The Digital StudyHall

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“Tutored Video Instruction”

- Stanford -> Santa Rosa plant of HP
- Minimally edited videos of unrehearsed lectures
  - Easy to make

1977

A long time ago in a galaxy far, far away....

“Tutor” job:
- Initiate and encourage stopping the videotape for discussions
- Rely on dynamic interaction to stimulate intrinsic interest
- Interfacing with on-campus instructor
TVI results
Stanford Engineering Graduate Students

- TVI students start with worse qualifications
- They come out ahead regular students

Lessons
- Although not sufficient by themselves, captured lectures are a good foundation
- Instigating interaction can significantly enhance effectiveness
- Successful instigation can be effected with relatively simple means
- Group learning can play a key role

Outline
- The “TVI prelude”
- India education background
- Introduction to the Digital StudyHall
- Connectivity: Postmanet and phttp
- Content capture
- EdTV
- Homework
- Pedagogy
- Other applications
- Conclusions
India

- Adult literacy rate: 61%
- 34% of adult illiterates in 9 most populous countries
- An average Indian spends about 2 years in school


Poor state of public/private education

- “Free” public schools of extremely poor quality
- Serious teacher shortage and absenteeism
- Exponential growth of unregulated private “teaching shops,” especially in rural areas

StudyHall

- Urban private school in Lucknow
- Principal: Dr. Urvashi Sahni
**StudyHall**

- Well-staffed
- Well-furnished
- Lots of facilities: sports, science labs, music rooms, computer labs

**After-school program**

- 1pm to 4:30pm
- Targets girls from the urban slums
- Would not have had access to education otherwise

**The Affiliated Village Schools**

- About 250 students per school
- 2-6 teachers
- Little training
- Difficult subjects: English, math, science

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• Narrow the gaps between:
  – Urban and rural
  – Private and public schools
  – The rich and the poor

• “Out-sourcing” model
  – Make shared resources available to those who can’t afford piecemeal instances of their own
  – Economy of scale: encourages specialization, fosters efficiency
  – Uniform standards and quality
In the longer run...

- Scale up
  - More villages
  - More students
  - Start schools where there's none today
  - More staff/volunteers
  - Including volunteers overseas

In the longer run...

- Allows distributed participants to "plug themselves in"
- Matches supply and demand
- Service offerers: both volunteers and professionals
- Flexible time and location commitments by participants
- "Open source" model

**Principle 1: cost realism**

- Schools in Bihar, Madhya Pradesh, Uttar Pradesh, and Rajasthan:
  - 63% leaking roofs
  - 58% no drinking water
  - 89% no functioning toilet
  - 27% no blackboard
  - 8% none of the above
- Weigh the cost of ICT against the above
- Cost realism crucial for scalability

Principle 1: cost realism

- Cost of “wiring” a village school < $1000
- Cost of “wiring” a child < $5
- (Not included: operational cost)
- Compare this against:
  - A GSM base station
  - Erecting a tower for a directional 802.11 antenna
  - Launching EDUSAT
  - Adding an extra telephone line to a house in the US
  - Wiring a household in the Salt Lake Area with fiber

Principle 2: build “systems” that solve education problems

- A lot more than connectivity
- “workflows” and pedagogy
- Work with people:
  - Headquarters staff
  - Teacher training institute volunteers
  - Village teachers
  - Students as students
  - Students as teachers

Recurring themes

- Any-to-any communication, customization, sharing, high bandwidth, cheap, solve education problems
- Enable collaborative learning among kids
Some hard questions

- How do you provide connectivity?
- How do you quickly populate your database with good teaching content?
- How do you address the “display problem”?
- How do you collect homework and provide feedback

Components: repository, phttp, EdTV
“Workflows:” content capture, homework feedback
Pedagogy research

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Low-latency low-bandwidth link

- India cell phone tele-density: 2.5% as of 2003
- Directional 802.11: a tower alone costs $2500
- Our current choice: packet radio (ham radio)
- Pro: range, cost; Con: low bandwidth

