

# Design of Learning Games

CS160: User Interfaces

John Canny

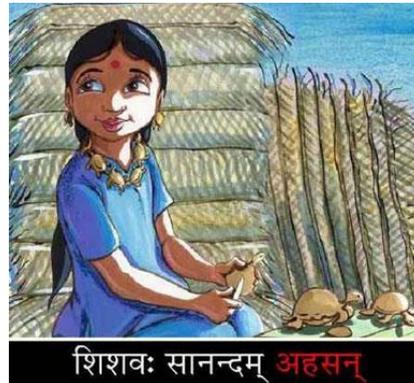
# Goals

What are appropriate technologies for education among low-income children in developing regions?

Some related projects:



Shared computers with multiple mice (Microsoft-Berkeley)



Same Language Subtitling (Kothari)

# Early Ideas

What are appropriate technologies for education among low-income children in developing regions?

Tablet PCs? Stagecast creator (Kidsim)? Storytelling?



# Early Ideas - lessons

Kids had very poor language skills.

Little or no experience with creative work in school.

Technology was daunting.

Value of learning these skills is unclear.

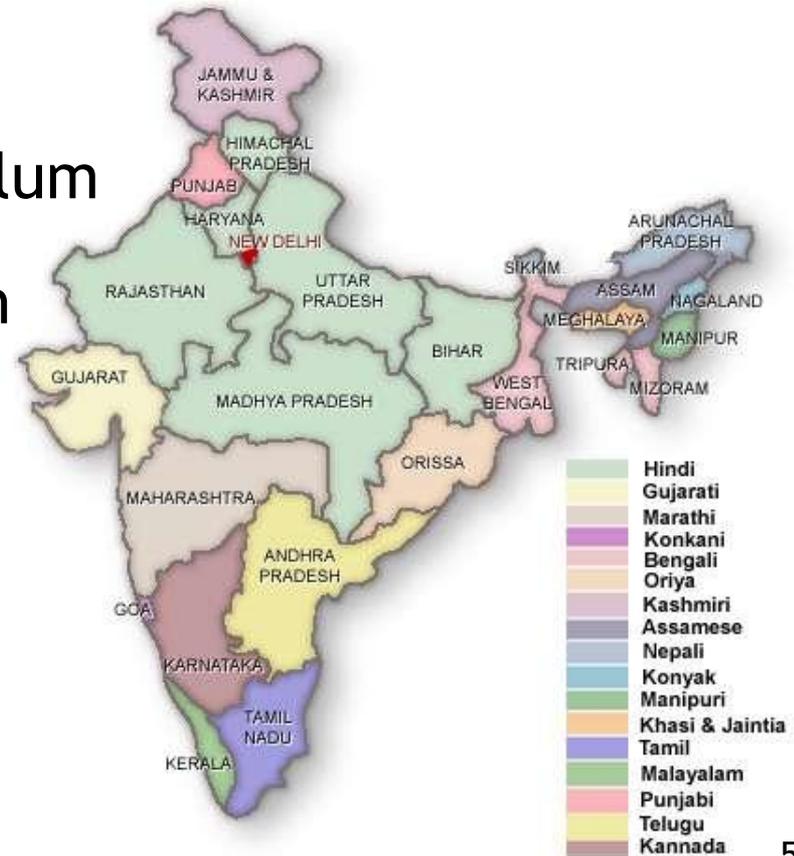


# English in India

English: One of the highest learning priorities identified by rural and urban parents in India

- Gateway to entry-level, non-subsistence jobs
- Prerequisite for the professions
- Taught as mandated state curriculum

90% of local Web content in English



# English as “Lingua Franca”

English is the power language in India, and is taught via ESL  
= English as a Second Language

Similar power languages (often the colonial ones) exist in  
Africa, Asia and Latin America

Typically only available to the middle and upper classes,  
create a hard barrier to progress by the poorest citizens.

# Schools Fail in Second Languages

In India, govt rural schools have poor outcomes  
(Azim Premji Foundation 2004, Pratham 2007)

- >25% of children cannot read English alphabet after 1 year
- >25% teacher absenteeism rate
- >43% of children do not attend school regularly



# Ground Conditions

Unreliable electricity (desktops need backup power)

Limited building space - security, weather, dust, humidity.



