This is a pre-print version of the webtext published in Kairos: Rhetoric, Technology, Pedagogy, 17(3), available at http://kairos.technorhetoric.net/17.3/topoi/walton

# Bridges & Barriers to Development: Communication Modes, Media, & Devices

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Technology has been associated with development (defined as efforts to improve the well-being of people in resource-constrained environments) since the birth of international development in the 1940s (Truman, 1949). More recently, digital communication technologies have been playing increasingly central roles in efforts to improve well-being, particularly within a subset of development called information and communication technology for development (ICTD).

Drawn from a four-month field study of seven ICTD projects in India, this web text reports a subset of findings about how communication modes, media, and devices affected the ability of projects to meet their development goals, such as improving the livelihoods of subsistence farmers. This research identified (1) communication-related factors that contributed positively (i.e., bridges) and negatively (i.e., barriers) to meeting development goals and (2) interrelations among those bridges and barriers. One important finding of this research is that some communication-related bridges to meeting development goals also exacerbate barriers to meeting those goals. This finding correlates with work in complex systems, which shows that in complex systems desired outcomes may directly compete with other, equally important goals or even directly contribute to negative outcomes (Churchman, 1968; Davenport, 1997). In other words, ICTD environments are complex enough that pursuing one aim—such as increased geographical reach—can directly lead to challenges—such as increased difficulty in identifying and conveying information that is relevant to stakeholders.

To convey communication contexts and constraints of ICTD projects, each page following the homepage conveys a communication scenario using a multimodal communication strategy: illustration (background image) and text (description in a yellow box on the right side of the screen). Because language and literacy pose a significant barrier to communication in the context of study, the Methods section conveys the first sentence in the Indian language Kannada with an English translation available as an audio file and in a pop-up box when you rollover the Kannada script. The primary navigation (the ”Next” arrow at the top right) will step you serially through the web text. To skip from section to section, you can use the secondary navigation at the bottom left. A PDF of this web text is available at the bottom of the references list.

## Framing

Information and Communication Technology for Development (ICTD) involves using ICTs as central components of efforts to improve the lives of people in resource-constrained environments, particularly in developing countries (Brewer et al., 2005). ICTD projects face a number of challenges to achieving development goals, but careful selection of communication modes, media, and devices can play an important role in mitigating some of those challenges. For example, where human capacity is limited, ICTs can amplify that capacity. If there are insufficient numbers of agricultural extension officers to visit villages and consult with subsistence farmers, for example, ICTs could amplify the reach of agricultural extension officers through SMS messages, video demonstrations, and computerized records of local farm histories. However, ICTs are not a silver bullet for meeting development goals such as improving

farmer livelihoods. The research presented in this web text identified communication-related bridges *and* barriers to achieving development goals.

## Information and Communication Technology for Development

ICTD projects often involve using ICTs such as mobile phones, computers, and various digital media to communicate technical information like agricultural procedures or healthcare information to local stakeholders. Thus, ICTD projects involve challenges familiar to technical communicators, such as selecting communication modes based on usage environment and stakeholder capacities and crafting rhetorically effective information products that affect people's decisions and behavior. Technical communication scholars have examined the roles that culture plays in effective technology-mediated communication, particularly in how people design, perceive, use, and interpret technology-mediated communication (Ding, 2009; McCool, 2006; St. Amant, 2002; Sun, 2001; Sun, 2006; Thatcher, 2012). Selecting appropriate communication strategies for a particular rhetorical situation is complicated by not only local and organizational contexts but also by larger cultural contexts (Thatcher, 2006). In ICTD environments, the considerations for selecting appropriate communication modes, media, and devices are further complicated by constraints in human capacities like technology skills and infrastructure such as electrical power.

Within ICTD, "amplification" has emerged as a key concept in vigorous scholarly debates about the role and value of technology in development work (see Donner & Escobari, 2010; Donner & Tellez, 2008; Toyama, 2011). Proponents argue that technology amplifies human capacity. If human intent is positive and institutional capacity is present, technology has the potential to magnify positive outcomes and existing institutional impacts (Toyama, 2011). In considering patterns of communication-related bridges and barriers to development goals, Toyama's theory of technology as amplifier (2011) provides a productive interpretive framework. This theory posits that technology can be a useful tool for meeting development goals only in contexts with preexisting positive capacities: i.e., technology amplifies existing capacity but cannot fill capacity gaps (Toyama, 2011). Addressing the relation of human capacity to technology, new media scholars DiMaggio and Hargittai have urged scholars to explore how desired outcomes relate to the usage of technologies (2001), and recent work by Pan et al. (2011) introduces a conceptual structure useful for identifying relationships among ICT users' desires, their capacity for technology usage, and their access to the necessary resources.

