



Computing for Global Development

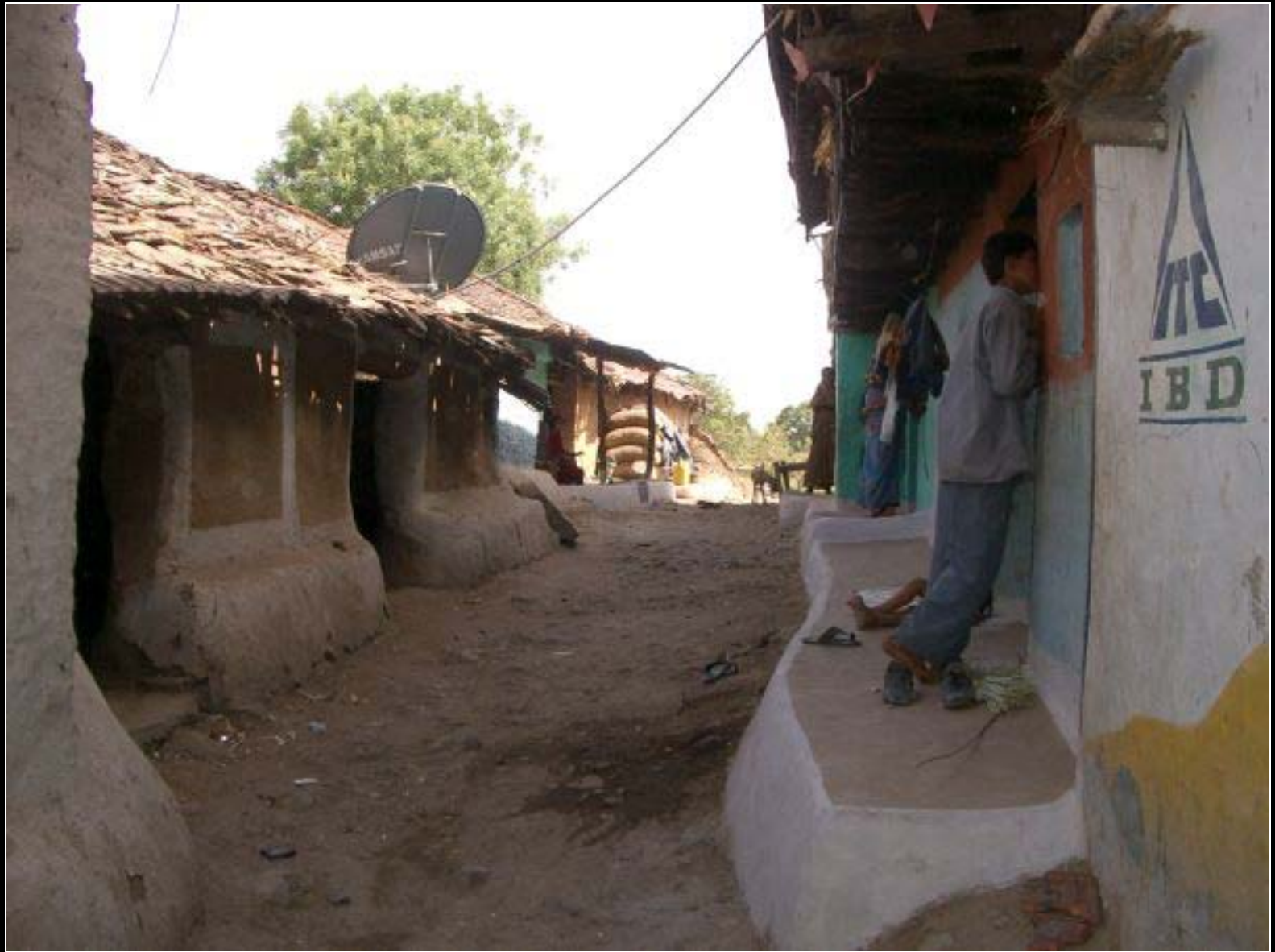
Kentaro Toyama
Visiting Scholar
University of California, Berkeley

Computer Science Department
Johns Hopkins University -- September 28, 2010





Photo credit: Nimmi Rangaswamy



“Kids in the developing world need the newest technology, especially really rugged hardware and innovative software.”

– Nicholas Negroponte (OLPC website, 2005)

“The world's poorest two billion people desperately need healthcare, not laptops.”

– Bill Gates (WRI Conference, Seattle, 2000)

