

## Computing for Low Resource Environments at UW

Richard Anderson

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## How can computing have a broader impact?

- Can computing have a positive impact on the lives of people with limited access to technology
  - Health
  - Education
  - Livelihood

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## Education

- Senior Capstone Course
  - CSE 477, Gaetano Borriello
  - Year long course
    - Fall term: Domain
    - Winter term: Design
    - Spring term: Develop and deploy
  - Group projects: 4-6 students

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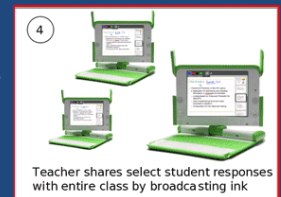
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## OLPC Presenter

- Teachers sharing content with students using low cost laptops



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## Starbus

- Provide real time bus information
- Technologies
  - SMS
  - GPS



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## Empower Artists

- Connect traditional artists with consumers
- Allow artists to get improved compensation
- Partner with Heritage University



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## Research Projects

- eIMCI – Community Health Workers
- CAM – MicroFinance
- Digital StudyHall – primary education

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## e-ICMI

- Hand held device to support delivery of medical protocol
- Target community health workers in Africa
- Brian DeRenzi

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## Motivation

- This year almost **10 million** children will **die** before reaching the age of 5
- Most live in low-income countries
- Almost 2/3 could be **saved** by the correct application of affordable interventions
- Every 6 seconds a child dies from a preventable cause

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## IMCI

- UNICEF, WHO and others develop medical protocols
- Integrated Management of Childhood Illness (IMCI)
- Address most common childhood illness
- Easy to use for lowly-trained health workers
- Originally developed in 1992 by WHO and UNICEF
- Adopted by over 80 countries worldwide
- Integrated most common causes of childhood illness into a single approach

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## IMCI Example

SIGNS	CLASSIFY AS	TREATMENT (Urgent pre-referral treatments are in bold print.)
<ul style="list-style-type: none"> <li>Any general danger sign or</li> <li>Chest indrawing or</li> <li>Stridor in calm child.</li> </ul>	<b>SEVERE PNEUMONIA OR VERY SEVERE DISEASE</b>	<ul style="list-style-type: none"> <li><b>&gt; Give first dose of an appropriate antibiotic.</b></li> <li><b>&gt; Refer URGENTLY to hospital.*</b></li> </ul>
<ul style="list-style-type: none"> <li>Fast breathing.</li> </ul>	<b>PNEUMONIA</b>	<ul style="list-style-type: none"> <li><b>&gt; Give an appropriate antibiotic for 5 days.</b></li> <li><b>&gt; Soothe the throat and relieve the cough with a safe remedy.</b></li> <li><b>&gt; Advise mother when to return immediately.</b></li> <li><b>&gt; Follow-up in 2 days.</b></li> </ul>
No signs of pneumonia or very severe disease.	<b>NO PNEUMONIA: COUGH OR COLD</b>	<ul style="list-style-type: none"> <li><b>&gt; If coughing more than 30 days, refer for assessment.</b></li> <li><b>&gt; Soothe the throat and relieve the cough with a safe remedy.</b></li> <li><b>&gt; Advise mother when to return immediately.</b></li> <li><b>&gt; Follow-up in 5 days if not improving.</b></li> </ul>

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## IMCI Barriers

- Expense of training (\$1150 -\$1450)
- Not sufficient supervision
- Chart booklet
  - Takes a long time to use
  - Natural tendency to be less rigorous
  - Social pressure

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## e-IMCI

- Put IMCI protocol on PDA
- Guide health workers step-by-step through the protocol
- Data collection is a by-product of care
- Can handle more complex protocols
- Interface with other devices and EMR



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## e-IMCI Interface



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## e-IMCI

- Code based on South Africa HUPA project
- Windows Mobile 5.0
  - PDA/SmartPhone
- Contains cough, diarrhea, fever and ear pain questions and treatment
- First visit, ages 2 weeks to 5 years