# How Can Games Help?

Mobile games hold the promise to make ESL learning

- More engaging
- More effective
- Expand reach outside of schools

Game-capable cell phones are selling explosively, and there are > 200 million overall.



# MILLEE (Matt Kam)

MILLEE = Mobile and Immersive Learning for Literacy in Emerging Economies.



# Precedents for E-Learning Games

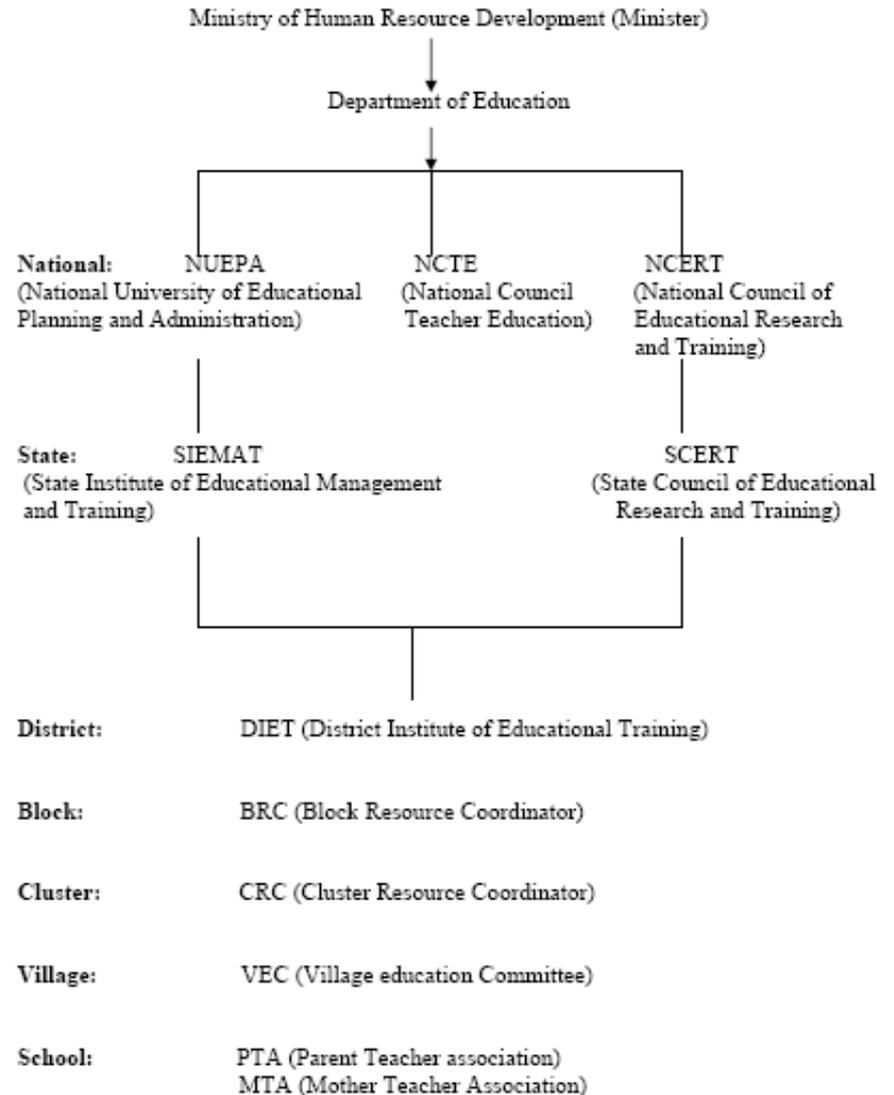
Can incorporate good learning principles (Gee 2003)

Have demonstrated learning benefits in India before

- 2 years, >10,000 urban slums students in India
- Math-learning computer games twice per week
- Significant gains in math test scores



