

Facilitated Video Instruction in Low Resource Schools

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ABSTRACT

We describe a two-year study of the use of facilitated video instruction in government primary schools in North India. The study involved deploying Digital StudyHall (DSH) in eleven schools, and following the progress of participating teachers in adopting the technology and pedagogy. The goal of the study was to evaluate the potential for large scale expansion of the DSH model into other government schools. Even though the system was used consistently, and was evaluated favorably by teachers and students, we found significant obstacles to scalability and sustainability of DSH in North Indian government schools.

Categories and Subject Descriptors

K.3.1 [Computing Milieux]: Computer Uses in Education – *distance learning*.

General Terms

Human Factors

Keywords

Educational technology, facilitated video instruction, Digital StudyHall, evaluation.

1. INTRODUCTION

Low quality primary schools are substantial obstacles to improving livelihoods of people in developing countries. One potential opportunity for addressing weakness of teaching and pedagogy is to augment educational delivery with appropriate use of information and communication technologies. The approach explored in this paper aims to improve teaching practice by supporting under-resourced, rural primary schools with educational video resources developed by stronger urban schools.

The specific intervention is Facilitated Video Instruction, where lessons of experienced teachers are shown in rural schools by local teachers. The teachers are instructed to alternate between

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playing the video and conducting activities with students. The goal is for students to benefit from the expert video materials and personal interaction with a teacher.

Digital StudyHall (DSH) has pioneered Facilitated Video Instruction for primary school education in low resource settings. DSH has been active in India and neighboring countries since 2005, and has developed a methodology and supporting technology for delivering video-based lessons that originate from high quality schools. Participating teachers are given training on facilitation techniques and ongoing professional support. Initial findings from earlier DSH deployments [30] were promising, indicating positive growth in pedagogical development of participating teachers and high levels of student receptivity.

Our work was motivated by a desire to understand the potential for scaling DSH to large deployments. We wanted to know if DSH could be deployed at scale on a sustained basis, and to assess the potential benefits of broad use of the system.

We chose an ambitious target for our study: government primary schools in the Indian state of Uttar Pradesh (UP). We deployed DSH in eleven schools that had not previously used the system or had contact with the DSH organization. The study lasted for two years and schools were monitored regularly with field visits. The basic questions under investigation were: can the DSH system be adopted by schools in a sustained manner with modest costs? what is the impact of video based education on students and teachers?, and does the system lead to measurable improvements in learning outcomes? This study is not intended as a comprehensive evaluation of either the DSH methodology or the DSH organization. DSH has been in used different educational settings, such as private schools, informal schools for unenrolled children, and in teacher training institutes and we recognize that there are major differences between those domains and the one that we studied.

The overall results of the study were mixed. On the positive side, the system was adopted and utilized successfully at most schools. There were changes in the teaching styles of some of the teachers, and the system was very popular with students. However, we do not believe that the system is sustainable; the evidence is that DSH would rapidly fall into disuse if our regular monitoring visits stopped. Our attempts at measuring learning outcomes were inconclusive.

2. PRIMARY EDUCATION

The Indian government has long faced challenges in providing quality primary education to its children. While the government has a far reach into rural areas in terms of school buildings, many schools fall short of infrastructural standards [28]. The teacher-to-pupil ratio in approximately half of rural schools exceeds 1:30, which is compounded by high rates of teacher absenteeism [16,28]. Government provided pre- and in-service training focuses primarily on teacher-centered, rote methods and does little to practically equip educators to meet the needs of their classrooms [7,8,20]. Teachers are also not provided with adequate teaching materials to enrich student learning and thus rely almost entirely on textbooks [20]. On top of these factors, rigid bureaucratic processes and a low social status for teachers have caused public educators' morale to sag [24]. Overall student learning levels have remained stagnant or declined in most content areas during recent years [28]. Many efforts to reform the system have been stymied by high levels of corruption [19].

Alongside these challenges, student enrollment in public and private schools has continued to rise significantly in the past decade [28]. Government supplied incentives, like providing a midday meal or school uniforms, have increased gross enrollment, especially for girls [9]. While some of this increase could be attributed to parents' favorable views of education, many never enroll their children or withdraw them early, citing reasons of economic hardships, lack of nearby schools, or students' difficulties with studies [20]. Teachers often cite parents' lack of interest in their children's studies as an inhibiting factor to their ability to teach [20,24].

3. DIGITAL STUDYHALL

DSH began in 2005 as a collaboration between computer scientists and education professionals who shared a vision to improve the quality of education in Indian schools. The DSH model was designed to harness low cost digital media technology to link educators in under-resourced schools to expert urban teachers and quality pedagogy and educational content. DSH envisioned that the videos would serve both to benefit the students and teachers; as ill-prepared teachers gained exposure to effective teachers, they would begin to adopt quality pedagogy into their own teaching practice which in turn would benefit student learning.

DSH is based on a hub and spoke model. A hub organization develops video content that is relevant to the local context. The hub organizations identify expert teachers and record their live classroom lessons. They then catalog films by grade and subject and make them available on an expansive online database and DVDs. These contain the filmed lessons, lesson planning resources, and correlating subject tests.

The hub then distributes content to 'spoke' schools, or local rural and urban slum schools that typically lack quality teachers and other resources. Spoke schools use a DVD player and a television for the DSH materials. The DSH organization supplies participating schools with sets of DVDs that span subject and grade levels, train staff in interactive teaching methods, and monitor the progress of teachers in their usage of the DSH system.

The DSH model encourages participating teachers to test out more interactive methods and take a direct role in mediating the video content to their students. This typically means pausing intermittently during the film to check for understanding, ask

questions, or infuse video content with stories, poems or other engaging activities for students.

The DSH model works to create ideal conditions for teachers' adoption of intended pedagogy. DSH content is aligned with state curricular standards and textbooks. DSH acknowledged that the video class demographics should match that of the intended rural audience. Although most DSH teachers are drawn from middle/upper middle class private schools, for the purpose of filming, they instruct local children from slum neighborhoods. This ensures that the pace of teaching suits the rural classrooms and allows remote students to identify more closely with the students in the video. DSH also has emphasized supporting participating teachers, both by semiyearly trainings, which model exemplary, interactive use of the DSH system and through frequent monitoring visits to participating schools. These visits function to hold teachers accountable for use and also provide pedagogical support and feedback to help teachers improve their practice.

