkeley, Stanford
IBM 801
Sun, SGI, IBM, HP

Mead/Conway, Mosis

many
Berkeley
Stripes, Datamesh
many

Illiac 4, C.mmp, HPC
IBM R3F, Intel
CM-1, Teradata, T3D

Gov't research
Industry research
Industry development
$1B business
Transfer of ideas or people
A few examples

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Gov't research
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National Research Council Computer Science & Telecommunications Board ~ 2002 ~
New:

- Client/Server computing
- Entertainment technology
- Data mining
- Portable communication
- World Wide Web
- Speech recognition
- Broadband last mile
Once upon a time, the “content” of the goods we produced was largely physical.
Then we transitioned to goods whose “content” was a balance of physical and intellectual
In the “innovation economy,” the content of goods is almost entirely intellectual rather than physical.
Every state *consumes* “innovation economy” goods

- Information technology, biotechnology, telecommunications, ...

Our state *produces* these goods!

- Over the past 20 years, the Puget Sound region has had the fastest pro-rata growth in the nation in the “high tech services” sector
What kind of education is needed to produce “innovation economy” goods?

National and regional studies conclude the 3/4ths of the jobs in software require a Bachelors degree or greater (and it’s highly competitive among those with this credential!)
Average Earnings as a Proportion of High School Graduates’ Earnings, 1975 to 1999

In Washington State:

- We rank 48th out of the 50 states in the participation rate in public 4-year higher education (1997 federal data presented by OFM)
  - We rank 41st in upper-division enrollment – “Bachelors degree granting capacity” – still in the bottom 20% of states
  - We rank 4th in community college participation

- Washington’s public higher education system is structured for a manufacturing economy, not an innovation economy!
On a per capita basis, Washington ranks 32nd among the states in the number of Bachelors degrees granted by all colleges and universities, public and private, and 35th in the percentage of our Bachelors degrees that are granted in science and engineering (1997-98 data, Dept. of Ed.)

Private institutions are not filling the gap
We rank 43rd in graduate and professional participation rate at public institutions (1997 federal data presented by OFM)

We rank 41st in the number of students pursuing graduate degrees in science and engineering at all institutions, public and private (1999 data, NSF)

At the graduate level, things are just as grim
We rank 5th in the nation in the percentage of our workforce with a recent Bachelors degree in science or engineering, and 6th in the percentage of our workforce with a recent Masters degree in science or engineering (1999 data, NSF; “recent degree” = 1990-98)

We are creating the jobs – and we are importing young people from elsewhere to fill them!
UW's state funding per student is ~25% below the average of its Olympia-defined "peers" (22% behind 24 HECB peers, 26% behind 8 OFM peers) (1999-2000 data, IPEDS)

In 1976, Washington spent $14.35 on higher education per $1,000 of personal income; by 2001, that number had dropped by nearly a factor of two - to $7.65 (Postsecondary Educational Opportunity #115)

We under-fund the relatively few student places we have. And it's getting worse
Don’t our sons and daughters deserve better support?
Over a Decade of Declining State Funding for WSU and UW

WSU and UW State Appropriations per Full-Time Student
2002 – 05 figures based on actual and projected budgets and OFM enrollment projections. Dollars are held constant at 1991 level (using Consumer Price Index.)

WSU and UW State Funding, Per Student, Relative to Olympia-Defined “Peers”
Washington ranks 46th out of the 50 states in state support for research.

This is the relatively modest “seed corn” from which large-scale federally-funded research programs grow.
Washington State is all geared up to fight the last war!
Implications for K-12

- It’s not about tools and technologies
- It’s about *fundamentals*
  - English
  - Math
  - Inquiry-based science
  - Fluency with Information Technology ("FITness")
- Information technology can help teachers and learners
"Fluency with Information Technology" ("FITness")

NSF Asked National Research Council ...

“How should everyone know about Information Technology?”

- It is a question of content
- “Everyone” means the population at large
- Why should they know something about IT ...
  - To be productive in the workplace
  - To be an informed citizen
  - To apply IT to personally relevant tasks
Committee’s Answer ...