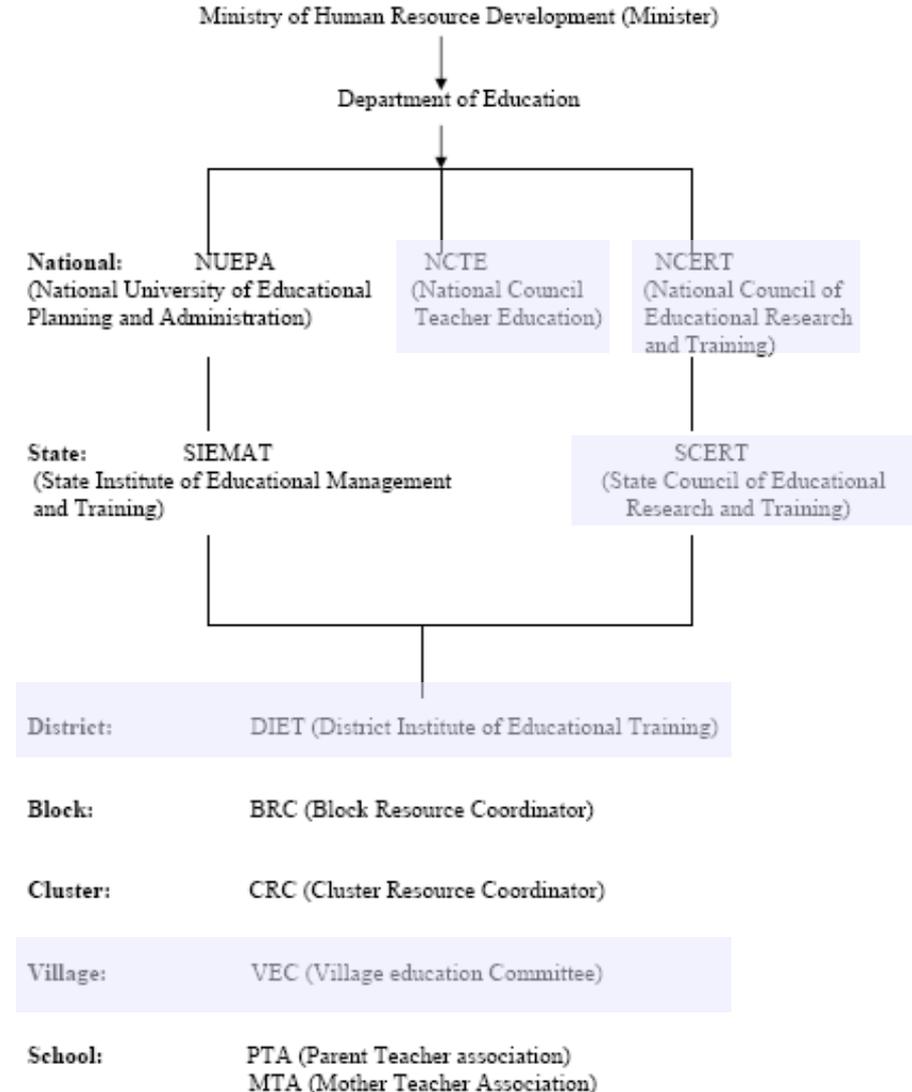
# Adoption Ecology



# Adoption Ecology

“One size fits all” approach is not appropriate

Need to support localization at these levels.