Since 2005, the main DSH hub has continuously operated out of Lucknow, Uttar Pradesh. The Lucknow hub has produced thousands of Hindi language videos and monitors six low-income, peri-urban private and non-profit schools and one rural government school. DSH has established additional hubs in Calcutta, Bangalore, and Pune which are no longer active. As of 2011, DSH has active hubs in Lucknow, India and Katmandu, Nepal. In total, DSH has produced approximately 5000 filmed lessons and other educational content in Hindi, English, Bengali, Kannada, Marathi, and Nepali.

4. RELATED WORK

A broad range of technological interventions have been proposed and evaluated for improving the quality of education in rural schools, common themes across the work are pedagogical change, infrastructure challenges, institutional adoption, cost realism, and sustainability. Examples include satellite television [5], computer aided instruction [2,22,25], shared use computing [4,27], personal laptops [26], tutoring programs [21], and mobile phones [15].

This paper is concerned with video supported education. A major reason that DSH has focused on digital video is the infrastructure limitations of rural schools including lack of internet access and poor electricity supplies. DSH is an adaptation of the Tutored Video Instruction (TVI) methodology pioneered by Gibbons [11] in the seventies at Stanford University. Gibbons showed that TVI students outperformed peers in both traditional classrooms and distance learning programs. The study also found that the facilitating tutor's style was important; students indicated a preference for tutors that were interactive and encouraged classroom discussion over those that simply answered student's questions. Bauman [3] also reported similar student performance between TVI and traditional classroom, but pointed out the importance of creating content that is academically thorough and reflective of traditional classroom experience. A later TVI study [1] illuminated the importance of teacher buy-in and the relationships between the students and teachers and the implementing organization.

The archival literature on DSH is limited. A paper (independent of this evaluation study) was published in AERA looking at the outcomes of DSH in a several schools [30], and additional non-archival talks and writings are available on the DSH website [6]. The AERA study was based upon a group of schools that had

been picked for DSH based on their potential to adopt the new methodology. This had been part of DSH's growth strategy, to work with schools that had the capacity and the desire for introducing facilitated video instruction. One explanation for why some of the results from the AERA study are different from those reported here is the different selection criterion for schools.

The topic of adoption and sustainability is central to the field of ICTD. There is a broad body of work aimed at understanding the process of technological adoption and transfer [29]. Complementary work exists to understand failures in interventions, looking at the mismatch between project design and conditions on the ground. Heeks develops a taxonomy of factors to explain failure in a series of papers [12,13] and other papers focus on specific conditions such as incentives [17] and cultural norms [14]. Broader critiques of interventionist ICTD [32] give a theoretical basis for the limitations of various approaches.

5. THE STUDY

To assess DSH, we arranged a new deployment in government schools in the North Indian state of Uttar Pradesh (UP). UP is the most populated state in India and one of the least developed [33]. DSH already had content for the state curriculum so it was not necessary to create new materials. Additionally, DSH had working relationships with district officials of the Ministry of Education which made it possible to get permission to work in the government schools.

The aim of the two-year study was to evaluate the scalability and sustainability of the DSH model through the lens of operational costs and benefits and obstacles to widespread use. The study employed a mixed methods format using quantitative evaluations of student performance and qualitative observational data of teacher performance and student receptivity from weekly field visits.

Some preliminary results from the first year of the study were reported at ICTD 2010 [31].

5.1 Study Process

After receiving government permission for the study, we held several meetings with principals and teachers, eventually receiving participation confirmation from all eleven selected schools. These schools became our 'focus schools' that we would intensely monitor for the two-year study. Starting June 2009, we installed DSH equipment, held offsite trainings for participating teachers and helped establish electrical connections in the schools.

The first year of our study included a quantitative component that tested student performance in 3rd grade English and 5th grade Math. We assessed two classes in each school, one a control class and one a DSH class. We used pretests and observational evidence to match schools for comparison, ensuring that the best performing schools were not paired with worst performing schools. We administered three tests at the beginning, middle, and end of the year of program implementation. The results were inconclusive, and there were significant difficulties in conducting testing, as we discuss in Section 9. We decided against continuing the quantitative component in the second year. Dropping the testing allowed more flexibility in selection of teachers and classes for DSH. In the second year, courses were taught in English, Math, Hindi and Science using DSH.

In the first year, we followed ten certified classroom teachers and

one paraeducator. A paraeducator is usually from the local community and responsible for teaching lower primary classes. In the qualitative study we evaluated the schools to assess teachers' use of DSH and interactions between teacher, DSH, and student. We made monthly observational visits to the schools to take field notes as well as conduct informal or structured interviews with teachers. Additionally, once a month in six of the schools, teachers' mediated classes were filmed and analyzed. Between August 2009 and March 2010, we made 70 field visits, collected 33 videos and 22 teacher interviews.

We were encouraged by the impact DSH had on teachers and the teachers' positive view of the program after the first year of the study. Through field notes and analysis of classroom footage of focus teachers, we determined that some of the teachers had incorporated interactive teaching methods into their teaching similar to those in the DSH videos. Towards the end of the first year, teachers began to request additional DVD content in other subject areas and grade levels indicating support for DSH and a desire for greater flexibility in its use.

For the second year, we bolstered our qualitative data collecting efforts, increasing field visits from monthly to weekly. Four paraeducators were added to replace teachers that had been transferred or did not want to continue using DSH. As in the first year, our data collection was comprised of informal and formal interviews, ethnographic fieldwork, and video recordings of mediated classes. During the second year of the study, we made approximately 230 visits, filmed 40 focus teachers' lessons, and conducted 24 structured interviews with teachers.

5.2 Background of Schools

The participating schools were at edge of a large city. The five schools located furthest from the center were predominately agricultural; parents either worked on their fields or for nearby brick kilns. The remaining six schools were located in peri-urban communities, where much of the land had been developed into apartments to house workers. While some parents were farmers, the majority worked as day laborers in the market or the nearby city.

We picked these eleven schools as the schools most suitable for DSH out of the twenty schools in the administrative area, so there was a selection bias in the study. The school buildings had at least three functional rooms, a veranda, running water, electricity, a large playground and a boundary wall. The participating school staff, on average, was comprised of one principal, one full time teacher, and two paraeducators for an enrollment ranging from 70 to 200 students. The students came predominately from low income, disadvantaged backgrounds with over 85 percent of the students from scheduled castes.