Outline

Introduction

MultiPoint and Split Screen

Caveats

Conclusion

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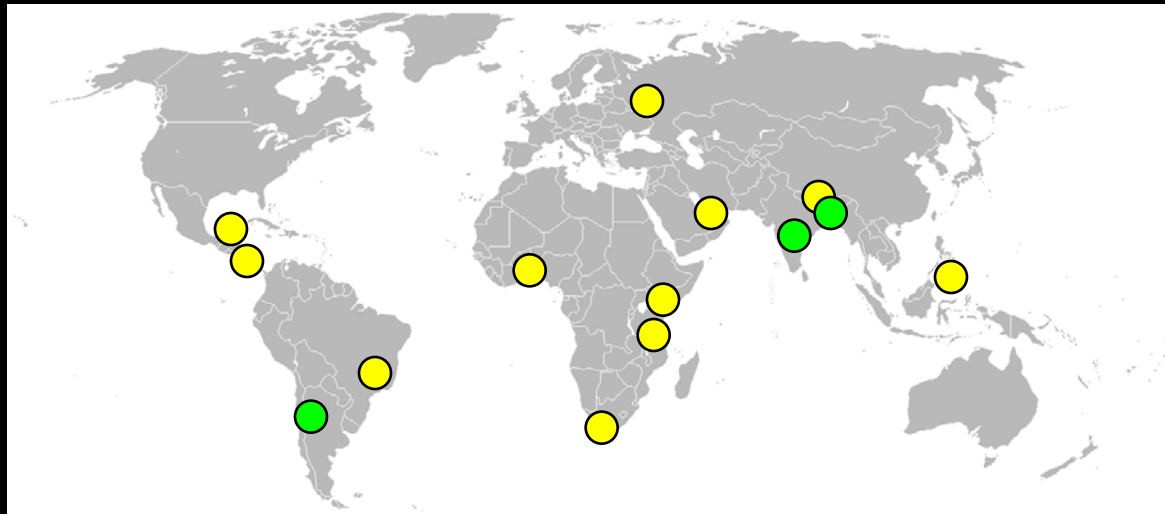
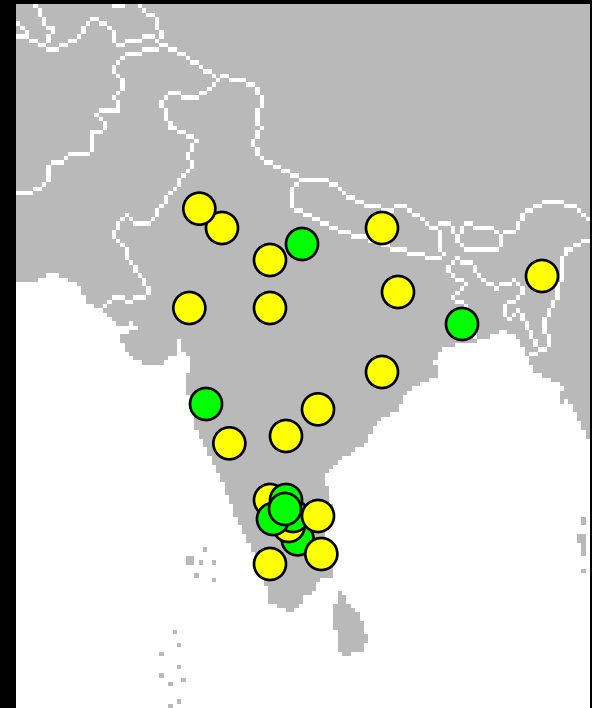


Photo credit: Natalie Linnell

Microsoft Research India
Bangalore, India

Research Sites

- - MSR projects
- - Other projects studied



Multidisciplinary Research

Partnership
NGOs, governments, local firms, communities

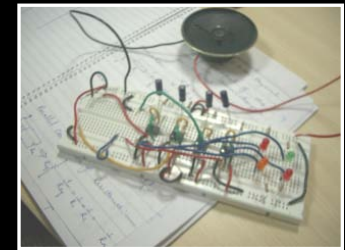
Immersion

- Methodology: ethnography
 - qualitative social science



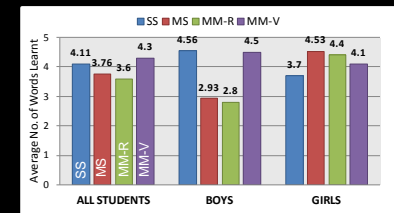
Design

- Methodology: iterated prototyping
 - design, engineering, computer science



Evaluation

- Methodology: randomized control trial
 - experimental science, economics



- Methodology: partnership
 - business, policy



Outline

Introduction

MultiPoint and Split Screen

Joint work with... **Udai Singh Pawar**, Joyojeet Pal (UC Berkeley), Divya Kumar (Intuit), Rahul Gupta (BITS Pilani), Sushma Uppala (SUNY Stony Brook), Sukumar Anikar (Azim Premji Foundation)

NGO Partners: Azim Premji Foundation, Hope Foundation, CLT India, Christel House

Conclusion

Education in India



Photo: Randy Wang

Teacher-less class in Chinhat, Uttar Pradesh

300M children aged 6-18; 210M enrolled in school; 105M actively attending.

Typically children of poor families earning \$1-2 a day

Plenty of challenges...

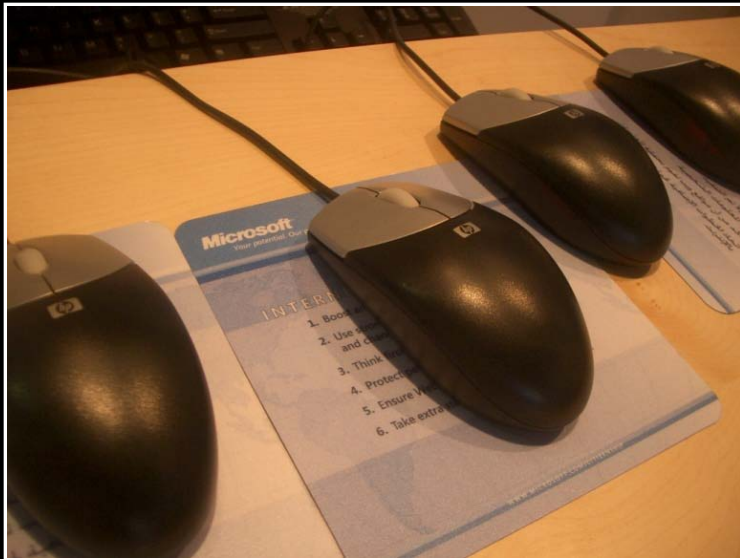
- Poor or missing infrastructure: buildings, walls, equipment, blackboards, toilets...
- Absent teachers
- Indifferent parents
- Truant students
- Etc.