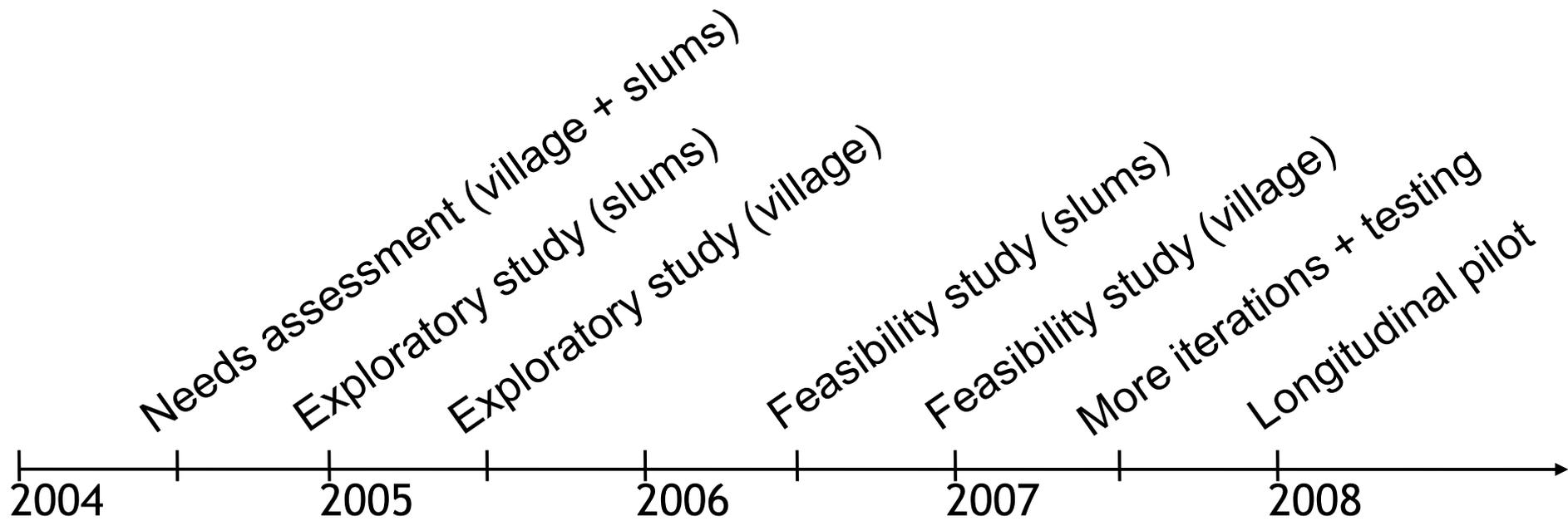
# PACE Framework [in ACM CHI 2007b]

## Four components of **PACE** framework

- **P**attern - best practices for learning and engagement
- **A**ctivity - design of student interaction
- **C**urriculum - targeted syllabus + audio-visual content
- **E**xercise - basic unit realizing Activity + Curriculum

# 7 rounds of field studies, totaling 7 months in India

## Human-centered design process



# Task-Based Language Teaching (TBLT)

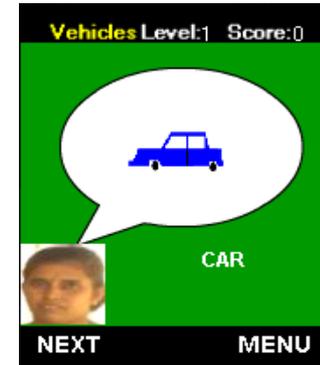
Instructional sequence is built around tasks

1. **Schema-building** exercises that introduce vocabulary, linguistic forms and context for the task
2. Communicative exercises to provide **controlled practice**
3. **Listening** to how above linguistic units are used in **authentic settings**
4. **Language development** exercises for above units
5. Freer practice in groups, e.g. information gap activities
6. Pedagogic task proper

# TBLT Example

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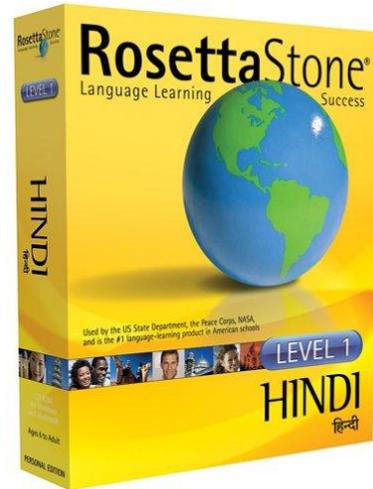
# Successful Embodiments of TBLT

Designers find it easier to work from concrete realizations

Reviewed sample of >35 applications

Sample has a balance b/w listening, reading speaking and writing skills

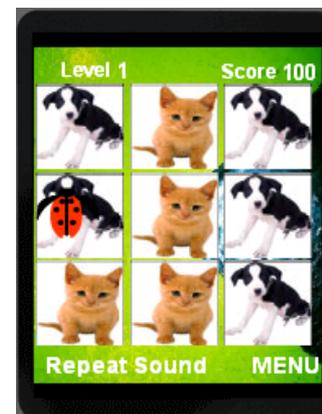
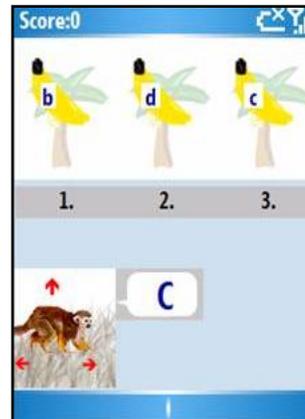
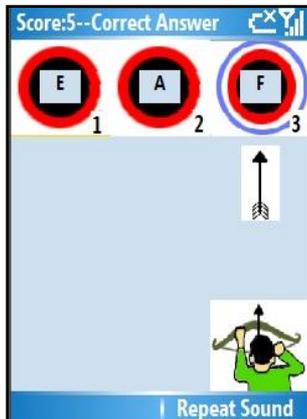
Distilled >50 design design patterns