Much ICTD research describes practical, applied case studies, so there is comparatively little research identifying patterns across case studies. However, the widespread failure of ICTD projects to meet their development goals has established the need for a better understanding of ICTD environments (Brand & Schwittay, 2006; Heeks, 2002; Toyama, 2011).There is a growing body of literature describing ICT usage and online behavior in developing and transitioning regions (Chen et al., 2010; Donner & Tellez, 2008; Dwivedi, Khan, & Papazafeiropoulou, 2006; Islam & Islam, 2007; Johnson et al., 2011; Mwesige, 2004; Pan et al., 2011; Ratan et al., 2009; Walton et al., 2009; Wyche et al., 2010). But few studies examine the role and effects of communication modes and media in developing regions (Parikh & Ghosh, 2006), though many ICTD projects have employed multimodal and/or multimedia communication strategies (Cetin, Plauche, & Nallasamy, 2008; Findlater, Balakrishnan, & Toyama, 2009; Kumar, Agarwal & Manwani, 2010; Parikh et al., 2006).

## Communication Modes, Media, & Devices

Considered altogether, communication modes, media, and devices address the production, dissemination, representation, and accessing of information. But these communication terms—mode, medium, device—can be difficult to untangle from each other and distinctly define (Lauer, 2012). One reason for this difficulty is that scholars from a variety of fields share a single term, such as

"multimodality," with each discourse community defining it differently. For example, Raisamo (1999) describes a human-centered view of modality, influenced by psychology, which focuses on input and output modes driven by human sensory systems: e.g., visual mode, auditory mode, tactile mode (Silbernagel, 1979). In computer science, a multimodal computer interface is one that accepts and combines input from multiple machine-facilitated stimuli such as mouse clicks and speech recognition (Chatty, 1994). In composition studies, multimodality involves intentionally and strategically using "all available means of persuasion and communication," such as text, still and moving images, and audio information (Cynthia Selfe quoted in Lauer, 2012). Seminal communication scholar Gunther Kress' definition of mode informs this web text: "Mode is a socially shaped and culturally given semiotic resource for making meaning. Image, writing, layout, music, gesture, speech, moving image, soundtrack, and 3D objects are examples of modes used in representation and communication" (2010, 79). By this definition, a magazine article that includes text, layout, and images would be multimodal, as would face-to-face communication involving spoken words, facial expressions, and body gestures.

Kress (2010) describes several factors shaping the modern media landscape, including the "convergence of representational, productive, and communicational functions in technologies and devices" (p22). This convergence has resulted in murky distinctions between media and devices. For example, Selfe distinguishes between medium and mode but equates medium with the device of dissemination: "Medium is the delivery mechanism. Modality is the semiotic channel that we use to communicate. So the medium is the computer, the television, the radio. For me, that's how I distinguish it" (Lauer, 2012). However, when addressing ICTD contexts, it can be useful to distinguish between digital and non-digital communication broadly and also to address issues of communication hardware more specifically. This distinction can be productive because communication-related barriers to development goals operate at different levels: e.g., limited literacy among stakeholders (which affects mode), lack of access to electricity (which affects media), limited skillsets (which affect device). Therefore, in this web text, media refers to the broader category of dissemination (digital versus non-digital), whereas device (e.g., mobile phone or computer) is a more specific component of digital media dissemination. Within a single ICTD project, a range of multiple communication channels may be necessary to facilitate communication. An ICTD project may employ a variety of communication strategies (e.g., online portal, SMS message, human mediator) with overlapping, redundant content to provide sufficient flexibility to make information available to a variety of stakeholders under a variety of conditions.

## Methodology

This web text reports a subset of findings from a four-month field study in India, exploring the transition of seven ICTD projects from research to implementation. The overarching research question guiding the larger exploratory study was, "Which elements are important to transitioning ICTD projects from research to implementation?" For ICTD projects to successfully transition into long-term implementation, it is centrally important for projects to continue to meet their development goals (for example, improving farmer livelihoods). This web text reports a subset of the study's research findings, addressing the question, "In what ways do communication modes, media, and devices affect ICTD projects' ability to meet development goals?"