Photos: Joyojeet Pal

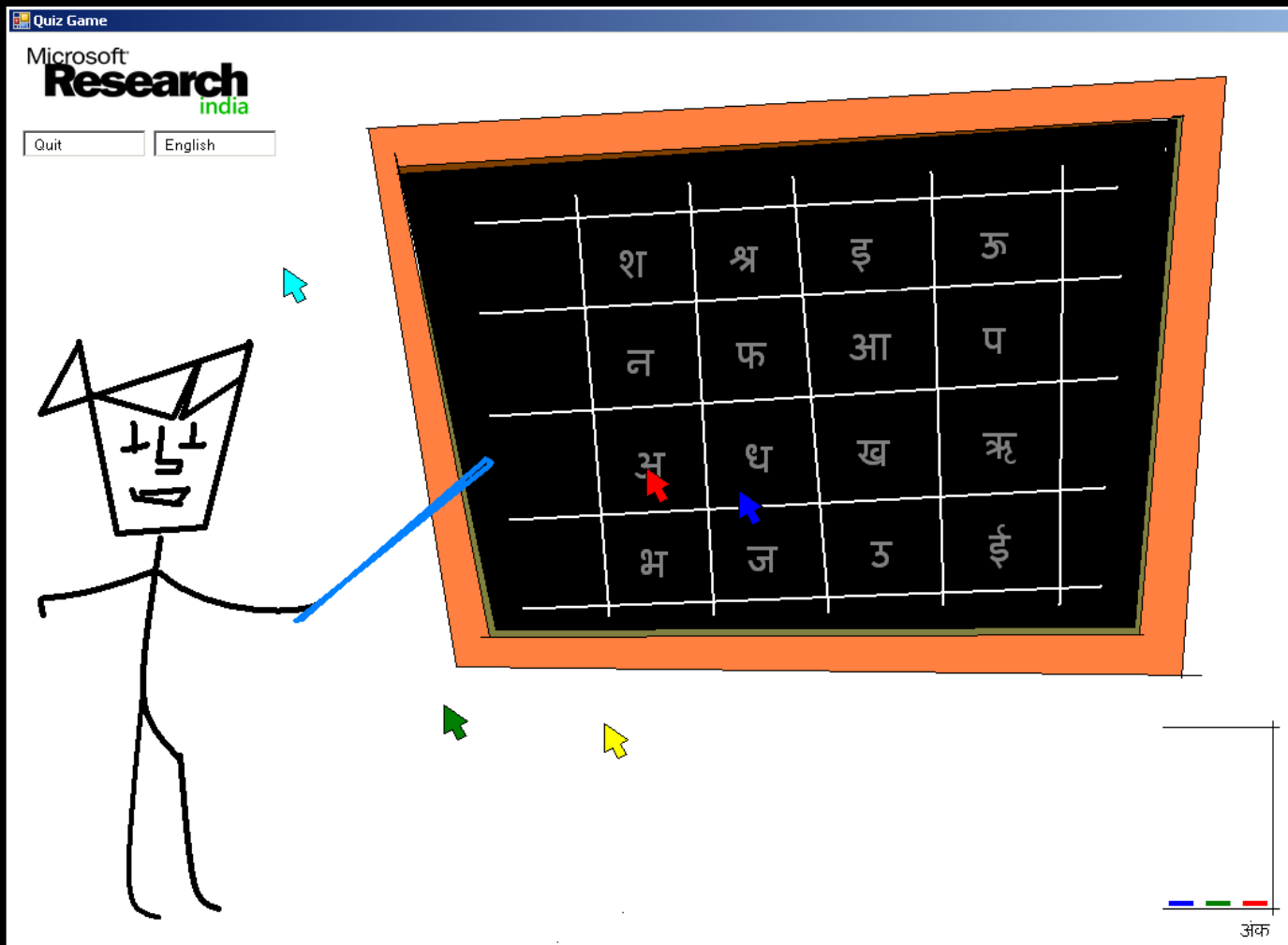
MultiPoint

Provide a mouse for every student



- One cursor for each mouse, with different colours or shapes
- USB mice
 - Experimented with up to 20
 - (Theoretically works up to 128)
- Reduces per-student cost of interaction
- Content modified
 - Game-like environment

MultiPoint



Screenshot of first MultiPoint alphabet-learning game

Technical Considerations

Basic approach:

- Avoid kernel and driver modifications
- **Hijack mouse-event callbacks**
- Handle mouse commands separately for each mouse ID
- Hide regular cursor and redraw one cursor per mouse
- Package functionality as a dynamic link library
- **Expose same programming model as for regular GUI programming**

```
protected override void
OnMouseLeftButtonDown(object sender, RoutedEventArgs e)
{
    // handle left button down
}
```



```
protected override void
OnMultiPointMouseLeftButtonDown(object sender, RoutedEventArgs e)
{
    // handle left button down, MultiPoint
}
```

Issues:

- Extra work to handle mice plug-in and unplug events
- “Lost” mouse events in some environments
- Doesn’t apply immediately to most existing applications

Initial Evaluation

Questions

- Can students understand MultiPoint paradigm?
- How do children interact with MultiPoint?
- Does MultiPoint increase engagement?