6. STUDY RESULTS

We followed the use of DSH in eleven schools for two years. Table 1 gives a school by school summary of the use of the system, with the focus classes, the number of visits, and textual descriptions of what happened each year. DSH was used by all of the schools with varying degrees of success. Two schools dropped out in the second year for the same reason – the equipment was stolen, and they did not want to bear any responsibility for replacement.

We now present our results from the study, using a framework developed by Linnell [18] to analyze facilitated video instruction deployments. The main results are:

- 1) Teachers were successful in adopting DSH and used it consistently during the study period.
- 2) There was acceptance of the interactive pedagogy behind DSH with some observed cases of teachers changing their behavior.
- 3) The technology and pedagogy was very well received by students.
- 4) Key components of the DSH implementation were validated, such as creating content appropriate for the target audience.

- 5) The testing did not show any performance gains by DSH students over non-DSH students. (The testing was discontinued after the first year of the study.)

However, our overall conclusion is negative: we do not believe that the DSH intervention is sustainable in the UP government schools without substantial support from an external organization (such as weekly monitoring visits). We predict if the deployment continued in our schools the system would fall into disuse.

6.1 Facilitated Video Instruction Framework

Linnell [18] developed a framework for assessing facilitated video deployments derived from the literature and experiences with similar projects. The framework captures key aspects of

Table 1. Summary of DSH use in study schools.

School	Focus Class yr1 / yr2	Field Visits yr1/yr2	1 st year summary	2 nd year summary
Gobinagar	3 rd /English 3 rd /English	6 / 8	Used DSH regularly and showed remarkable growth in teaching practice. Observed mediated classes progressively were more interactive.	Lead teacher was transferred. Equipment was stolen early in the year and program ended.
Dhaangaon	5 th /Math 5 th /Science	6 / 24	Used the DSH system semi-regularly and showed moderate growth in teaching practice. Asked more questions, developed more activities for her students throughout the year.	Consistently used DSH video, but mostly without mediation instruction. Improved from previous year, incorporated even more interactive teaching techniques and activities.
Hathipur	5 th /English 5 th /Math	7 / 24	Showed great improvement over the year. Incorporated interactive activities and questions into her classroom.	Continued to use DSH, but did not show as much pedagogical growth. When observed during a non-DSH lessons at the end of the second year, used rote instead of interactive methods.
Shantipur	5 th /Math 5 th /Science	11 / 20	Used DSH films semi-regularly and showed strong growth in teaching practice. Became more interactive with larger set of the class.	Used DSH consistently but did not mediate. Watched video occasionally before class to get ideas. No considerable growth seen between the first and second year of program.
Suryagoan	3 rd /English 3 rd /English	7 / 26	Used the system semi frequently and showed moderate growth in teaching practice.	Showed moderate growth in teaching techniques. Clearly asked more questions, gave more board work and incorporated more activities into her lessons throughout the year.
Pratikigigoan	5 th /Math 5 th /Math	9 / 6	No noticeable changes in teaching practice. Did not regularly use DSH and was not receptive to working with DSH staff.	Equipment was stolen early in the year and program ended.
Dharshanpur	3 rd /English 4 th /Hindi	5 / 24	Used DSH semi frequently and showed moderate growth in teaching practice. Asked more questions, became more interactive with students	Did not mediate with DSH videos, used them to get new ideas and as a form of revision. Did not demonstrate much pedagogical growth during the year.
Pattaganj	5 th /Math 5 th /Math	7 / 24	No noticeable changes in teaching practice. Did not regularly use DSH and was not receptive to working with DSH staff.	Regularly used the DSH system and showed significant improvement in interactive lessons, asking more questions, and calling on children for boardwork.
Malikpur	3 rd /English 3 rd /English	7 / 27	Used DSH regularly and showed great interest and progress in adopting DSH methods. Began to ask questions and interact more with her students.	Continued to show moderate improvements in her mediation techniques and teaching practice.
Uppargaon 1	5 th /Math 2 nd /Hindi	5 / 24	No noticeable changes in teaching practice. Did not regularly use DSH and was not receptive to working with DSH staff.	Regularly used DSH system and showed moderate improvement in interactive teaching practice. Developed poems to aid mediated lessons and asked more questions.
Uppargaon 2	3 rd /English 3 rd /English	7 / 25	No noticeable changes in teaching practice. Early in the year, her son passed away. She remained despondent for most of the year.	Demonstrated remarkable improvement throughout the year. Watched films before class to prepare learning materials and familiarize with content. Classes became more interactive.

facilitated video instruction that influence project outcomes. Our simplified version of the framework consists of the following four components:

- Infrastructure to support the playback of video.
- Relationships between the different actors, including the students, teachers, principals, DSH organization, and the video teacher and class.
- Educator self-perception, understanding, and buy-in.
- Perception of value by students, teachers, administrators, and parents.

6.2 Study Results

In the following subsections we develop these categories as we discuss our research findings within the framework. For each category, we present our outcome assumptions while designing the model and study. Each criterion is then assessed through its actual outcome and given a label based on its alignment with outcome assumptions: aligned, semi-aligned, or non-aligned. By aligned we mean that participant behavior mirrored our assumptions or there was a positive outcome from the intervention. Semi-align labels are reserved for categories where some behavior matched our expected results. Non-aligned is given to categories where the program had no impact on teachers or learning or our assumptions were false.

6.2.1 Infrastructure

The infrastructure must support reliable replay of video materials without placing a substantial burden on the facilitator. Adequate quality infrastructure is a necessary, but not sufficient, condition for a successful facilitated video deployment.

Video Replay Infrastructure: Aligned

DSH Assumption: The TV/DVD player will be reliable and easy to use by teachers.

Outcome: Since the inception of DSH, there has been substantial refinement of the video replay technology, with a general trend towards simplicity, so that the current model is based on physically distributing DVDs and using commercial televisions and DVD players [10,34]. Teachers had few difficulties in using the system, and equipment was generally reliable.

Physical Infrastructure: Semi-Aligned

DSH Assumptions: Electric power with battery backup would be adequate for regular use of DSH and a steel case would be sufficient for physical security of the equipment.

Outcome: The start of the project coincided with the installation of electrical connections in all schools, which gave us optimism that grid electricity would be sufficient. However, maintaining connections in some schools was an obstacle, and after events such as theft of electrical wires there were long delays in re-establishing connections. In the second year, there were four instances of theft, which led to two schools dropping from the program since they no longer wished to be responsible for the equipment.