### Projects

ICTD projects were selected using the following inclusion criteria: (1) project was led by a professional researcher; (2) project began as exploratory research with the intention to transition successful findings into implementation; (3) project occurred in India. In addition to meeting these inclusion criteria, the

projects shared a few other characteristics. For example, all projects were led by a researcher who was knowledgeable and experienced in ICTD, Indian culture, or both; all projects incorporated some aspects of user-centered design, such as user testing of pilot approaches; and all projects included partner organizations, such as nonprofit or government organizations with expertise in the domain area (such as education or agriculture). The projects and their development goals are briefly described below:

1. **Project 1:** An academic researcher at an Indian university led a project to provide customized advice to farmers using technologies including digital photography and databases. The development goal was to improve farmer livelihoods by increasing their crop yield. The exploratory pilot research investigated whether agricultural experts could provide customized, accurate advice to farmers based on records of a farm's history, digital photos of crops, and weekly information forms. After an extensive and successful pilot effort, the project sought to transition into a long-term implementation through a start-up company that would charge farmers a fee to continue to receive customized advice. At the conclusion of this study, the project leaders were also exploring the possibility of partnerships with other organizations offering services relevant to farmers.

2. **Project 2:** An industry researcher at a corporate research lab led a project to connect domestic workers with employment opportunities through a job-matching website. This project's development goal was to meet a user-identified need by increasing domestic workers' awareness of and access to employment opportunities, providing information that would enable them to select jobs based on factors important to them such as location and pay. Stakeholders engaged in a year-long pilot effort that exposed the complexities of establishing relationships and procedures among stakeholders such as potential employers seeking trustworthy domestic help, domestic workers seeking fair treatment and compensation, a local nonprofit organization seeking to unionize workers, and researchers seeking to design and test computer interfaces for semi-literate users. After the year-long pilot, the project ended because of the extensive infrastructure and resources that would be necessary to sustain the project.

3. **Project 3:** An academic researcher at a U.S. university led a project to use mobile phone-based games to support literacy education. The development goal of this project expanded over time from the narrower and more straightforward goal of developing a single technology application to support education to the broader, long-term development goal of helping to develop an educational "ecosystem" around mobile technology. This project began as exploratory research into the ways that ICTs might appropriately mitigate barriers to literacy education. The project expanded over time into a formal research group that develops and tests culturally appropriate mobile phone games that coordinate with English literacy curriculum in Indian schools. At the conclusion of this study, the project leader was exploring the possibility of long-term implementation through the founding of a nonprofit organization in India.

4. **Project 4:** An academic researcher at an Indian university led a project to develop locally designed and manufactured ICT hardware and software that could be customized for a variety of user-identified purposes. The development goal was to increase the use of information technology across the broader population in India by producing a device appropriate for local users and contexts (e.g., low power usage, capable of displaying Indian language characters, etc.). The early exploratory work involved investigating a range of needs that a portable computing device could meet for Indian users and then designing flexible hardware and open-source software. The project leader founded a start-up company to market and sell the device, and a larger company eventually bought the start-up. At the conclusion of this study, the larger

company had employed many of the original team members, who were designing modified versions of the device for specific uses (rather than the originally envisioned general-use device).

5. **Project 5:** An academic researcher at a U.S. university led a project to support microfinance groups by developing a method to combine paper and electronic recordkeeping. The development goal was initially to develop technology to help microfinance groups to better meet their own development goals (i.e., to do what they do better), but because the technology was so flexible, the development goal expanded to support a range of nonprofit organizations' development goals through customized technology applications and IT support. The exploratory work involved exploring how mobile phones could be used to capture data from paper records and wirelessly transfer the data to a database. The long-term implementation involved handing off the technology to a start-up company that offered technology services to nonprofit organizations.

6. **Project 6:** An industry researcher at a corporate research lab led a project to use locally filmed digital videos to supplement and improve existing farmer-training programs. The initial development goal was to improve farmer livelihoods by increasing subsistence farmers' adoption of agricultural techniques taught in existing training programs. The exploratory research involved incorporating locally produced demonstration videos into a single nonprofit organization's existing training, with a focus on increasing adoption of the agricultural techniques being demonstrated. The long-term implementation strategy was to found a new nonprofit organization with a greater geographical reach to support the slightly broader development goal of appropriately using technology to improve farmer livelihoods.