Before MultiPoint

Methodology

- Trials:
 - 20 min single mouse
 - 20 min MultiPoint
 - 10 min free play
- 3 trials of 6-10 children

Initial Evaluation: Results

Everyone wants a mouse.

Young children understand MultiPoint immediately.

All students more engaged for longer periods of time.

- Even children without mice engage longer.

Self-reporting is positive.

- Exception: one student didn't like MultiPoint because of competitive atmosphere



Before MultiPoint



After MultiPoint

Formal Evaluation

More rigorous study of learning with an English-vocabulary learning task.

Four modes:

- SS (single-user / single-mouse)
- MS (multi-user / single-mouse)
- MM-R (MultiPoint, racing)
- MM-V (MultiPoint, voting)

Subjects:

- 11-12 yrs; 6-7th grades
- Very basic English ability
- Some exposure to PCs
- Rural government schools

Subject grouping:

- Mixed groups (some all male, some all female) of 5 each
- 238 subjects total

Randomized assignment to modes

Task:

- 7 minutes pre-test
- 30 minutes PC usage
- 7 minutes post-test

Measured:

- Change in vocabulary
- All on-screen activity logged

All comments recorded; some trials video-recorded.

Results

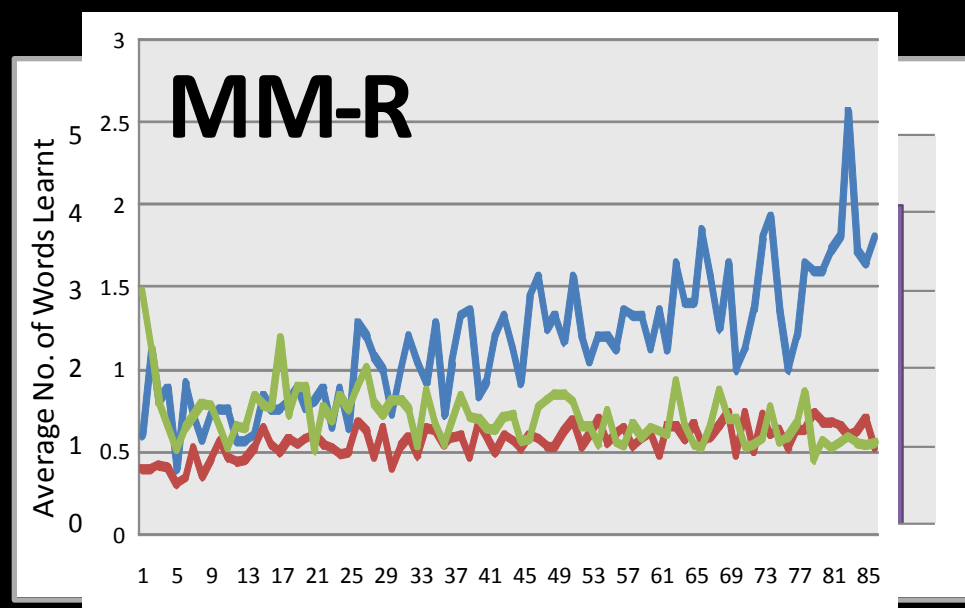
Number of words learned under MM-V roughly the same as with SS (no statistically significant difference)

MM-V unique among non-SS configurations in showing equal learning

MS okay, but not with boys

Strong gender effects:

- All-girl groups do better in all multiple person configurations.
- Boys learn much less in competitive scenarios; rampant clicking.



Average number of words learned during PC usage for one group of boys in MM-R configuration

Further Research with MultiPoint

Mitigating “Dominance” Behavior

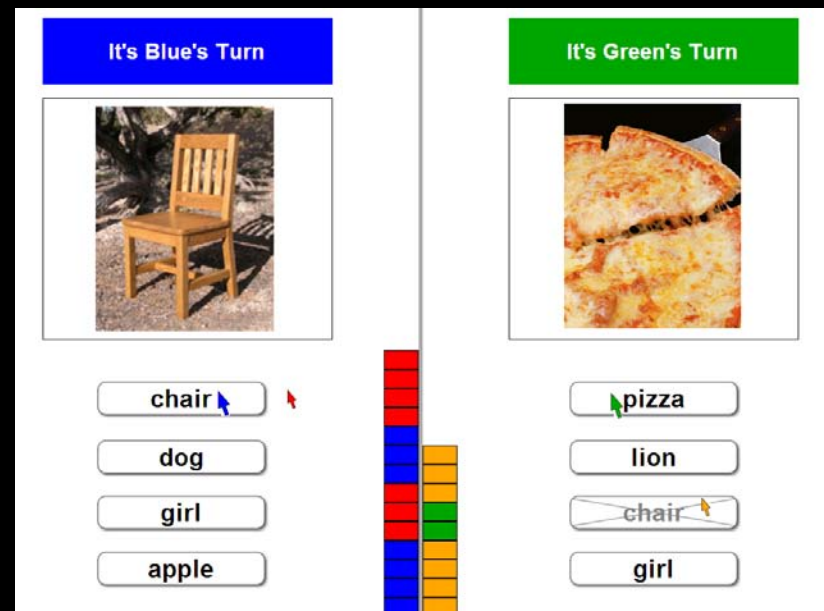
Work by Andrea Moed, Owen Otto,
Joyojeet Pal, Matthew Kam, Udai
Pawar, Kentaro Toyama

Can we combine the best aspects of
competitive and cooperative play
through team games?