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## Mtwara, Tanzania

- Worked with IHRDC in Mtwara, Tanzania
- Southern Tanzania
- Rural
  - Subsistence farming
  - Fishing
- Piloted e-IMCI at a dispensary



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## Study Design

- Started with 5 clinicians
- Four clinicians completed study
- Goals:
  - Discover usability issues
  - Discover if e-IMCI helped adherence
  - Determine how e-IMCI effects patient visit

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## Study Design

- Started with some pre-trials to fix major bugs
- Semi-structured interview of all clinicians
- Observed 24 current practice IMCI sessions
- 31 e-IMCI sessions
- Exit interview for each clinician

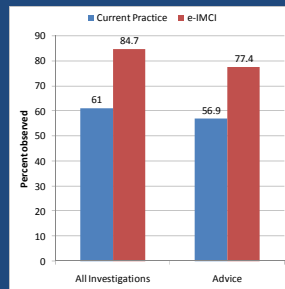
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## Adherence

- Measured adherence by 23 questions/ investigations IMCI asks the practitioner to perform
- e-IMCI significantly improved adherence to the IMCI protocol



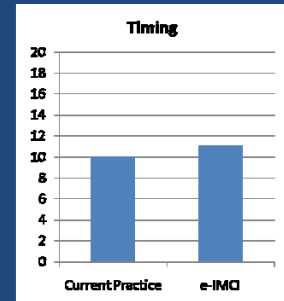
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## Timing

- No substantial increase in patient visit time
- Factors
  - Number of classifications
  - Interruptions



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## Clinician Reaction

- Unanimously cited e-IMCI as easier to use and faster than following the chart booklet
- Wanted to use the system for Care Treatment Clinic
- Liked being able to review answers to questions
- Asked to be in future studies
- "Sometimes since I have experience [with IMCI] I will skip things, but with the PDA I can't skip."

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## Lessons Learned

- Limitations
  - Question Grouping
  - Threshold Problem
- Requirements
  - Flexibility
- Incorrect IMCI
  - Cough syrup
- Local Preference
  - Antibiotic
  - Lab use

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## e-IMCI for Training

- Current training lasts 11-16 days
- Costs \$1150 - \$1450 per person
- Using e-IMCI to train, could reduce time and cost



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## User-Driven Model

- "Expert" mode
- Allow users to decide what investigations to perform
- Flexibility will encourage long-term use
- Merge with current system-driven approach to ensure correct care



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## CAM Cell Phone Data Collection

- Tapan Parikh

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## Financial Services for the Poor

Microfinance: Global Movement

- Grameen Bank & Muhammad Yunus – 2006 Nobel Prize

Self-Help Groups (SHGs) -

- Collect savings during meetings
- Use capital for small loans
- Business, livestock, education, health care, etc.
- Repayment based on peer pressure

Decentralize financial service provision



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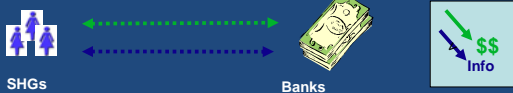
## Linking Formal and Informal

SHGs are being linked to banks

- ✓ Access more credit at better rates
- ✓ Other services (insurance, investment, savings, etc.)
- ✓ Local intermediation can reduce cost of service
- ✓ Excellent repayment performance (90-98%)

However, many obstacles Parikh, ICTD 2006

- \* Spread across remote rural areas
- \* Limited education, infrastructure, financial capacity
- \* Documentation practices are inconsistent
- \* Difficult to assess credit risk and make decisions



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## Information can be the Bridge

Information can bridge the divide

- Connect the formal and the informal
- Provide oversight and understanding for SHGs
- Provide credit ratings and risk analysis for banks
- Result: SHGs get better rates for better performance

Can we design a system for SHGs to aggregate data?