Source: http://smallwonderlabs.com
A Postmanet Router

- Basic idea of using DVDs not new
- What is new: general and transparent
- General:
  - Support for multiple applications
  - Generic infrastructure (public transit system)
  - 2-way communication
  - Multiplexing/demultiplexing onto/from minimum disks
- Transparent:
  - No manual inspection of DVD content
  - No manual staging, copying
  - No manual handling of acks, losses, duplicates, …
  - Just insert/remove DVDs from the box

Advantages

- Wide reach: a truly global “network”
- Great bandwidth potential, technology trends:
  - “Sneaker nets” becoming more powerful
  - Storage density growth > Moore’s Law
  - Wide area bandwidth growth bound by digging ditches, launching satellites, erecting WiMax towers…
- Low cost
- Incremental deployment:
  - Classic chicken & egg problem: infrastructure, applications, users
- Good scalability


DVD Capacity

- HD-DVD: 15-20GB per layer, maximum of 40GB dual-layer discs
- Blu-Ray: 27GB per layer, 54GB dual-layer discs
- Sony plans to commercialize 4-layer 100GB Blu-Ray discs in 2007
- Sony has demonstrated 8-layer 200GB Blu-Ray discs in October of 2004
- Torok of Imperial College London
  - Asymmetric pits encode more than one bit per pit
  - Expects 4-layer 1TB discs 2010-2015

phttp: Postmanet-enabled http

- Network packets carried by DVDs in the postal system
- Transparency:
  - Minimum manual involvement beyond postal workers’ leg work
  - Crucial for scale-up
Difference from offline browser

- Offline browsers
  - Eventual connection
  - No support for server scripts
- Phttp
  - May never be connected
  - Explicit migration of server script fragments

DVD Robot

- Why DVDs? Capacity, cost, weight, ...
- Robot automation

The key is transparency

- Transparency and efficiency needed for:
  - Scale up
  - Handling exceptional events
  - Splitting server scripts
Complement with low-latency network

- Catalog of metadata
- Small requests, acks, NAKs, retransmission requests, etc.

Recurring theme: any-to-any communication

- Customized content, customized schedule
- High-bandwidth
- Cheap

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Lecture capture

- Replaying captured lectures, by itself, will not suffice, but
- It can be an important part of a bigger solution
- (We will talk about other parts of the solution)
Real-time MPEG4 encoders

- 720x480 (DVD quality), DivX codec
- 30fps generates 1GB/hour
- 5fps generates 250MB/hour

Still camera: periodic shutter release

- 2048x1360
- 6 seconds per frame, 180MB/hour

Real-time MPEG4 encoders

- 720x480 (DVD quality), DivX codec
- 30fps generates 1GB/hour
- 5fps generates 250MB/hour

Other content

- Homework and feedback (more later)
- Asynchronous question and answer sessions
- Student-authored content
- Contributions from elsewhere
- Multiple centers of content accumulation
  - A peer-to-peer architecture of the repository
Recurring Theme: any-to-any communication

- Customized content, customized schedule
- High bandwidth
- Build “systems,” not just providing connectivity
- Cheap

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The display problem

- Additional computer displays
- Projectors
- Expense and power consumption

EdTV components (“output”)

- Graphics card with RCA/S-Video output
- Small TV signal transmitter
- A 12-inch TV set burns 20W
EdTV

- Multiple TVs serve as displays
- Cheap and low power
- Plus cheap “input” devices

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EdTV (“output”)

- Extra graphics cards, sound cards, and transmitters for extra channels
EdTV ("output")

EdTV leaving the classroom

- Kids work during the day
- (50% attendance during mango-picking season)
- Customize EdTV schedule: catch up at nights

EdTV leaving the classroom

EdTV: more profound potential

- EdTV is not regular TV:
  - Personal media vs. mass media
  - E.g.: "village idol", same-language-subtitling
- EdTV is not WebTV:
  - Shared infrastructure, shared backend connectivity, cheap
- EdTVs are not kiosks
  - Brings a face into each household
  - Shared experience
Extending EdTV range

- Used VCRs, balloons, directional 802.11, …

A "repeater"

EdTV “input” devices

- A ham “remote”: a simple transmitter that emits several command signals: a couple bucks
- Same ham receiver at base-station that handles both:
  - Input from ham remote, and
  - Input from long-distance communication with headquarters
- TV and radio control signals: ways of bridging the last mile

EdTV “input” devices

- Walkie talkies, microphone, voice recognition
- Use Hindi
- Paid $10 apiece but can do better
EdRadio

- Radios even more pervasive
- Direct computer-to-air (can be without Kothmale human operator)
- Customized local content: songs sung in schools, teaching English, recordings of "town hall meetings," kids being "DJ's for the day," text-to-voice of content relevant to locals, ...