6.2.2 Relationships Between Stakeholders

A central component of Linnell's framework is that success of facilitated video is determined by the relationship between the different actors, including the students, facilitator, the video materials (video teacher and video students), the school administration and the implementing organization. Of these, the

relationship between the implementing organization and the students and facilitator has been significant in several previous facilitated video deployments [1,11]. Due to space limitations, we focus on only a subset of the relationships.

Student Relationship with Video: Aligned

DSH Assumptions: Participating students will engage with DSH video teachers' questions and activities. Students will not see significant difference between themselves and their video peers.

Actual Outcome: Students observed exhibited a high level of interaction with DVD teachers that paralleled behavioral patterns with their live, classroom teacher. Students regularly responded to the DVD teacher's questions and call and response activities. They watched attentively to the film just as they did during regular instruction, swaying back and forth, a traditional student marker in India of concentration. It was observed that students raised their hand to be called on after the DVD teacher asked a question. Although the students soon realized that the video teacher would not call on them and ceased the practice, the act illustrated the level of excitement generated by the video teacher's lesson.

Students were asked what differences they saw between their peers and the video students. While some were able to notice discrete differences, such as how the video classes were comprised of all female students or how they wore different uniforms, the majority of students said "the students were just like them". Interestingly, students also often interacted with their video peers. Expert teachers in the DSH DVDs encourage their students to clap for their peer after correctly answering a question. The participating classroom students adopted this practice, often clapping for their DVD peers as they answered questions regardless of whether or not they were prompted by their instructor to do so. The fact that the rural students felt that they were peers with the video students who were from a poor, urban background is important validation of the content creation strategy used by DSH.



Figure 1. Student raising hand during DSH lesson.

Educator Relationship with DSH Organization: Semi-Aligned

DSH Assumptions: Teachers will work well with DSH field staff and be open to feedback.

Actual Outcome: Participating educators built friendly relationships with DSH staff, although paraeducators showed greater propensity to work with researchers and incorporate feedback. For example, a paraeducator, Menal, was overly

didactic in her teaching approach and rarely interacted with her female students who academically lagged behind their male peers. DSH staff had a conversation with her regarding the frequency and distribution of questions in her lessons with an emphasis on inclusiveness. After the discussion, subsequent filmed classes demonstrated a change in Menal's teaching approach, both in terms of the number of questions asked and the question distribution between male and female students.

Paraeducators tended to work more closely with DSH staff during workshops aimed at developing both video mediation and child-centered teaching skills. One workshop session focused on making English more accessible in the classroom by labeling common classroom items with their English name. Within a week of the workshop, Rani, a paraeducator, had incorporated the practice in her classroom, placing large index cards with their English names on the blackboard, cupboard, wall and other items in the class.

Certified teachers were more reluctant than their paraeducator counterparts to work with DSH staff. This reluctance will be explored in a following section.

Student Relationship with the DSH Organization: Aligned

DSH Assumptions: Students will have a favorable view of DSH from interactions with field staff and DVD content.

Actual Outcome: Two DSH researchers regularly visited schools to gather observational data on teachers' progress with the program as well as facilitated classes to model appropriate video mediation pedagogy. This led to a high level of interaction between DSH researchers and the students. On occasion when focus teachers were absent, DSH researchers would teach classes when visiting understaffed schools. Students enjoyed the change of pace and interactive lessons that the researchers provided and soon formed positive relationships with them. The research staff also added novelty to the schools by bringing in technology (such as video cameras) and arriving by car. One of the researchers was a Hindi speaking Caucasian American which was very unusual for this environment. Students referred to DSH staff with the same titles as their teachers (Ma'am ji and Sir ji) and would run outside to greet researchers on their visits.

The level of interaction between the students and DSH researchers provided valuable information about the students' school environment, but potentially conflicted with evaluation of the DSH intervention. The frequency of evaluation visits likely had a positive impact on student attitudes, but would not be possible in a larger scale offering of DSH.

6.2.3 Perception of Value

For a novel educational intervention to be successful, it is critical that the participants perceive that it offers value relative to available options. This is particularly true for facilitated video instruction, where the comparison is made between the use of video materials and a live instructor.

Educator Perception: Semi-Aligned

DSH Assumptions: Teachers will see value in DSH as a mechanism to improve delivery of lessons and to upgrade teaching skills.

Actual Outcome: Most participating educators found value in DSH either within the framework of facilitated video instruction or adapted the model to meet the needs of their classroom. The

value of DSH differed between certified teachers and paraeducators.

Certified teachers often used DSH as a preparatory tool, watching the films prior to class to draw out new ideas for classroom instruction without prompting from DSH staff. One teacher, Asha, reported watching DSH lessons in her school during early dismissal or after school hours to get new ideas for the following day's class.

Although interested in the content, fewer teachers saw the value of the pedagogy advocated by DSH. Asha commented, 'We do not have enough time to play the film and teach [mediate]. We have a large syllabus to cover and not very much time to do so. I will watch the DVDs for new ideas, but I will not play them in class while I am teaching. Sometimes I show them to my students when I am busy with another class.' When asked about how she uses DSH, another teacher, Nandani, told DSH researchers, 'I first take the class normally using my own techniques and teaching materials that I have already used before DSH. I never use DSH in the beginning of the lesson. We then watch the DSH film to go over the concept again.' Generally, certified teachers saw the potential of DSH in contributing to classroom management, a resource for new teaching ideas, and for revision.

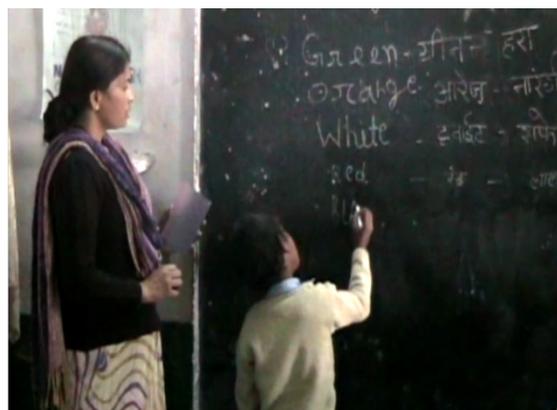


Figure 2. Kavita with learning material and student.

All of the participating paraeducators in the study told researchers that they did not watch DSH films prior to their classes. Most cited a scarcity of time during school hours because of the strict syllabus and conflicts with household responsibilities. But, paraeducators were much more responsive to the interactive pedagogy, all using variants of methods introduced at DSH trainings. Paraeducators would play the film in short intervals, infusing their own methods to the video content and checking for student understanding. DSH became more integrated into paraeducator classrooms, where they would lean more upon DSH and facilitated instruction techniques perhaps to make up for a lack of training and content knowledge.