- Everyone should be *Fluent* with Information Technology
Education For A Lifetime

- A college education should have an expected “useful life” of roughly 55 years ...
- What should the Class of ‘44 have been taught considering that ...
  - Electronic computers are 53 years old
  - ARPANet came on-line 30 years ago
  - The term “PC,” as in personal computer, is less than 20 years old
  - WWW has been “visible” less than 5 years
- Fundamentals
Fluency

- The goal must be
  - teach what people need to know
  - teach what people need to know to learn what they need to know
- Adopt “fluency” for this deeper knowledge
- “Fluency” connotes expertise, the ability to synthesize, use medium effectively
- Fluency with information technology describes the objective, and FITness is the term the committee has adopted for it

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A Tripartite Solution

- Fluency with Information Technology requires the acquisition of three kinds of knowledge
  - Concepts
  - Skills
  - Capabilities

- Concepts, Skills and Capabilities are different dimensions of IT knowledge
  - Interdependent
  - Co-equal
Skills

- Knowing contemporary applications
- Approximates traditional “computer literacy”
- Essential for
  - Job preparedness
  - Education, as a tool making a student productive
  - Learning the other parts of FITness
- A moving target, reliant on the state-of-the-art

Example: Use a word processor
Concepts

- The foundations of information technology
- Concepts refer to material that might be called the “book learning” part of FITness
- Concepts explain ...
  - How and why IT works as it does
  - Constraints and limitations on applications
  - Principles on which to build new understanding
  - Ideas that can be used to make IT more personally relevant

Example: Know how a computer works
Capabilities

- Higher level thinking
- “Life skills” applied to information technology
- Capabilities entail ...
  - Abstract thinking
  - Logical reasoning
  - Analysis
  - Judgment, estimation, analogies
- The raw material for life-long learning

Example: Engage in sustained reasoning
Ten Skills

- Setting up a personal computer
- Using basic operating system features
- Using a word processor
- Using a graphics/artwork/presentation tool
- Connecting a PC to a network
- Use the Internet to locate information
- Using a computer to communicate with others
- Using a spreadsheet
- Organizing and querying a database
- Using online tutorial information
Ten Concepts

- How a computer works
- Information systems
- Networks
- Digital representation of information
- Information structure and assessment
- Modeling phenomena with computers
- Algorithmic thinking and programming
- Universality
- Limitations
- Information in society
Ten Capabilities

- Engage in sustained reasoning
- Manage complexity
- Test a solution
- Locate bugs in a faulty use of IT
- Organize and navigate information structures
- Collaborate with others using technology
- Communicate IT to other audiences
- Expect the unexpected
- Anticipate technological change
- Think about IT abstractly, learn by analogy
What has been technology's impact on education?

- Slates → blackboards → whiteboards
- Printing
- Film
- Microfilm
- Radio
- Instructional television
- Transparency projectors
- Computers

Material courtesy of Andy van Dam, Brown University
Thomas Edison

Motion pictures as an educational tool

- "Scholars will soon be instructed through the eye." - 1913
- "I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks." - 1922

Material courtesy of Andy van Dam, Brown University
Benjamin Darrow

Radio as an educational tool

“Radio may come as a vibrant and challenging textbook of the air.”
- 1932

Founder and first director of the Ohio School of the Air
Radio: the Assistant Teacher, 1932

Material courtesy of Andy van Dam, Brown University
Television

  - “Radio with its eyes open ... When the eye and the ear have been remarried in television then we shall indeed be challenged to open wide the school door. There will be no ‘blindness gap’ to be bridged.”

- Larry Cuban, *Teachers and Machines* - 1986
  - “Television was hurled at teachers. The technology and its initial applications to the classroom were conceived, planned, and adopted by non-teachers, just as radio and film ...”

Material courtesy of Andy van Dam, Brown University
Ted Nelson

*Computer + student choice as an educational tool*

"... a student (or other user) may browse and ramble through a vast variety of writings, pictures, and apparitions in magical space, as well as rich data structures and facilities for twiddling them. These we may call 'responding resources' ... Let the student control the sequence ... Teach him to orient himself ... 'No more teachers' dirty looks.'" - 1974


Material courtesy of Andy van Dam, Brown University
Alan Kay

- **DynaBook**
  - "Well, the one thing that we don't withhold from children that adults do is books. So I said, What if the computer were like a book? And so that got me thinking that way."
    