Challenges:

- Mouse as a text-entry device
- Restricted screen real estate
- Occlusion among cursors

Status: studies completed; paper
accepted to CSCL 2009



Further Research with MultiPoint

Whole-Class MultiPoint



Photo: Miguel Nussbaum

Ongoing work by Miguel Nussbaum, Heinz Susaeta, Kentaro Toyama; related efforts by Neema Moraveji, Taemie Kim

What kinds of educational games can be effective for 20-40 children and multiple mice?

Challenges:

- Restricted screen real estate
- Varying distance to screen
- Pedagogical model

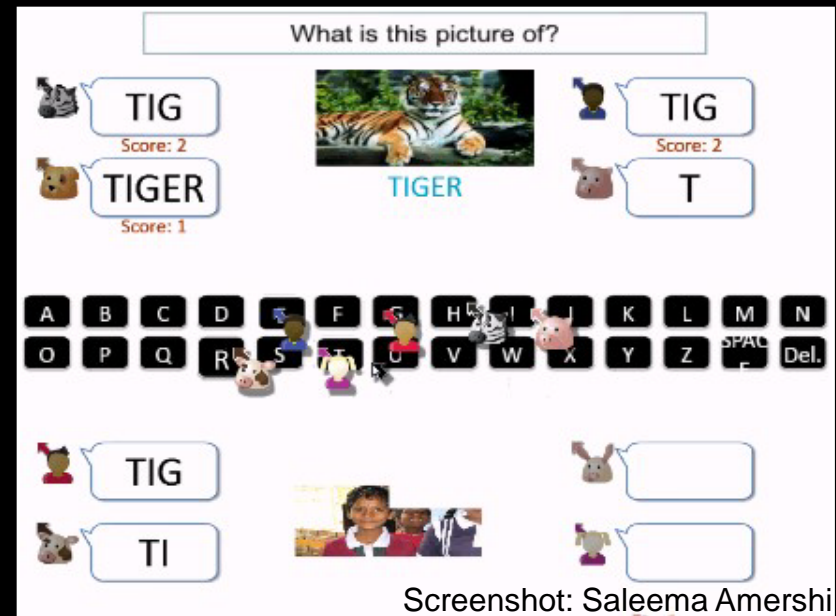
Status: Prototypes built; studies in Chile begun; planning comparative studies in India

Further Research with MultiPoint MetaMouse, Etc.

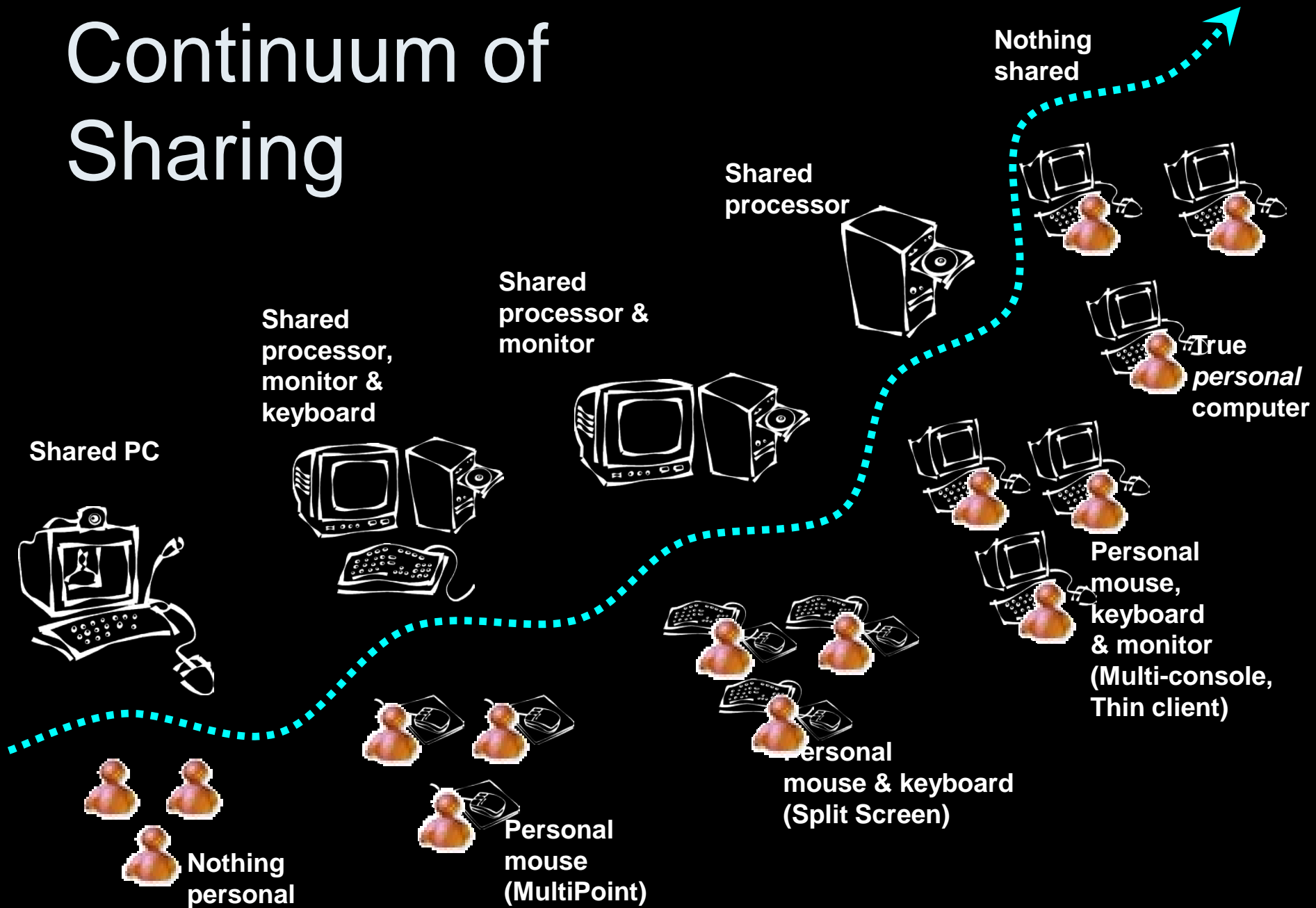
Ongoing work by Kurtis Heimerl,
Emma Brunskill, Joyojeet Pal,
Saleema Amershi, etc.