- Accessible to users
- Accurate and efficient
- Intermittent power, connectivity
- Generalizes to other applications



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## Mobile Phones

Mobile phones are the perfect client device

- Exponential growth across developing world
- Numeric Keypad, Speakers & Microphone
- Intermittent network, Battery-operated, Low-cost
- Supports Agent-based service model

Problems and Limitations

- Small screen: adapted WIMP metaphor
- Numeric keypad: text entry is difficult
- Difficult to program applications



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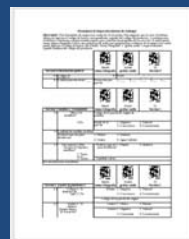
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source: gramshen.info.org

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## CAM: Application Toolkit for Mobile Phones

Parikh et al. - IEEE Pervasive 2005, WWW 2006

**CAMForms**  
interactive paper forms



**CAMBrowser**  
mobile phone app  
to process forms

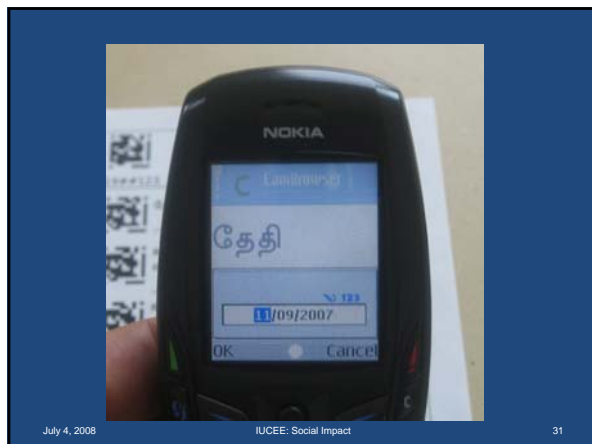
```
<function name="a_click">
  d = input_date("Date", "date.wav");
  i = input_int("Interest", "int.wav");
  p = input_int("Principal", "pri.wav");
  if (d & p & i)
    http_put("...");
</function>
```

**CAMScript**  
scripting language for form  
interaction

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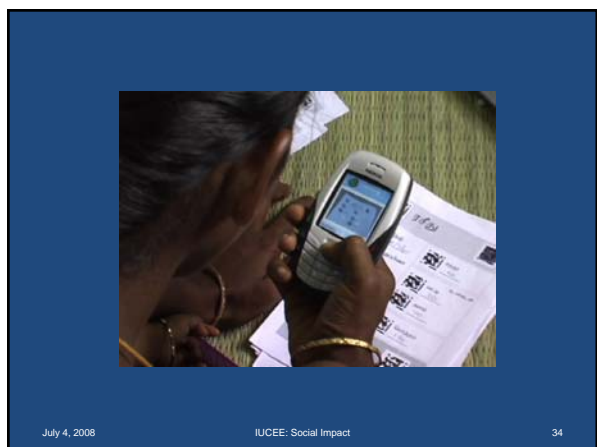
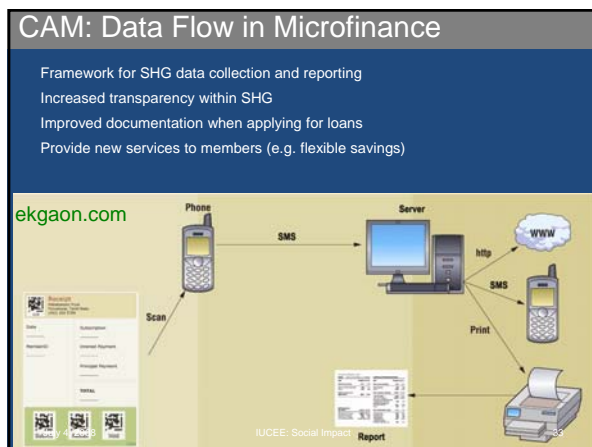
## CAM: Key Features