7. **Project 7:** An academic researcher at an Indian university led a project to answer agriculture questions online. The development goal was to make available appropriate, credible, accurate information for Indian farmers who had specific agricultural questions. The exploratory work involved setting up an online forum, partnering with region-specific agricultural experts employed by the Indian government's agricultural extension program, and facilitating technology-mediated communication between farmers and agricultural experts. To support a long-term implementation, the project went through the university's business incubation program and then launched as a start-up company.

## Data Collection & Analysis

Data collection occurred onsite in India from October 2009 through January 2010, primarily through semi-structured interviews with 44 project stakeholders. The stakeholders informing this research study are grouped into four categories:

- **Project Leaders**: These stakeholders envisioned the project from the beginning and spearheaded the early, exploratory research efforts.

- **Project Team Members**: These stakeholders were involved in the early research, working under the project leader in areas such as technology design, field testing, or partnership development.

- **Intended Beneficiaries**: These stakeholders represented people who were intended to benefit from the project: for example, subsistence farmers who sought increased yields.

- **Members of Partner Organizations**: These stakeholders belonged to government organizations or NGOs relevant to the development domain. Their role involved liaising with intended beneficiaries, providing domain expertise, or funding the project.

The number of stakeholders involved in each project varied, depending on factors such as the current state of the project, the geographic scale, and the level of involvement by original project leaders. To balance the effect of each project on the overall patterns of outcomes, I sought to interview a comparable number of stakeholders for each project and to speak with stakeholders in a variety of roles. I conducted formal, semi-structured interviews with 5-8 stakeholders for six projects. For the seventh project, I conducted formal semi-structured interviews with the three project stakeholders who were centrally involved in the early research and transition efforts. I interviewed every project's leader, as well as the stakeholders who were most heavily involved in early research and transition efforts. These stakeholders included (1) project team members involved with technology design and research and (2) members of partner organizations that played a variety of roles, such as liaison with intended beneficiaries, subject matter expert in the development domain, and funding agency. For two projects, I also interviewed intended beneficiaries who were involved in the early pilot research.

Stakeholder quotes are labeled by role in the Findings section to help clarify the participant's perspective, but roles were not always exact or easy to determine. For example, one project had two leaders at the time of the interviews because they were in the process of transitioning leadership from the project's founder to a former team member. Other stakeholders seemed to straddle the line between team member and member of a partner organization because of the influential and dedicated role they played in their respective ICTD project, and some stakeholders originally had more in common with potential beneficiaries but became team members of an ICTD project. When roles were potentially murky, stakeholders were labeled based on their own description of their role in the project.

Participants were recruited through snowball sampling, a recruitment method in which participants refer the researcher to additional participants. This recruitment strategy is particularly appropriate for building upon existing trust and relationships in social networks. Snowball sampling also proved useful for reaching non-English-speaking participants. These participants were contacted directly through members of their social networks, who also served as interpreters during interviews.

Interview topics included the role of the participant, the goal of the project, project scope, and the transition of the project from exploratory pilot research to long-term implementation on the ground—identifying changes, surprises, and successes related to project transitions. Interviews ranged from almost ninety minutes to twenty minutes, often depending on how centrally the participant had been involved with the project. Interviews were documented through digital audio recordings and typed notes; notes were fleshed out shortly after interviews.

The subset of findings reported in this web text was identified through iterative formal coding of interview notes and transcripts to identify patterns of meaning. The first round of coding noted all direct and indirect mention of communication strategies relevant to a project's development goal, including modalities such as written text, digital or non-digital media, or communication devices such as mobile phones. During this first round of coding, I created memos to note potential patterns and relationships among these patterns. Based on iterative review of these memos and the data culled in the first round of coding, I developed the following coding structure for more finely grained analysis:

- Amplification: Communication strategies that enable project amplification (e.g., amplification of reach, impact, scope)

- Digital and Non-Digital Media: Communication strategies involving combinations of new and old media
- Appropriate Technology: Suitable fit of communication technology with users and/or their environments
- Customization Requirements: Tensions related to communicating information that is appropriate, useful, or actionable for the full range of stakeholders
- Language & Literacy Constraints: Ways that language and literacy limit or impede communication
- Limited Skills & Participation: Constraints upon communication strategies related to stakeholder skillsets or participation
- Equipment & Infrastructure Constraints: Environmental hindrances to communication

It is constructive to group these codes into two major groups: The first three codes are "bridges," which have primarily positive effects on efforts to meet development goals, and the next four are "barriers," which impede development goals. The bridges and barriers and their relationships are discussed in detail in the Findings section.