  "Kay + Hillis" - *Wired Magazine*, January 1994

- Smalltalk was originally an exploratory programming environment for kids

Material courtesy of Andy van Dam, Brown University
Seymour Papert

- Computer + student choice as an educational tool

“There won’t be schools in the future…. I think the computer will blow up the school. … but this will happen only in communities of children who have access to computers on a sufficient scale.”

“Trying to Predict the Future”, Popular Computing, October 1984

Material courtesy of Andy van Dam, Brown University
Reality: The educational technology track record

for each new technology

{ euphoria and hype
  struggle to produce material for the new medium
  mature judgment
  disappointment and cynicism
  wait for the next technology that will be the answer

Material courtesy of Andy van Dam, Brown University
So, why now?

- Increased knowledge of how individuals learn
  - Technology can accommodate multiple learning styles
- Moore’s Law is finally paying off
  - Something that matters is doubling every 18 months
- Networks and the Web connect us
  - Fosters exploration, interaction, community
- There are early examples to inspire us
  - Interactive, adaptive, flexible
- There’s a clear recognition that teaching and learning must be the focus, not technology
- “Digital kids” are ready!
How?

- Accessing Information
  - Access to primary resources
  - Self-directed learning
  - Access to real-time data
  - Serendipity

- Publishing
  - Data collection and analysis
  - Creating and publishing for a wide audience
  - Immediate feedback
Collaboration

- Communication with others, everywhere
- Sharing ideas, work, and responsibility
- Eliminating boundaries and exploring commonalities

Community Building

- Creates new communities of learning, new partnerships
- Opportunities for involvement by diverse groups
Adaptive Technologies
- Access for LD and PD students
- New opportunities and motivation for disabled students

Tools for Teachers and Administrators
- Creating a global community of teachers
- Curriculum, lesson plan, and idea sharing
- Administrative efficiencies
- Professional development opportunities
Self-paced and adaptive learning systems

- Dynamic content creates interest and motivation
- Can address multiple learning styles
- Simulate “one teacher per learner”
Instrumentation
- Control and manipulate devices to retrieve realtime data
- Access limited resources and places

Simulation ("exploratories" "clip models")
- Connection between classroom learning and real-world experiences
- Makes the inaccessible accessible
- Explore new worlds
This is a multi-disciplinary grand-challenge-scale problem!

- So what is our current level of investment?
  - Measured as a fraction of total expenditures, the computer chip industry spends 200X as much on R&D as does the education industry.
  - The potato chip industry spends 20X as much!

- It's time to get serious!
K-20 Educational Telecommunications Network
K-20 Intranet Utilization

Billions of Bytes per Day

JFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASOND

1999 2000 2001

Billions of Bytes per Day
K-20 Switched Video Utilization

Site Events per Day

1999 2000 2001

K-12 Intranet Usage per Student

**Urban**
- 37%

**Rural**
- 63%

**Rural**
- 216,869 Students
- 192 Districts

**Urban**
- 785,062 Students
- 102 Districts

*Usage per student = \( \frac{\text{total usage}}{\text{total number of students}} \)*
K-12 Video Usage per Student

* Usage per student = \( \frac{\text{total usage}}{\text{total number of students}} \)

**Urban**
- 785,062 Students
- 102 Districts

**Rural**
- 216,869 Students
- 192 Districts
Washington State’s “New Students”

- Today’s students are very different than those of generations past
- Computers and digital technology are a day-to-day part of their lives
- Little reluctance to use technology
Have a Home Computer...

Yes, Has Home Computer: 98%

No Home Computer: 2%

Base: ~ 586,146 Children at the 6th-12th Grade Level
Middle School (6th-8th)

- 29% use 1 Hour or Less
- 41% use 2 to 3 Hours
- 15% use 4 to 5 Hours
- 15% use 6 Hours or More

Early High School (9th-10th)

- 21% use 1 Hour or Less
- 34% use 2 to 3 Hours
- 20% use 4 to 5 Hours
- 25% use 6 Hours or More

Late High School (11th-12th)

- 13% use 1 Hour or Less
- 29% use 2 to 3 Hours
- 29% use 4 to 5 Hours
- 30% use 6 Hours or More

Middle School Base: ~ 252,100 Children at 6th-7th Grade Level
Early High School Base: ~ 181,206 Children at 9th-10th Grade Level
Late High School Base: ~ 152,840 Children at 10th-12th Grade Level
Online courses offered by third parties (e.g., Federal Way Internet Academy, Apex, etc.). Approved for credit by central authority. Juried by content experts, state students, teachers and parents.