Problems:

- Can MultiPoint be retroactively fitted to existing applications?
- Can software adapt to different rates of learning?
- What other input devices would work?
- What about text entry using a mouse?



Continuum of Sharing



Split Screen: Preliminary Research



Preliminary studies at an IT training centre in a busy low-income urban community

- Computer basics
- Office productivity software

No problems with usability; individual Split-Screen users can accomplish as much as single-screen users.

Minor technical problems.

Collaboration effects strongly correlated with existing degree of friendship between users

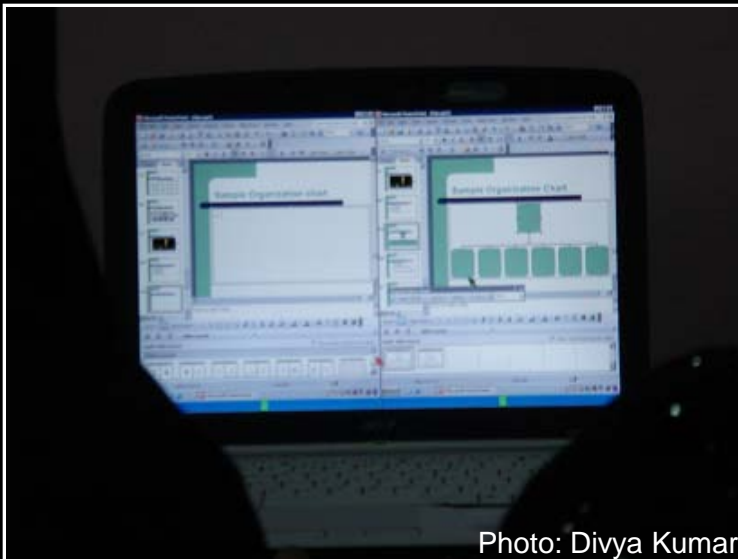


Photo: Divya Kumar

Related Work

MultiPoint

- Bier (1991), Hourcade (1999)
 - Technical issues of multiple mice
 - “Single Display Groupware”
- Inkpen et al. (1995)
 - 2-student education scenario
 - Cursor control toggles between two mice
- Bricker (1998)
 - 3-person collaborative “education”
- Greenberg et al. (2004)
 - Multiple mice for collaborative work

Split Screen

- Thin-client work
- Gyanshala
 - Frame-based split with one user on keyboard, one on mouse



Photo: Udai Pawar

One mouse is not enough for some.

Current Status

Pawar, U. S., Pal, J., and Toyama, K. (2006) Multiple mice for computers in education in developing countries, *IEEE/ACM Int'l Conf. on Information & Communication Technologies for Development, ICTD 2006*.

Pawar, U.S., Pal, J., Gupta. R., and Toyama, K. (2007) Multiple Mice for Retention Tasks in Disadvantaged Schools, In *Proceedings of ACM CHI'07*, ACM Press.

Microsoft released free MultiPoint SDK, June 2007

Related research efforts ongoing at several institutions.

New hypothesis: Better *anywhere* for primary education, over one PC per child?



Sharing hardware

Digital Slates in Microcredit



Technology for easing the burden of digitizing records in microfinance transactions

Embedded Systems

Secure Mobile Banking



Security for mobile banking, especially where transmission channels are flakey

Cryptography and Security

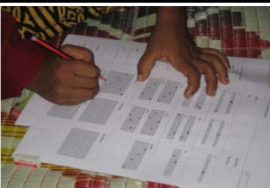
Accent-Robust Speech



Speech recognition that is robust to differences and accents and dialects

Speech Recognition

Paper-and-Digital Forms



Tools to support generation of easy-to-use forms that can also be easily digitized

Machine Learning, Vision, HCI

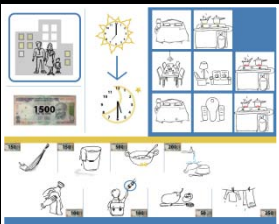
SMS Server Toolkit



Information systems that deliver content over SMS text-messaging

Mobility and Systems

'Tooning for Text-Free UIs



Creating cartoons from photographs to support creation of UIs for the non-literate

Vision and Graphics

Increasing Online Donations



Can sites such as Kiva.org increase online donations through design tweaks?

HCI, Social Computing

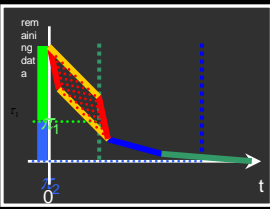
Gaudy Photo Editing



Photo-editing tools designed for a culture-specific aesthetics

Computer Vision

Cost-Aware Data Transfer



Cost-aware transfer of data across heterogeneous channels, e.g., for mobiles

Networking

Value of PCs in Schools?