## Findings

Communication-related bridges and barriers to development goals emerged in all seven projects. Figure 1 shows the complexity of interrelations among the three bridges (symbolized by the black bridge icons) and four barriers (symbolized by brick wall icons) that emerged from the data.

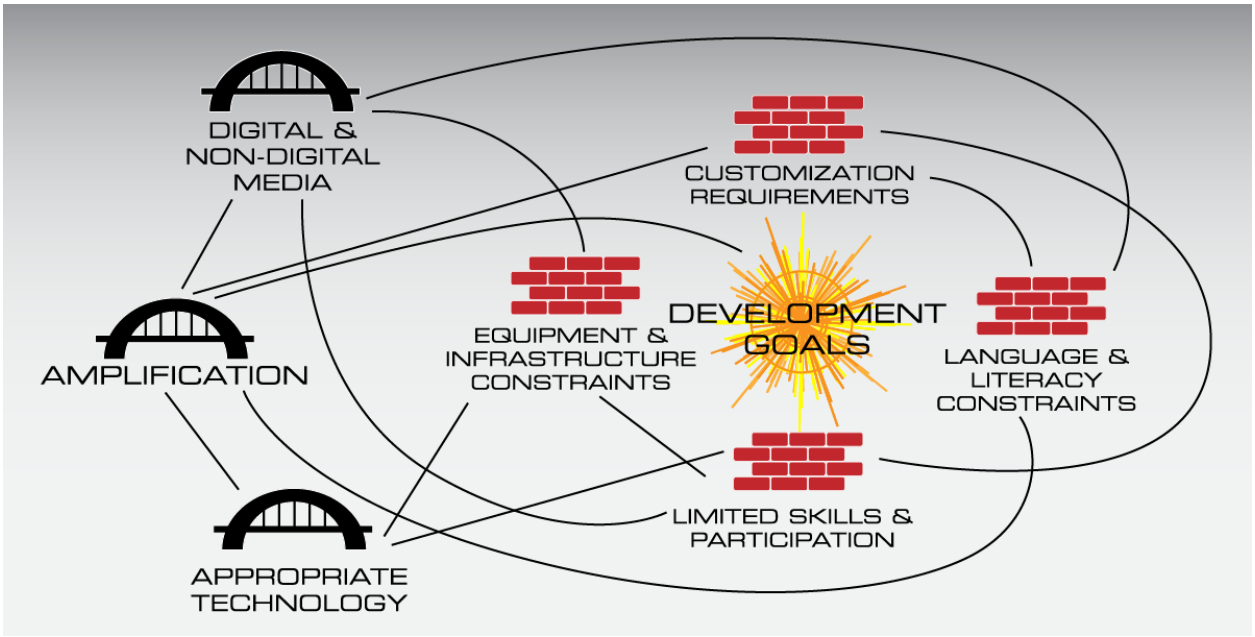


**Figure 1:** Relationships among barriers and bridges to development goals

**Language & Literacy Constraints (Barrier)**

Language and literacy constraints formed barriers to meeting development goals for several projects. Facilitating development goals like improved farmer livelihoods required that project stakeholders share a highly contextualized understanding of language:

> "That is a kind of limitation because fortunately or unfortunately in India we speak so many regional languages. So for example a farmer in [one Indian location] asks a question using some regional word about a pest or a disease or a plant. Then an expert sitting in [another Indian location] may not be able to get the correct interpretation, what in particular the farmer has in his own mind. So that becomes a bit difficult for us to exactly answer his particular question." (Member of partner organization)

To mitigate this barrier, the project team recruited partner organizations from several regions of India to bring region-specific knowledge in both agriculture and language. But localized language capability is difficult to maintain with the broad geographical coverage enabled by the Internet:

> "When we started, our entire focus was on [the Indian state of] Maharashtra because farmers are not comfortable with English. So we said let's have a portal in their regional language so they would be able to understand the content in a much better way. So originally when we started we thought it could be Maharashtra, so we focused on some specific parts of Maharashtra. But later on we realized that questions started coming in from the neighboring states, people started using English, and then we decided, we realized that being an Internet-based activity, there was no reason for restricting ourselves to one particular state… The Internet can be accessed anywhere and everywhere in the world, so people can send the question and view it." (Member of partner organization)

In the above quote, we see that technology's ability to amplify geographic reach had the initially unintended consequence of attracting new project stakeholders outside the intended area of focus—a positive consequence for the development goal of improving farmer access to agricultural information. Because the agricultural portal was available online, farmers from regions outside of Maharashtra could post questions. However, India is an incredibly linguistically diverse nation with more than 150 languages (Katzner, 2002). Therefore, amplified geographical reach led to language challenges:

> "We incorporate mother tongue, but every time we move to a new locality, it requires whole new voiceovers, and you are developing new games with different voiceovers. We have written out words in Hindi right now, but they need to be in the mother tongue." (Team member)

> "Content [became difficult to convey] because there are so many languages across the country. And unless you make content in local languages, you're not going to reach people. Ten percent know English, right?" (Project leader)

> "India has a lot of local languages. We need to localize the content that we have based on the type of user and location. This is what we are looking at." (Team member)

Thus, human capacity to communicate through shared language was a challenge. But even when human capacity allowed for messages to be conveyed in local languages, technology-mediated communication posed challenges to conveying those messages:

> "Indian fonts are more complex, so you need a graphic display; text display will not work." (Project leader)

> "We tested a few things where users can send questions [using SMS]. That has limitations in characters. They are maybe illiterate, and that we cannot help. They would like local language, but the fonts are not available on all phones. There is no standard for which phones have local language. It was rarely used. Not many people were using it." (Team member)

Some projects avoided the challenge of communicating in local languages by using English, an approach which posed its own challenges due to limited English ability among stakeholders (particularly intended beneficiaries) and the international differences in how English is spoken:

> "Often in [project name], if someone asks a question in Hindi, it's answered in English. Just because the person can type in English doesn't mean he can understand English." (Project leader)

> "Initially we used American English voiceovers, and they couldn't understand. Without that the kids would not have understood what's going on." (Team member)

> "Sometimes language is a problem for them. They do not really understand the exact meaning of an English word like 'prediction.' They said, 'We did not get the meaning of "prediction."' So we started using simple English that they could completely understand, and there was feedback that they say, 'If we don't understand one or two words, but as a whole we can relate, then we can finally get the meaning of the message, or we go to someone who is learned and we ask them what exactly is the message' because what they can read is that it has come from [partner organization]. That they can read for sure. So without deleting they will go to somebody and ask what is the meaning of this particular word or what does this message mean." (Member of partner organization)

This last quote shows a great value of combining digital and non-digital media for mitigating some language constraints. A single, device-enabled message like an SMS has amplified reach, but a traditional communication approach like a face-to-face conversation with a member of one's social network enables better understanding. Combining new and old media, particularly digital media and in-person communication, can mitigate some language barriers and make use of the strengths of each medium.

Where human mediation may not be available, other strategies were necessary to mitigate barriers created by illiteracy or semi-literacy. India has a literacy rate of 74.04 percent, according to the 2011 Indian census. In the 2001 census, the literacy rate was significantly lower (64.84 percent), which is relevant to these findings, as several of the projects under study began in the early 2000s. Literacy required for interpretation of the textual mode (regardless of how those messages are conveyed) thus presented a barrier to achieving development goals for some project stakeholders. Mitigation strategies included replacing SMS messages with recorded voice messages, supplementing text-based computer and mobile phone interfaces with audio messages, and replacing text with icons or images. While audio supplementation proved useful, the effectiveness of image-based communication proved highly dependent on the communication message and situation:

> "You see, I'm doing sweeping. I can understand immediately a picture of someone doing sweeping. But if you have a doctor trying to say, 'Do you have a headache?' how do you say without the words? If you just point to your head, what are you saying?" (Intended beneficiary)

**Customization Requirements (Barrier)**

A communication-related barrier to meeting development goals was the need to customize information for stakeholders' needs. Technology-mediated texts like SMS or websites amplify the capacity of development projects by enabling messages to reach larger numbers of intended beneficiaries (a bridge). However, technology-mediated communication also amplifies the complexity of language and literacy demands (a barrier) and the difficulty of conveying specific, relevant information (a barrier). Disseminating general information was of limited value:

> "All these information disseminators are not serving farmers properly; they are providing certain kinds of information; but that information is unusable. Farmers say, 'We have a problem, and we can't use that information… To know what I should do, that information they are not giving.'" (Project leader)

> "We don't have specific information in response to crop or region. So since we don't have that, we send very general [information]. So we have people who call with more specific questions." (Team member)

> "At this point we were depending on video-based systems where we deliver [a] single speech and all over India are delivering it. So that is too generalized a system. So farmers should get their own advice; that is a personalized system. Personalized systems are difficult to build." (Project leader)

Matching actionable, relevant information to intended beneficiaries was a challenge for several reasons. Sometimes stakeholders had conflicting needs and capacities. For example, in the project that sought to connect domestic workers with potential employers, there was a mismatch between the skillsets desired by employers and the skills of the domestic workers. Employers sought information regarding available cooks, for example, but domestic workers sought job information regarding opportunities to provide basic cleaning or laundry services. But even when stakeholders desire the same type of information, their needs may conflict in other ways. For example, in the project to develop mobile phone-based literacy games, challenges arose in matching the level of difficulty to the varying levels of language capabilities across schools and across students:

> "With fifth graders, you are working with a huge bell curve of students. Ages range from nine to fifteen; the range of English knowledge is very widespread. It's not like they stay in the same school. There is so much more migration there, especially at the bottom of the pyramid." (Team member)

Other problems stemmed from the difficulty of identifying stakeholder information needs as the pool of stakeholders grew and their needs changed. For example, the agricultural projects aimed to provide farming tips relevant to farmers' current crop and season:

> "We are sending messages. We have to filter them so that the wheat farmer gets a wheat crop tip. Farmers change what they are growing." (Team member)

> "The technology is easy; collecting the right information is the hard part. So if you're growing wheat in an area which is otherwise growing rice, you want to be careful about those combinations. You can't generalize." (Project leader)

> "We need scientists who know the local phenomena perfectly. We can't tolerate any mistake here. Everything is typed; your name is typed. And everything is on record. We can't risk it." (Project leader)

The above quotes indicate the importance of conveying accurate, relevant information to meeting development goals. Inaccurate information could not only irrevocably damage project credibility with vital stakeholders like intended beneficiaries, but it could also directly oppose development goals: e.g., harm farmer livelihoods. Project members engaged in several strategies to mitigate the challenges of providing relevant information to intended beneficiaries. For example, the job-matching project expanded its scope to begin offering cooking instruction to the domestic workers involved in the project. It proved too challenging to identify and recruit potential employers who needed services in line with the domestic workers' current skill sets, so the project leader and partner organization arranged cooking training. This enabled the project to then convey desired information to both parties: potential employers could receive information about available cooks, and domestic workers could receive information about job opportunities they were qualified to pursue.

Other projects engaged strategies like (1) creating user profiles to enable a better match between information and user needs and (2) incorporating locally based human mediation to select and convey relevant information:

> "The answers must be very specific and pointed in their solution ability even if the question is not. That's tough. So how do you bridge the gap between the vagueness of the question and the requirement of the answer? You keep focused. You create a profile of the user and use the knowledge from the past to answer the question." (Project leader)

> "We are gathering information from sources which are national and statewide, but users want information that is regional. There are few small ideas about how to do this. In small regions, there are farming-related shops. We could give interface to people in the shops to post on [project name]. This would allow us to bring it into the scope." (Team member)

In the second quote above, we see a strategy that makes use of current routines and communication patterns (e.g., farmers visit their local agriculture shops) to develop a useful path to information. This example suggests one way that a combination of technology-mediated and in-person communication can mitigate barriers to conveying customized information.