Modified versions of tools already in existence (e.g., Catalyst); commercially licensed tools and resources; tools and resources offered by other Washington state non-profits (e.g., The Learning Space); tools and resources submitted by state schools and teachers.

Hosted or linked vetted content provided by: state teachers and students; state funded third party commercial providers (e.g., ProQuest); fee-free third party content on the Internet (e.g., Smithsonian, NASA, etc.); third party Washington state resources (e.g., UW collections, state museum collections, etc.).

Tie-ins to Pacific Northwest Giga-Pop and other similar institutions that can provide enhanced access, enhanced content, etc.

Connectivity from each district’s K-20 drop to each classroom in the district

Additional access for teachers, parents and students from public libraries and homes

Computers and peripherals, tech-support, etc. for administrators, teachers and students

Mentors for online courses

Teachers trained to utilize tools, resources and content

Funding for computers, tech support, mentors, trained teachers and online courses

Broadband, always on Dial-up, DSL, etc.

Libraries via K-20 Network

Homes via ISPs

State Undertaking

Local Undertaking

K-20 Network

Digital Resources

Teaching & Learning Tools

Online Courses

Washington State Digital Learning Commons ("DLC")
Myths, Opinions and Facts about Females and Computing

Maria M. Klawe
Chair, Board of Trustees, IWT
President of ACM
Dean of Engineering and Applied Science, Princeton University
Take home messages

Getting more females into computing

- matters
- is complex
- takes commitment and time
- can be done
- is up to all of us
Why do fewer females

- Play computer games?
- Take computer science courses?
- Major in computer science?
- Go into computing careers?
- End up in senior positions?
Myths about computing?

- Computing is a guy thing
- [Girls, women] can’t do math
- You have to program 24/7 and ...
- Programming is boring
- Computer people have no life
- To succeed you need to be born with the computer gene
- Computing jobs are all gone now
K-12 SWIFT Career Interest Survey 1998-1999

- 7300 Vancouver students in grades 8, 10, 12
- participation decided by English class teacher (60% participation) but results from entire schools analogous
- interest in subjects, ability in subjects, career influences
- participation, interest, ability in IT activities
- perception of different kinds of careers
Interest in taking a course

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<th>Female</th>
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Expected performance
Career influences
Choice of careers follows interest and perceived ability

Most females think that computing is less interesting than other options and that they won’t be as good at it
Issue 2

- Females often have the “impostor syndrome” to a higher degree than males
  - [lack of confidence, lack of sense of belonging]
- this causes many females to leave computing courses and careers
- Imposter syndrome occurs at all ages, career points, and levels of achievement
solutions

- Increasing interest in computing
- Increasing confidence
- Increasing sense of belonging
Increasing interest

- Change the image
  - media, games, contests, workshops, speakers, programming in math curriculum
- Emphasize applications
- Have computer science majors with...
  - psychology, biology, art, music, languages, statistics, math, chemistry, theatre, business
- Provide work experience (coop terms)
- Include team work, users, communication, volunteer opportunities
- Give her a [new] laptop of her own
Increasing confidence

- Unfailing encouragement, positive feedback
- Role models and mentors
- Peer cheer-leading groups
- Comfy home base
- Ok to cry
- Learning how to become strong in an area of weakness
Increasing sense of belonging

- Achieving critical mass
- Creating environments supportive of personal lives
- Ensuring inclusive language, images, examples
- Suppressing jerky behavior
- Treasuring difference of opinion, difference of experience
- Hearing female voices
Everyone can contribute

- Encourage
- Provide role models
- Work on the image
- Make your environment PL-friendly
  - photos, kid presence, part-time, flex-time
- Hear female voices
- Support IWT
This morning

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- What about women?