- Tight linkage to paper practices
  - Retain paper as the authoritative local record
  - Avoid abstract, menu-driven interaction
  - Not optimizing for local labor – don't need OCR!
- Simple, scripted programming model
  - Easy to program and use
- Multimedia Input & Output
  - Capture audio and images instead of text
- Disconnected Operation
  - Transfer data using SMS, MMS, Email (and HTTP)

```

<function name="a_click">
  date = input_date("Enter Date" "date.wav");
  amt = input_int("Enter Amount", "amount.wav");
  message_note("Say your name", "sayname.wav");
  record_audio("name.wav");
  email("tap2k@yahoo.com", "a="#amt, "name.wav");
</function>
  
```

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## CAM: Usability Evaluation

Parikh et al. - ACM CHI 2006

Task: Record transactions during SHG meetings

- Users: 14 field agents from NGO
- 7<sup>th</sup> grade to college educated
- Simulated and in situ testing

Results:

- Learnable: Learned within 1-3 sessions
- Efficient: 30 secs per form, 8-10 mins per meeting
- Accurate: Error rate < 1% (0% for in situ tests)
- Users performed significantly better with audio

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## CAM: Impact in Microfinance

Commercialized by ekgaon technologies pvt.ltd

2 NGOs / 17 agents / 700 SHGs / 10000 members

In active use in Tamil Nadu since October 2006

ekgaon.com

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## Digital StudyHall

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## Digital StudyHall



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## Educational Challenges in Rural India



- Lack of qualified teachers
- Poor infrastructure
- Teacher absenteeism
- Poor teaching techniques
- Few books or supplies

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## Digital StudyHall

### Record lessons at central school



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## Replay lessons at rural schools

### Facilitators play a key role



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## Digital StudyHall

- DSH Partners with *Educational Centers of Excellence*
  - Radiate their excellence to surrounding slum and village schools
- First DSH Partner: *StudyHall Private School* in Lucknow
  - Employs many excellent teachers
  - Afternoon school program for neighboring slum children



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## Project Background

- Project started by former Princeton Professor Randy Wang
- Initially established at StudyHall Private School in Lucknow, India



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## Capturing Pedagogy

- How do we distribute *excellent* teachers?
  - Typically centralized at private schools
- Build a database of excellent teachers
  - Deliver sequences of classes from the government curriculum



9th Std. Math



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## Lesson Database



- Videos of live classes, by best teachers
- Of *all* subjects
- Of *all* grades
- In *all* languages

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## Videoring Live Classes



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## Lessons based on state curriculum



- Based on state government textbooks
- Carefully planned coherent sequences

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## Recording of Live Lessons



- Highly interactive, with lots of:
  - Questions and answers
  - Role playing
  - Activities

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## Matching student background



- StudyHall morning sessions
- StudyHall after school program for slum girls
- Madantoosi (village) school (public)

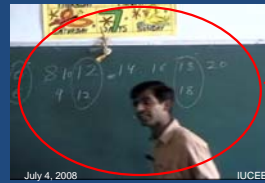
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## Mediation Based-Pedagogy

- The teacher and the digital lesson form a team
- The teacher is the most important part
  - Digital lesson provides the framework
  - Teacher engages the class, conducts activities



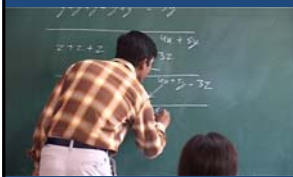
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## Why being video-centric is key



5<sup>th</sup> Std. Math



- Society: low literacy rate
- Content production: easiest to scale
- Effective in capturing pedagogy and showmanship of great teachers

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## A Network of Hubs and Spokes

- Networked centers of excellence
- "Radiating" content and methodology into neighboring slums and villages
- Content in local languages



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## Key technologies



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## Digital Video

Relatively cheap digital video cameras



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PC Software for video editing



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## Cheap replay devices

### Televisions and DVD Players



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## Content distribution by DVD

### Central database of recorded lessons



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### Send selected lessons on DVD



## Digital Green (MSRI, Bangalore)



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## Digital Study Hall for Agricultural Education

### Compost Pit



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### Rice planting for water conservation



## Digital Green Screening

### Public square



### Village house



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## Digital Green

### Video Replay



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### Database of Agricultural content