Children attend school more, if they have an opportunity to interact with PCs. [anecdotal]

Computers in schools don't automatically lead to better test scores.

Computers can help good schools, but they don't do much for poor schools.



A Shanti Bhavan 6th grader, and potential computer engineer, with her mother

Sources: Barrera-Osorio, Felipe and Linden, Leigh L. The Use and Misuse of Computers in Education: Evidence from a Randomized Controlled Trial of a Language Arts Program, Policy Research Working Paper Series 4836, The World Bank. 2009.

Warschauer, M. *Laptops and Literacy: Learning in the Wireless Classroom*. Teachers College Press. 2006.

Pal, J., M. Lakshmanan, and K. Toyama, 'My Child Will be Respected': Parental Perspectives on Computers in Rural India, Proceedings of ICTD2007.

Outline

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Caveats: Myths of ICT for Development

Conclusion

You and a poor rural farmer are each given a single e-mail account and asked to raise as much money for the charity of your choice.

Who would be able to raise more money?

Myth 6

~~ICT undoes “rich getting richer.”~~

Or, “the Internet democratizes...”

Or, “the world is flat (because of technology)”

- **Technology is multiplicative, not additive** (e.g., Tichenor et al., 1970; Agre, 2002)



Photo credit: Rikin Gandhi

References: Tichenor, P.J., Donohue, G.A., & Olien, C.N. (1970). Mass media and the differential growth in knowledge. *Public Opinion Quarterly*, 34, 158-70. Agre, Philip. Real-time politics. *The Information Society*. 2002.

Are you as rich as you'd like to be?

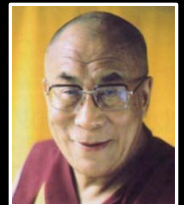
Results 1 - 10 of about 41,100,000 for how to be rich. (0.24 seconds)

Are you as educated as you'd like to be?

 Free Online MIT Course Materials | Electrical Engineeri...

Are you as compassionate as you'd like to be?

A Guide to Cultivating Compassion in Your Life,
With 7 Practices



Sources: <http://www.google.com/search?q=how+to+be+rich>
<http://ocw.mit.edu>

<http://zenhabits.net/2007/06/a-guide-to-cultivating-compassion-in-your-life-with-7-practices/>

Myth 10

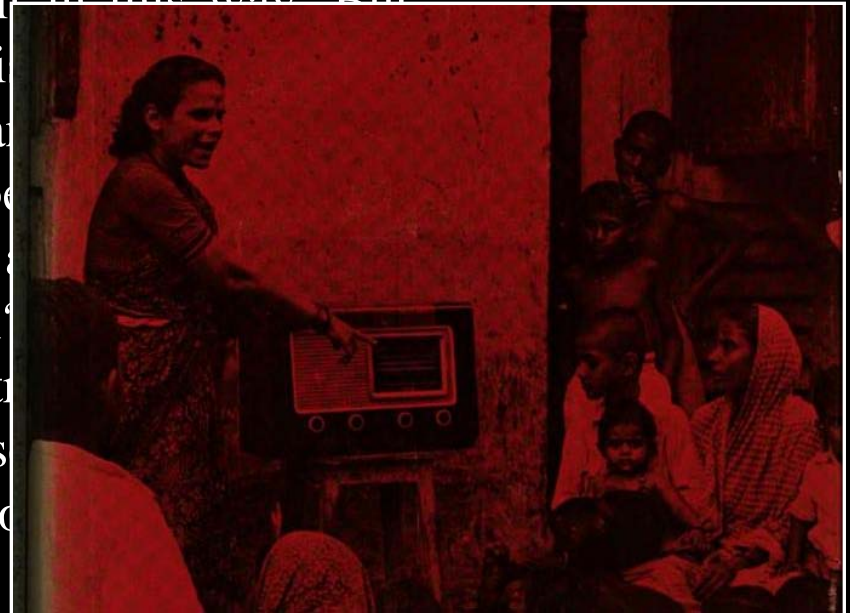
~~Information is the bottleneck.~~

Information is just one of many deficiencies in developing world.



- Other deficiencies:
 - human capacity
 - economics
 - infrastructure
 - institutional capacity
 - political clout
 - etc.
- Information \neq education
- Communication \neq commerce

“... X has never been used to its full capacity in support of economic development. It may be financially impossible to use it in this way. But still the possibility is there. It is the full power and the teaching were to be used in schools develop educational patterns persuasive and instructional. X were to be used in community development modernization of would the break-even point come? Where would the saving in rate of change catch up with the increased cost?”



X = “television”

Source: Schramm, Wilbur. (1964) *Mass Media and National Development: The Role of Information in the Developing Countries*. Pp. 231

Myth 1

~~Technology X will save the world.~~

Wasn't true for X = radio, TV, or landline phone, despite initial expectations and significant penetration.

Doesn't seem true for X = PC.

How about X = mobile phone?

- There are *still* poor communities with no phones.
- Many poor villages have only a few phones.
- Ownership \neq usage
- Usage \neq sophisticated usage
- Sophisticated usage \neq increase in welfare



Outline

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Technology is Just One Part

Physical

building,
goods,
transport,
roads

Human

education,
computer literacy,
motivation,
awareness

Social

institutions,
norms,
political support

Financial

operational costs,
maintenance,
training

Digital

hardware,
software,
connectivity,
content



In the *Developed World*...