# E-Learning Games

Realized PACE framework with 10 mobile games, designed w/ game principles

- Letter-sound correspondences
- Listening comprehension
- Word recognition



# Example Game Design

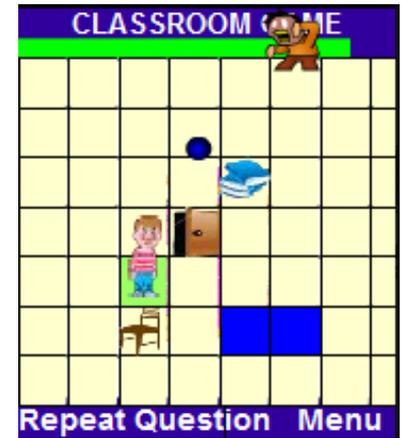
Listening comprehension: Spoken word → Semantics pattern



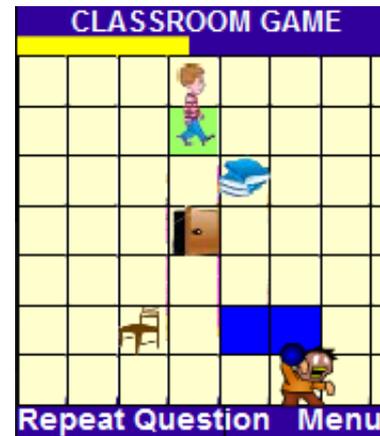
Teacher character says word for a classroom object



Player has to push correct object to blinking squares



While avoiding ball



# • Iterative Design and Testing

Field-tested 10 games with three communities in North and South India

1. Urban slums school
2. Private village school
3. Government village school



# Results: Learning Outcomes

First major quantitative study in summer 2007, with 47 rural school children (grades 2-5)

## Targeted vocabulary

- Nouns for animals and vehicles
- Verbs for common actions, e.g. run, jump

Demonstrated short-term vocabulary retention ( $p < 0.001$ ,  $d = 1.42$ )

- 1.96 out of 5 on pre-test, and
- 3.85 out of 5 on post-test

# Results: Gameplay Enjoyment

Players enjoyed showing off game achievements.

Children didn't mind showing the same achievement many times.

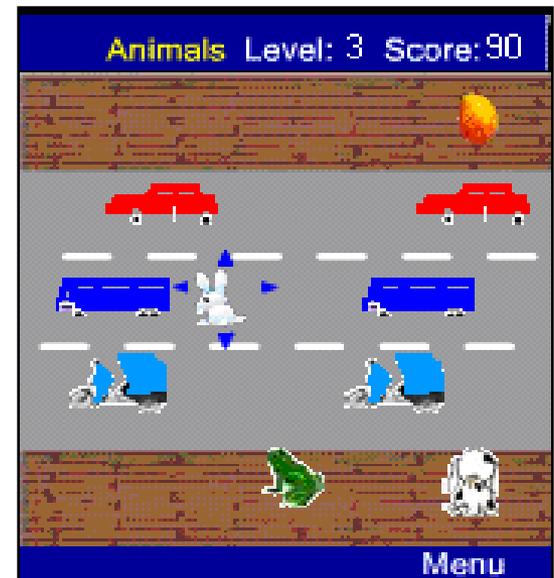
Scores helped.



# Weaknesses of Earlier Games

Most e-games failed to match the understanding & expectations that rural children have about games

- What are characteristics of traditional village games?
- How do village games differ from Western videogames?