Student Perception: Aligned

DSH Assumptions: Students will see value in program and actively participate in DSH classes.

Actual Outcome: Students were overwhelming positive about DSH materials. Teachers reported their students frequently asking to study with the TV. As mentioned above, students actively participated in DSH classes. When asked how they would feel if the TV system was taken away, students

resoundingly said that they would be sad or angry. In a school where the DSH equipment was stolen, students remarked that they missed the DSH lessons and still used fraction-solving methods that they had learned through DSH mediated classes six months prior. Students also expressed value in the role of mediating teachers, the majority adding that they could not learn from the films without the help of their classroom teacher. The level of enthusiasm by students exceeded our expectations since we thought they would be passive with respect to their education.

Administration Perception: Semi-Aligned

DSH Assumptions: Principals will value the role of DSH in their school and take ownership over the program.

Actual Outcome: Although focus schools were vetted in part by conversing with school leadership and gauging interest, soon after the program began most participating principals became ambivalent towards DSH. After providing schools with more content during the second year, it was expected that more teachers would use the program at each school. Despite efforts from DSH field staff to work with principals to increase DSH usage, only three of the eleven participating schools had more than one teacher who regularly taught with DSH. In these three schools, principals took ownership over the DSH program, making sure that the equipment was maintained and used by multiple members of their staff.

The ways in which principals handled theft of equipment in three schools was indicative of the overall administrative view of DSH. In one of the schools, the principal promptly filed a report to the police department after their DVD player and stabilizer was stolen. Teachers at the school immediately notified DSH about the theft and requested replacement equipment. When DSH brought new equipment, the principal shifted the DSH setup for use in her office, which had the most secure lock in the building. In contrast, two other schools that were afflicted by theft pulled out of the project soon after, citing that they did not want to bear the additional responsibility having the equipment in their schools.

Parents' Perception: Non-Aligned

DSH Assumptions: Parents will believe that the DSH program adds value to their school.

Actual Outcome: In informal conversations with students, DSH researchers discovered that the vast majority of students had told their parents about DSH and the television in their school. When parents were asked, most did not recall the conversation and, once the project was explained, expressed ambivalence towards it. Although all parents interviewed owned televisions, most felt that a television could be used as a tool of instruction, but would not significantly improve the school. This contrasts to the findings of Pal [25] on parent perception of educational technology that found a significant number of parents in rural Southern India believed that the addition of computers to the school increased the value to their children's education and school. The difference could be explained either as different views of a common object (at TV) and an exotic object (a computer), or as a difference between the two locations.

6.2.4 Educator Self-Perception, Understanding, and Buy-In

It has long been recognized that the attitude and behavior of the facilitator is important to the success of video instruction [11]. The theory behind facilitated video instruction is that that the

video materials and pedagogy can allow a less experienced person without strong content knowledge, to lead a class. However, there is still the requirement that the facilitator understands and is supportive of the methodology. It has been noted [1] that a cause of failure of video instruction deployments is lack of buy in by the facilitator.

Perception of DSH as Teacher Training: Aligned

DSH Assumptions: Teachers will view DSH as a way to improve their teaching practice.

Actual Outcome: Paraeducators recognized the professional development aspect of the program. DSH staff observed how paraeducators drew upon DSH to help manage their classrooms, learn new teaching strategies, and make up for deficiencies in content knowledge. Many educators liked the DSH English lessons, conducted completely in spoken English, since they had extremely limited English skills. One of the focus teachers, Rani was especially interested in the English content, and would attentively watch and participate in lessons with her students. She said that she had not studied English since 10th grade and told staff that she was using the content to improve her English so she could teach English to her own son.

Certified teachers put less emphasis on the training aspect of DSH. In interviews, all teachers told DSH that they had already received training from the government and thus had a repertoire of quality teaching practices. When a participating teacher Nandini was asked if she had improved through the program she responded, 'I can't say that it has improved my teaching, I don't see any improvement, ... Remember that I am very trained. I received my B.Ed with special government training and M.Sc, and have submitted my thesis for PhD.' When asked what she had learned from DSH, she had much to say, 'I have definitely learned much from DSH. I have gotten ideas on how to make interesting teaching materials and use new examples and assignments. I use these things often. When I came to the [biyearly] training, I saw one interesting English class. The teacher was teaching G, she would draw a picture of a gate, goat, etc to get the concept of G. Before, I thought that you should just teach by simply saying, 'G is for goat,' but I found that the children learn better from this because using of the picture the concept makes it very clear.' Although hesitant to admit that it DSH functions as an agent of professional development, she definitely defines how DSH has changed her practice.

Job Attitude: Non-Aligned

DSH Assumptions: DSH could help improve educators' attitude towards their profession and motivate teachers.

Actual Outcome: The DSH intervention had no impact on changing focus teachers' very negative attitudes towards their jobs. Through frequent informal interviews, teacher stated how frustrated they were with capricious government mandates, poor quality in-service training, the syllabus, and parents disinterest in their children's education. This negative attitude coupled with a lack of oversight from higher administration, reflected upon the way that they approached their profession. Teachers were frequently late to school by a half hour to an hour and it was clear that teaching was not always a priority. In some schools, teachers spent much of the day completing paperwork required by the government, in others teachers simply didn't teach. Researchers observed a day in a focus school where the three teachers did not teach a single lesson instead spending the day chopping vegetables for dinner and chatting amongst themselves.

Classroom Ownership: Semi-Aligned

DSH Assumptions: The implementation of DSH would not be perceived as undermining classroom ownership.

Actual Outcome: Paraeducators generally did not perceive DSH as a threat to their classroom autonomy comparative to certified teachers. Again, most paraeducators lacked training and content knowledge so many viewed the program as an asset to their practice. Credentialed teachers were more skeptical of DSH methods and its role in the classroom. In Nandini's interview above, she states that she only uses the program after she had covered the topic with her own teaching methods and learning materials. In doing so, she makes a clear assertion that DSH is a supplement to her own instruction and that it should not interfere with her methods and techniques.

Understanding and Buy-In: Semi-Aligned

DSH Assumption: Teachers will have a thorough understanding of DSH pedagogy and will believe that the pedagogy is appropriate for their classroom.