(includes wealthier segments of developing countries)

Physical

building,
goods,
transport,
roads

Human

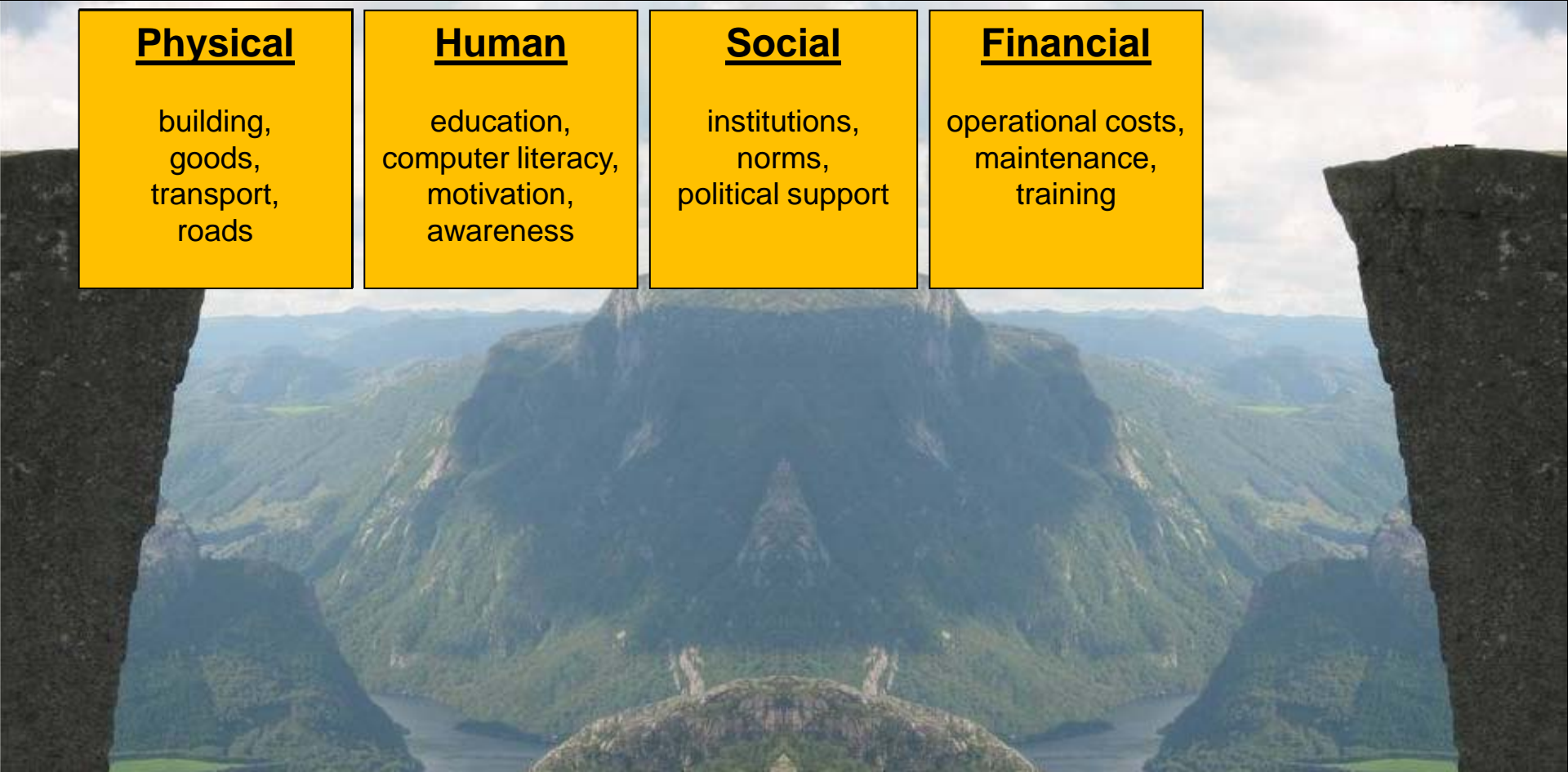
education,
computer literacy,
motivation,
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Social

institutions,
norms,
political support

Financial

operational costs,
maintenance,
training



In the *Developing* World...

Digital

hardware,
software,
connectivity,
content



*Technology **magnifies** human intent and capability.*

If competent, well-intentioned institutions are absent, technology's impact will not be significantly positive.

For maximum impact with technology, work with competent, well-intentioned institutions that are already having impact.

Summary

MultiPoint and Split Screen

Caveats: Myths of ICT for Development

- ~~—Technology counteracts socio-economic disparities.~~
- ~~—Information is the bottleneck.~~
- ~~—Technology X will save the world.~~

Conclusion:

Computer science can support international development, but best impact is likely when it is in support of existing, successful development efforts.

ICTD Conference

IEEE/ACM International Conference on
Information and Communication Technologies and Development

Co-founded by MSR India, UC Berkeley,
MIT, CMU, IIIT-Bangalore

**Focus on rigorous academic work, with all
papers double-blind peer-reviewed**

Established a multidisciplinary community of
academic researchers in technology for
development

First: May 25-26, 2006, Berkeley (UCB)

Second: Dec 15-16, 2007, Bangalore (MSR)

Third: April 17-19 2009, Doha, Qatar (CMU)

**Fourth: December 13-16, 2010, London
(followed by ACM DEV conference)**



UC Berkeley, site of
ICTD 2006



Photo: Udai Pawar

Thank you!

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