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Goal: start schools where there’s none

- Assume minimum staff expertise beyond operating equipment
- Minimum interaction needed: homework graded by outside staff
Obvious solution too expensive

- Village
  - Scan homework in
  - Transmit to headquarters
- Headquarters
  - Print it out
  - Grade it on paper
  - Scan it
  - Transmit back to villages
- Village
  - Print it out
- Problems
  - Expensive computer papers
  - Expensive printer cartridges
  - Some printing ok, but not massive amount of printing

The homework workflow (1): digitizing

- Camera instead of scanner: speed, versatility, portability, simple power requirements
- Microphone: digitize voice questions
- Webcam: video for a personal touch, not strictly necessary

The homework workflow (3): grading

- Step 3B: Batch image editing software + tablet pen
The homework workflow (3): grading

• Step 3C: produce a feedback video with screen capture

The homework workflow (4): feedback

• Collective feedback played to all students on EdTV in classroom
• Use it to instigate group learning
• Individualized feedback “scheduled” at convenient times on EdTV
  – In-classroom, or even during evenings
  – Pause, rewind, zoom, etc. might prove useful
  – Review graded raw images if necessary
• Showcases customized content/control of EdTV

Implications (1): better experience

• Not only comparable to what urban kids receive,
• But also better than existing homework feedback experience: more personal, richer
• Same workflow useful for less structured question/answer sessions

Implications (2): content reuse

• Permanent storage, reuse, and sharing of prior interactions
Implications (3): peer-to-peer help

- What can an experienced staff do?
  - Mix and match feedback snippets from the repository
  - Contribute good content back to the repository for use by other villages
- Get higher-grade “genius” students to grade for other students

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Two different questions

- Given a reasonably competent teacher, can any technology better a blackboard?
- Where there’s no teacher at all, how do you make the most out of what you have?
TVI and StudyHall

- Challenges:
  - Different audience
  - Different subjects
  - Unstructured “discussion” may not work
- Resources:
  - Digital technologies beyond pause-and-resume
  - Skilled and cooperative headquarters staff
  - A digital repository that “remembers everything”
  - Village staff of varying levels of skills

Example types of instigations for the StudyHall

- A 5-minute in-class quiz
  - Conducted in headquarters lectures
  - Graded and feedback provided on the spot
  - All captured and replayed
  - Same quiz administered in villages
- Homework feedback (in rich media, as discussed earlier) integrated into regular lectures
- Village staff as “pattern recognizers” in a “program”

Interactions in StudyHall

- Encourage students to help students
- Harvest “leaders”
  - But be careful not to produce consistently passive followers
- Harvest upperclassmen
- Communication between urban and rural students
- Foster positive group dynamic
- Encourage social, artistic, entertainment exchanges

Ambition

- What’s the ultimate scalability bottleneck of the Digital StudyHall?
  - Not computers
  - Not bandwidth
  - Probably not even money (to some extent)
  - It’s the skilled man power!
- Ultimate ambition:
  - To turn every kid into both a teacher and a student
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The “big picture”

- Components: repository, phttp, EdTV
- “Workflows:” content capture, homework feedback
- Pedagogy research

Synergy: phttp + repository

- A simple distributed file system analogy
- Generic abstraction that can support all manners of shared applications (without a conventional network)
Synergy: phttp + repository

- A simple distributed file system analogy
- A network analogy: a “network with memory”
- Why not direct peer-to-peer transfer between villages?

Synergy: phttp + EdTV

- A natural two-hop “network”
- The phttp “hop:” pervasive, high-bandwidth, cheap, asynchronous
- The EdTV “hop:” cheap end devices, bridging last mile
Synergy: repository + EdTV

- The repository abstraction makes it easy to build shared EdTV applications, like voice mail

Recurring themes

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Interested in helping?

Collaboration
Interested in helping?

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www.cs.princeton.edu/~rywang/distance