Actual Outcome: DSH held biyearly workshops for participating teachers to systematically introduce and develop practical methods of using DSH techniques in government classrooms. Most focus educators were able to participate in several such workshops and had positive feedback about the experience. Participating educators also received additional support through weekly field visits. If focus educators were equivocal about DSH techniques, field staff clarified questions through demonstrating proper form and providing feedback.

Regardless of participating educators' knowledge of DSH pedagogy, few, mostly paraeducators, used it in a manner that suggested buy in. As mentioned above, most certified teachers chose to use the equipment in a more passive manner, either as a tool for classroom management or to gather new ideas. Paraeducators, on the other hand, actively experimented with DSH pedagogy and integrated the practice into their classrooms.

7. CHALLENGES TO SUSTAINABILITY

Our overall conclusion is that teachers would not continue to use DSH without the extensive monitoring and support given during the study. Given the costs of such monitoring efforts, this approach would not be sustainable on large scale in government schools in UP. Even during the study, we observed that usage diminished when monitoring was less frequent. For example, in the first year, usage was lower with less intensive monitoring. Gaps in DSH use also occurred due to long term electrical outages. An example from the second year of the study supports our concerns about viability. In one focus school teachers made no attempt to restore electricity to the school for over a month. On weekly visits, the focus teacher reported that there was no electricity for the day, but failed to mention that it had been cut for the entire village because of unpaid bills. When we discovered this information, we called a local leader and the electricity was reestablished to the school in two days. The focus paraeducator, Menal had worked very closely with DSH staff and valued DSH, but this did not lead to the school getting the electricity reconnected.

We believe that the main obstacle to scalability is the educator's views of their profession. Our conversations with focus educators revealed very negative attitudes about their profession, very

similar to the findings of Mooij [24]. Teachers felt most frustrated with the parents, most citing that they were illiterate and did not care about their children's studies. They also relayed that the government did not respect their professions. Teachers felt overburdened by additional governmental duties, administrative responsibilities, and the large syllabus that they were mandated to complete in a short timeframe.

Within this backdrop of teacher discontent, there is also little accountability or support system to help inform teaching practice. While there are occasional monitoring visits from district officials to schools, they are mostly to check various registers for attendance, provision of midday meals, and test scores. Teachers reported to us that the visits were little more than drinking tea with officials and showing them their school registers. With minimal oversight on teaching practices from district officials and a low perception of their profession, many teachers do not see incentives to actually teach and therefore, many decided not to.

The overall results of the study combined with teacher apathy and lack of oversight are consistent with Toyama's amplification theory [32] that "people have intent and capacity, while technology is merely a tool that multiplies human capacity in the direction of human intent. If there is a foundation of well-intentioned human competence, then the appropriate technology can amplify that and contribute to a positive outcome. But, in circumstances with negative human intent...no amount of technology will turn things around."

For DSH to be sustained at a large scale there would need to be sufficient buy-in from teachers and administrators to ensure regular use and that infrastructure remained in place. Weak electrical systems and equipment theft were also continued threats to implementation so there would need to be sufficient institutional support to counteract these.

8. COUNTERPOINT: A SUCCESSFUL DSH DEPLOYMENT

To contrast with our results, we now discuss a separate deployment of DSH which had a very different outcome. The school, Bhal Vidyalaya (BV), is also a government school, located about 60 km away from our study sites. BV is more rural than our study schools, but otherwise similar in terms of student and staff size, demographics, and infrastructure.

DSH has been deployed at BV for six years, and is now institutionalized with minimal oversight from the DSH organization. BV administrators run the school with efficiency and order. Teachers are in their classrooms with students attentively participating. All teachers regularly use DSH mediation techniques two to three times a day according to a timetable set by the school. Students perform well on their examinations, some eventually transferring to English medium schools, a rarity amongst government school graduates. The principal has fully bought into the model and monitors staff to ensure continued use and effectiveness as well as using DSH himself in his role as the fifth grade teacher. The school has considerable pride in the program and had a painter write 'Digital Study Hall' prominently on the school building.

BV faces the same challenges as the study schools, yet still is able to provide a high quality education to its students and effectively use DSH as a mechanism of professional development. The introduction of DSH to BV was very different from the

introduction to the study schools. The DSH director, a prominent local activist, worked with BV since 2001, facilitating the introduction of an earlier ICT project, Hole in the Wall, which provided computer education to villagers [23]. In 2005, BV was one of the first schools to use DSH, which meant the director and other staff made frequent visits to the school to work with teachers.

When technology and technique were in place, field staff made multiple weekly visits to the school to work with teachers, sometimes spending weeks at a time conducting intense workshops and monitoring teacher's use. DSH staff would devote entire days to discussions with educators about the value of the program, how it should be incorporated into the regular timetable, and how to mediate lessons. Even with these efforts, DSH staff expressed similar frustrations as in this study. Despite large organization inputs from DSH, teachers remained apathetic towards the program. During gaps between visits, teachers would not use the program and forget facilitation techniques.

Momentum started to shift when a certified teacher, Sanjay, began to value the program. Sanjay says, 'I noticed a difference between the DSH teachers and us. First, they have more [content] knowledge about the subjects, and teach to the child's environment. We are not able to teach as well, but we are watching the DSH teachers and trying to learn.' He began to integrate mediation into their practice and their classes started to become more interactive and students more engaged.

The difference between a teacher like Sanjay and most of the study teachers is a high perception of his profession and a commitment to the education of his students. When asked why the program has been successful given the conditions in government schools he replies, 'This is our school, these are our students, and this is our profession. We need to be honest to our profession and our students... The government system can be blamed for a number of problems, but if a teacher wants to teach, then the system isn't much of an issue. For example, I have a lot of administrative responsibilities for the midday meal, etc. But I sometimes will take classes after the school timing or on holidays, in order to ensure that the course is completed and the students do not suffer because of the government rules.'

Sanjay was eventually transferred to a different school. When the BV principal retired three years into the program, Sanjay was hired back as the new principal which led to a deeper use of DSH. He helped secure another TV and DVD player so that teachers could use the system multiple times during the day. On top of his principal duties and teaching fifth grade, he has taken over the role previously played by DSH field staff by monitoring educators' use of DSH and their professional development. Sanjay is entirely competent in this role, thus DSH has reduced its monitoring role to bi-monthly field visits.

There are other private and non-profit schools in UP that have also employed DSH in a successful manner with relatively little oversight. As with BV, the key has been at least one motivated staff member who is passionate about teaching as well as buy-in from strong school leadership.