# Traditional Village Games

## Example: Tree-Tree



# Tree-Tree Structure

Nouns, i.e. entities	Game Player	Tree
Adjectives, i.e. state	(x,y) coordinates, side $\in$ {pursuer, non-pursuer}, state $\in$ {active, protected, eliminated}	(x,y) coordinates, name
Verbs, i.e. actions	move from $(x_1, y_1)$ to $(x_2, y_2)$ , touch ( <i>obj</i> ) where $obj \in$ {player, tree}	

## Goal states

- **Pursuer** eliminates a non-pursuer by touching him/her, or
- **Non-pursuer** protects him/herself from elimination

# Clustering Approach

Identified similarities and differences in

- Players and team composition
- Objects in games, e.g. ball, stone, stick
- State variables
- Actions and rules
- Goals and end conditions

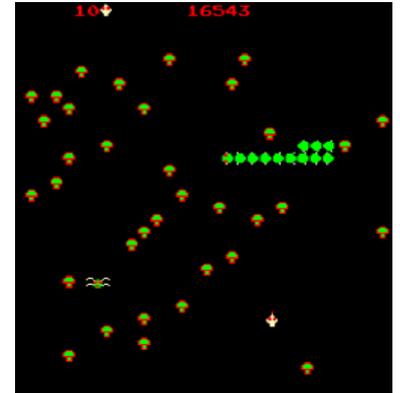
For each structural element,

- Expand by accommodating differences into existing cluster,
- Taking union as new cluster

# Differences in Games

How are traditional Indian village games different from existing Western videogames?

Compared design grammar against 296 game design patterns documented in Bjork and Holopainen.



# Differences in Games

Identified 37 non-trivial differences

- Difficulty based on sub-goals
- Resource management
- Skill-acquisition
- Score-keeping
- Rituals associated with space
- Inter-team interactions



# Using Game Structure

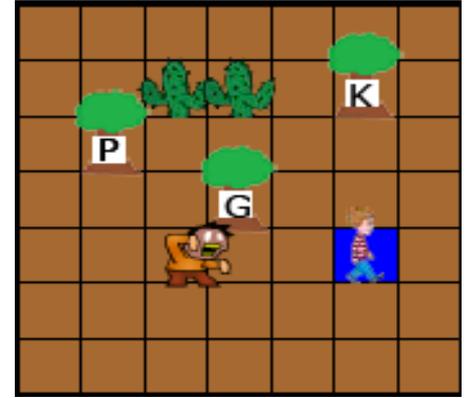
## Leveraged mappings



Tree-Tree  
(playground version)



Design  
grammar



Tree-Tree  
(digital version)

# Qualitative Benefits

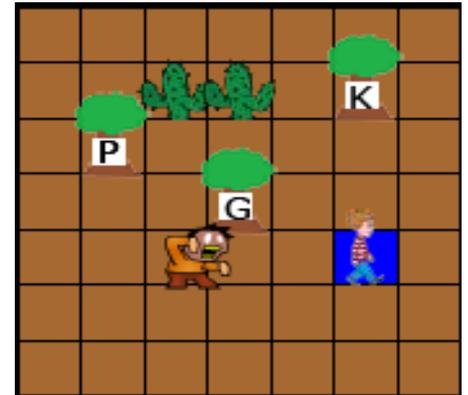
## Players

- Relate readily to digital version
- Repeated aloud after game

Potential transfer into real-world games



Tree-Tree  
(playground version)



Tree-Tree  
(digital version)

# Ongoing Work

## Longitudinal pilot deployment

- Commenced in January 2008
- Three times per week
- After-school program at private village school
- Expand to 12 sites after summer 2008

## Long-term curriculum development



# Assessment

## Qualitative

- Video analysis of learner behavior
- Interviews with learners, parents and teachers

## Quantitative

- Pre-tests, post-tests and delayed post-tests
- Benchmark against standardized English exam

Expect participants to learn more compared to their lessons in government rural schools

# Audio-Only Language Learning

Listen to ESL learning audio, while hands and eyes are focused on manual work

Potentially use work time more efficiently for learning

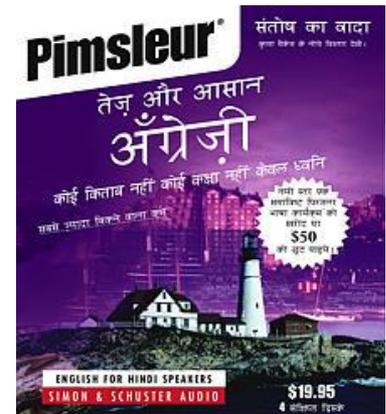


# Pimsleur Audio CDs

Target second language conversational skills for functional contexts

- E.g. Greetings, travel

Supported by research on human memory, retention and learning (Nation 2001)