9. DIFFICULTIES WITH OUTCOME ASSESSMENT

The initial ambition for the study was to evaluate performance outcomes. In the first year of the project, we carefully designed a

quantitative component of the study with pre- and post-tests with DSH and control classes. The results were utterly inconclusive, with no discernable difference between DSH and control classes. We chose not to continue the testing for the second year, and are drawing no conclusions about the efficacy of DSH. We revisit the testing and argue that there are fundamental difficulties in evaluating learning outcomes in this environment. *We believe that even if our intervention led to substantial gains over traditional teaching, we would not have been able to detect it in a study of our scale and duration.*

9.1 Student Attendance

One major difficulty we faced was poor attendance by students. Attendance is highly variable throughout the year, dropping drastically during harvest and festival periods. Although schools have an official start date in July, student attendance gradually ramps up, making it difficult to schedule a pre-test. We scheduled one of our tests during the potato harvest when attendance was disastrously low which necessitated giving a new test. During our study we collected student attendance during field visits, which placed average attendance at approximately 45 percent. This number is complicated by the tendency of many students to skip school either after morning attendance or the midday meal. Regardless, this is a much lower number than what teachers record in their attendance registers, which averages around 70 percent. Teachers openly related that they misrepresent attendance registers to avoid repercussions from higher administration.

Variable attendance made it difficult to get a sufficient number of students who had taken both the pre and the post test. In the end, we had pre and post test from less than half of the students in the sample. This number would have meant that the results were not statistically strong. Another factor that would have weakened the statistics is a fraction of the students were completely unprepared for the grade, and would receive zeros on tests (if taken honestly).

9.2 Frequency of Instruction and Use of DSH

The total number of days of instruction with DSH was less than we had hoped. This arose from multiple factors: schools being closed for holidays or weather, teachers being on leave or performing other duties, teacher present but not teaching, and teachers choosing not to use DSH.

Schools were frequently closed for holidays. With Hindu Muslim, Sikh, state and national government holidays, many days of school were cancelled. Schools would close if the weather was either too hot or too cold. In both years of the study there were three week closures in January for low temperatures. Exam periods and preparation also led to lost days of instruction. Most teachers were regularly absent due to vacation and leave or through government-mandated duties. For example, one teacher took medical leave for close to a month to prepare her son for his 10th grade board exams. Teachers were regularly called away from school for other duties including running voting stations, distributing election cards, collecting census data, facilitating board exams, and aiding vaccination campaigns. We estimate out of the nine month school year, there were approximately three months of instruction with significant teacher and student attendance. The quality of instruction during those periods is debatable as teachers would often come late to school or spend time at school on paperwork or conversation.

9.3 Culture of Testing

Another complicating factor was the lack of a testing culture. Throughout the study we observed rampant copying on tests and assignments. Teachers often would leave the room after giving a test or were distracted by other work in the classroom. Students routinely copied from others' tests and assignments, behavior that was never corrected by teachers. On a visit during a government final examination, we found a group of 3rd graders huddled around a sheet of paper working in their notebooks. When the field researcher asked the teacher what they were doing, she unapologetically said that she had given them the answer sheet to copy for their test. They had not learned the subject during the year and she knew that if she didn't give them the answer sheet they would not perform well, which would anger her superiors.

We did not consider using the official exams to measure student performance because we were aware that the scores were often fraudulent. In proctoring our own examinations, we found it extremely difficult to prevent copying, even after explaining that students would not receive a grade on the examination. Spreading students out amongst the room and posting two staff members to monitor the test reduced, but did not eliminate the copying.

In summary, there were multiple obstacles to getting believable performance results. The variability in instruction meant that we did not have full confidence in how much the intervention had been used. Therefore, we do not know how strong a comparison there was between control and DSH, and which schools would potentially be showing gains. Problems with school attendance greatly reduced the number of test scores, which would compromise the quality of the statistics. Finally, deploying a testing instrument that gives accurate information on individual performance is very challenging in this environment.

10. CONCLUSIONS

The findings from our study illuminate the systemic challenges in North India that make it difficult for interventions such as DSH to have a large scale and sustained impact. In light of these challenges we do not believe that the DSH model is ready for wide deployment in government schools in North India. The intervention was only sustained in the eleven schools we worked in by regular monitoring, and it would not be possible economically to maintain this level of monitoring in a scaled deployment.

We do not view the findings as completely negative for DSH. For example, the enthusiasm shown by students for DSH and the uptake by some of the paraeducators suggests that there could be a role for facilitated video instruction if it is possible to cross the adoption barrier. Operationally, there was significant improvement in the study schools between years one and two, leading to higher utilization of DSH. The technology is usable in schools at relatively low cost, and course materials recorded at an urban school were appropriate for the rural schools.

The sustained use of DSH in the BV school is intriguing, since it shows that with appropriate teacher and principal support, the system can be used as it was originally intended. However, evidence suggests that individuals such as Sanjay from BV are relatively rare in the government school system. Given the diversity of India, we are cautious about over generalizing these results. The government schools of UP (and likely other North India states) have characteristics that will make the scalability of DSH difficult to achieve. Other Indian states have different

educational contexts, as do private schools, which potentially would make the intervention more successful.

The majority of ICTD projects only reach the pilot stage. In this work, we evaluated a deployment at the next level of scale to investigate sustainability and impact. The contextual evaluation identified obstacles to sustainability, as well as aspects of the program that worked although we were not successful in measuring educational impact. Implementing a study of this scale required significant attention to field deployment issues, and there was a large investment in making arrangements to initiate the work. We anticipate that as the ICTD field matures there will be increasing emphasis on larger evaluation studies.