# How Pimsleur Works

## Learning principles

- Organic learning
- Anticipation
- Graduated interval recall

# Drawbacks

Not localized for developing regions needs

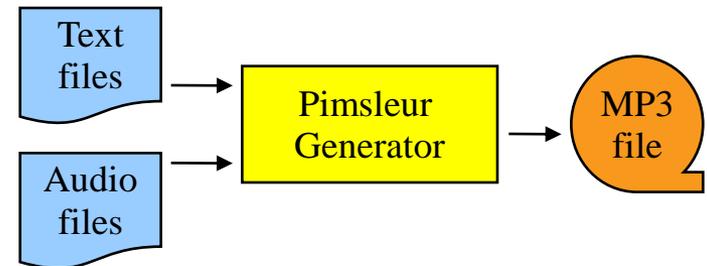
## Observations

- **Separability**: Localization can take place at content level, reuse pedagogical principles
- **Automatizability**: Pimsleur principles are repetitive, can be expressed in computational form

# Pimsleur Generator

Authoring tool for generating custom Pimsleur-like audio units

- **Input:** custom conversational script from local curriculum developer (in XML-based declarative language)
- **Output:** audio track which embodies learning principles in commercial Pimsleur units



Female: Hello.  
Male: Hello Ma'am.  
Female: Are you from India.  
Male: Yes I'm from India.  
Male: Do you understand Hindi?  
Female: No, I don't understand.  
Oh you understand English.  
Male: Yes I understand English.  
Female: You understand very well.

In future, can be extended to interactive version, e.g. conversational agent

# Designing Algorithms and Data Structures

Transcript analysis based on TBLT framework

Imposed uniform logic based on second language acquisition principles

Abandoned grammar rewrite rules in favor of patterns

- Formulaic phrases, e.g. “This is a \_\_\_\_.”
- Curriculum developer declares syntax tree to specify phrasal structure

# Algorithms

## Pimsleur principles

- Organic learning
- Anticipation
- Graduated recall

```
teach (node) {
  if (node is a leaf) {
    if (learner has not been taught meaning of
        node's phrase) {
      say node's meaning in native language;
      say node's phrase in target language,
        and asks learner to repeat aloud;
      pause;
      teach_pronunciation (node);
      anticipation (node);
      insert node into queue;
    }
  }
  else {
    if (learner has not been taught meaning of
        phrase's meaning or linguistic structure
        pertaining to node) {
      if (first child of node is a leaf)
        say node's meaning in native language;
      for each child of node {
        teach (child);
        graduated_interval_recall ();
      }
      if (learner has not encountered linguistic
          structure pertaining to node & node has
          explanation for this structure)
        say node's explanation in native language;
      anticipation (node);
      insert node into queue;
    }
  }
}
```

# Pimsleur Generator: Results

Evaluated **expressiveness** w/ 3 conversation scripts developed for grades 1 and 8 by India partners

- Declarative language for conversational script was sufficiently expressive

Evaluated **learning outcomes** w/ 47 rural school children (grades 1-5) over two weeks

- No post-test gains on short-term retention
- Enjoyed listening to audio material
- Did not pay attention or respond to prompts

# Pimsleur Generator: Lessons

## Challenges

- Assumptions about school-based language learning
- Differences between rural and urban accents
- Lack of engagement with audio prompts

## Redesign ideas

- Interactive prompts
- Use local accent for local language
- Games to improve engagement