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12. REFERENCES

- [1] R. Anderson, G. C. Harrison, M. Dickey, and H. Perkins, "Experiences with Tutored Video Instruction for Introductory Programming Courses Papers" in *Proc. Online/Distance Learning - Sigcse Bulletin*, 2001 vol. 33, no. 1, pp 347.
- [2] A. Banerjee, S. Cole, E. Duflo, L. Linden, "Remedying Education: Evidence from Two Randomized Experiments in India," *The Quarterly Journal of Economics*, vol. 122, no. 3, pp. 1235-64, Aug., 2007.
- [3] E. Bauman, and D. Jurgens, 'Undergraduate Electrical Engineering via Tutored Video Instruction,' in *Proc. Frontiers in Education Conference*, no. 460, 1994.
- [4] E. Brunskill, S. Garg, C. Tseng, J. Pal, and L. Findlater, "Evaluating an Adaptive Multi-User Educational Tool for Low-Resource Environments" in *Proceedings of the IEEE/ACM International Conference on Information and Communication Technologies and Development*, London, UK, December 13-16, 2010.
- [5] S. Chaudhary and S. Garg, "On using satellite-based networks for capacity building and education for all: A case study of Rajiv Gandhi project for EduSat-supported elementary education," *Educational Research and Reviews*, vol. 5, no. 4, pp 158-168, Apr. 2010.
- [6] Digital StudyHall website, dsh.cs.washington.edu
- [7] C. Dyer, "Decentralisation to improve teacher quality? District Institutes of Education and Training in India," *Compare*, vol. 35, no. 2, pp. 139-152, May 2005.
- [8] C. Dyer and A. Choksi, *District Institutes of Education and Training: A Comparative Study in Three Indian States*, London, Department of International Development, 2004.
- [9] J. Freze and G.G. Kingdon, 'School Participation in Rural India' *Review of Development Economics*, vo. 5, no. 1 pp. 1-24, Feb. 2001.
- [10] N. Garg, A Postal System Based Digital Network and a Distance Learning Application, PhD Dissertation, Computer Science Department, Princeton University. June 2006.

- [11] J. F. Gibbons, W. R. Kincheloe, K. S. Down, "Tutored Videotape Instruction: A New Use of Electronics Media in Education," *Science, New Series*, Vol. 195, No. 4283, pp. 1139-1146, May 1977.
- [12] R. Heeks, "Information systems and developing countries: failure, success, and local improvisations", *The Information Society* 18 2, pp 101-112, 2002.
- [13] R. Heeks, "Health information systems: failure, success, and improvisation", *Medical Informatics*, 75, pp. 125-137, 2006.
- [14] L. Hosman and E. Fife, "Improving the prospects for sustainable ICT projects in the developing world," *International Journal of Media and Cultural Politics*, 4 (1), pp 51-69, 2008.
- [15] M. Kam, A. Kumar, S. Jain, A. Mathur, and J. Canny, "Improving Literacy in Rural India: Cellphone Games in an After-School Program," in *Proceedings of the IEEE/ACM International Conference on Information and Communication Technologies and Development*, Doha, Qatar. April 15-19, 2009.
- [16] M. Kremer, N. Chaudhury, F. H. Rogers, K. Muralidharan, and J. Hammer, "Teacher Absence in India: A Snapshot" *Journal of the European Economic Association*, vol. 3, no. 2/3, pp. 658–67, Apr. 2005.
- [17] R. Kuriyan, I. Ray, and K. Toyama, "Information and communication technologies for development: The bottom of the pyramid model in practice", *The Information Society*, 24, pp. 93-104, 2008.
- [18] N. Linnell, *Technologies and Techniques for Supporting Facilitated Video*, PhD Dissertation, Computer Science and Engineering, University of Washington, 2011.
- [19] A. Little, "Access to Elementary Education in India: Politics, Policies, and Progress," Consortium for Research on Educational Access, Transitions, and Equity [Online] Available: www.create-rpc.org/pdf_documents/PTA44.pdf. Sept. 2010.
- [20] S. Mehrotra, P.R. Panchamukhi, R. Srivastava, R. Srivastava, *Universalizing Elementary Education in India: Uncaging the 'Tiger' Economy*, New Delhi, Oxford University Press, 2005.
- G.A. Mills-Tetty, J. Mostow, M.B. Dias, T. Sweet, S.M. Belousov, M.F. Dias, and H. Gong, "Improving Child Literacy in Africa: Experiments with an Automated Reading Tutor," in *Proceedings of the IEEE/ACM International Conference on Information and Communication Technologies and Development*, Doha, Qatar. April 15-19, 2009.
- [21] S. Mitra, "Minimally invasive education: a progress report on the 'hole-in-the-wall' experiments," *British Journal of Educational Technology*, Vol. 34, No. 3, pp. 367-71, 2003.
- [22] S. Mitra and V. Rana, "Children and the Internet: experiments with minimally invasive education in India," *The British Journal of Educational Technology*, vol. 32, no. 2, pp. 221-232, 2001.
- [23] J. Mooij, 'Primary education, teachers' professionalism and social class about motivation and demotivation of government school teachers in India', *International Journal of Educational Development*, vol. 28, no. 5, pp. 508-523, Sept. 2008.
- [24] J. Pal, M. Lakshmanan, and K. Toyama, "My child will be respected: Parental perspectives on computers and education in Rural India," *Information Systems Frontiers*, vol. 11, no. 2, pp. 129-144, Jan. 2009.
- [25] R. Patra, J. Pal, S. Nedeveschi, M. Plauche, and U.S. Pawar, "Usage Models of Classroom Computing in Developing Regions," in *Proceedings of the IEEE/ACM International Conference on Information and Communication Technologies and Development*, Bangalore, India. December 15-16, 2007.
- [26] U.S. Pawar, J. Pal, R. Gupta, K. Toyama, "Multiple Mice for Retention Tasks in Disadvantaged Schools" in *Proceedings of the CHI2007 ACM Conference on Human Factors in Computing Systems*, San Jose, California, April 28-May 3, 2007.
- [27] Pratham, "ASER 2010—Annual Status of Education Report (Rural)," New Delhi, Pratham, January, 2011.
- [28] E. Rogers, *Diffusion of Innovations*, Free Press, NY, 1983.
- [29] U. Sahni, R. Gupta, G. Hull, P. Javid, T. Setia, K., Toyama, and R. Wang, "Using Digital Video in Rural Indian Schools: A Study of Teacher Development and Student Achievement", *Annual Meeting of the American Educational Research Association*, March 2008.
- [30] A. Saxena, R. Anderson, N. Linnell, U. Sahni, A. Arora, and R. Gupta, "Evaluating Facilitated Video Instruction for Primary Schools in Rural India," in *Proceedings of the IEEE/ACM International Conference on Information and Communication Technologies and Development*, London, United Kingdom, December 13th-16th, 2010.
- [31] K. Toyama, "Technology as an amplifier in international development", *Proc. of the iConference 2011*, Seattle, USA, Feb. 8-11, 2011.
- [32] "Uttar Pradesh Human Development Report" United Nations Development Programme, New Delhi, India, 2007.
- [33] R. Wang, S. Sobti, N. Garg, E. Ziskind, J. Lai, and A. Krishnamurthy, *Turing the Postal System into a Generic Digital Communication Mechanism*, ACM SIGCOMM 2004.