# Ongoing Work

## Scenarios for informal learning

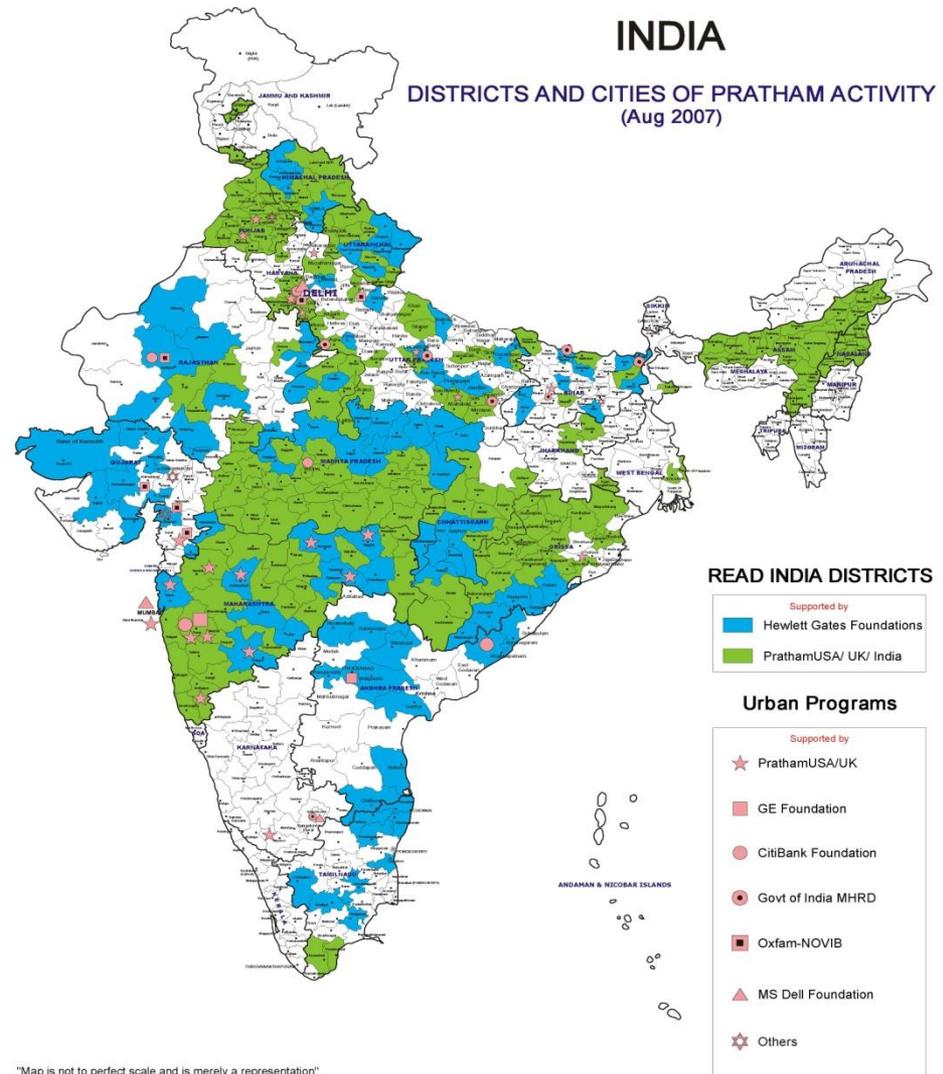
- Incentives for out-of-school learning?
- How much will children play ESL learning games?
- How to encourage collaborative play?
- Learning outcomes?



# Adoption Plan for India

Hand-off design tools to 3<sup>rd</sup>-party content developers

- Azim Premji Foundation
- Byrraju Foundation
- Pratham
- Sesame Workshop India



# Technology Transfer

## Tools for micro-localized designs

- PACE framework for modular design and reuse
- Design patterns for language learning
- Design grammar informed by traditional village games

## Workshops

- Instructional design
- Game design
- Monitoring and evaluation



# Future Work

Goal: games that integrate language and literacy learning with other subject domains

- Mathematics
- Science
- Life skills
- Health knowledge



# Challenges: OOS learning

Work now is focused on out-of-school learning, to reach the children who dont/cant regularly attend school.

We did several “day in the life” field studies of poor children.

They do have time during the day to use games

When and where depends on demographics

They do have cell phones in the house

Gender and family dynamics are a big challenge

# Challenge: Field studies & Development

Parents are usually eager to participate and see the value of these technologies for their kids. They have far more at stake than the experimenters.

Families don't understand the idea of a "study" and expect the deployment to continue indefinitely.

Its better to have a small number of long-term field sites to build on those relationships.