**Equipment & Infrastructure Constraints (Barrier)**

Infrastructure gaps and lack of widespread access to ICTs created communication-related barriers to meeting development goals. The projects that began in the late 1990s or early 2000s experienced the most extreme limitations:

> "So the first realization was technology has not reached 90-plus percentage of India at that time-- 1998. It's a lot different now. In '97-'98, mobile phones were few and far between; mobile phones were unheard of and so in that context computers were one percent of population had knowledge of them. So thing was, computers were not benefiting the vast majority of India." (Project leader)

> "Historical context of [project name] is that when we started, cell phones in India, they were very expensive. It was unaffordable for people to buy a cell. Even a landline phone was a luxury 40-50 years ago. I remember on the street I lived there were 3 phones in 50 families, maybe 30 years back. There were no other phones." (Team member)

The use of mobile phones proliferated over time, but infrastructure gaps, particularly inconsistent electrical power, continued to pose challenges:

> "At any time you try to reach remote areas, the main problem is infrastructure. There is a power issue. When the test was done, there was no phone line. There was no power for 7-8 hours." (Team member)

> "You cannot assume they will have power. So you need a low power device; it cannot be a power guzzler." (Project leader)

The second quote points to a connection between this barrier (equipment access and infrastructure gaps) and a mitigating bridge: appropriate technology. Using low power devices, intermittently connected devices, or applications that run on minimum bandwidth can mitigate some access-related barriers. Several project leaders said that the communication strategies employed in their project were driven by local constraints, which eliminated several possibilities they had initially tested:

> "It was a lot about just trying to understand how things actually work on the ground, what are some of the main local conditions. We experimented with all kinds of ideas for education technology interventions, and as we started experimenting, we realized that a lot of these ideas cannot work." (Project leader)

A participant associated with one of the agricultural projects said that in more population-dense areas with regularly scheduled power outages, they used televisions to show agricultural training videos. Village farmers could easily congregate at a single location, and the outage hours could be avoided. But then the project expanded to less population-dense areas, where the closest available electricity was 5-10 kilometers away. To show agricultural training videos in these communities, project members experimented with several technologies, including battery-powered televisions and Pico projectors:

> "So what we've now moved to these Pico projectors, which are these handheld types of projectors that have onboard batteries which have extra loud speakers which can be loaded with SD cards, very portable, can be compact and protected from some of the rain water and dust types of issues that can often plague these DVD readers and TV CRT tubes. And so we've kind of adapted in this sort of iterative way." (Project leader)

This iterative design strategy proved useful for several projects to mitigate access-related barriers to development goals. For example, several projects that initially used computers to convey information shifted to mobile phones because of dwindling access to computers as Internet kiosks closed down:

> "PCs are not that widespread, not among the users we are targeting if you look at targeting people in rural areas." (Team member)

> "The number of kiosks has almost gone down to zero in the pilot [area]." (Project leader)

> "The pilot kiosks have dwindled to zero, but across the country they still continue. What happened was the client base [couldn't support the kiosks]." (Project leader)

**Limited Skills & Participation (Barrier)**

Limited stakeholder skills and participation formed communication-related barriers to meeting development goals. Interestingly, some participants described contexts in which technology access was less of a barrier than the skills to use technologies:

> "I must confess that all the schools have computers. Having said that, we must create a method by which they know how to use the computers-- students and teachers. This is a major concern with ICT." (Member of partner organization)

> "Even though you may have the communication technology, still it has to be used by human resource. So that human resource itself was a very limiting factor. And to first of all train them and then for them to understand this whole idea and to be able to use it and then also to evaluate what are the impacts." (Member of partner organization)

Although training sufficient numbers of stakeholders was a challenge in some projects, training was the most common strategy for mitigating the barrier of insufficient skills:

> "We have a whole cadre of farmers called animators, so they had to be trained in handling the equipments, both playing the video as well as making the videos, and then the storyboards. Things like this they were trained in. But we had some issues of scaling it up." (Member of partner organization)

> "We were look at educating farmers on using Internet, but other partners are doing that. They focus on this part. We have some workshops in rural areas and meet farmers and tell about the project and how they can benefit and help them get familiar with the system." (Team member)

> "So all of it, almost all of it requires some element of customization, training, technical support, especially for these NGOs that don't have in-house capacity." (Project leader)

Other responses to the barrier of insufficient technology skills included

- **Accepting limited skills as a factor outside the project scope:** "Some farmers are not literate, to go to Internet and type something. That is a problem. The farmers say they are not used to this technology. This is not in scope of our project. We provide things to them." (Team member)
- **Recruiting more technology-savvy partner organizations:** "It sounds pretty naïve that the coordinator would actually pull up an Excel sheet with information that could put employers and employees together. But I mean, who is going to handle the database? The NGO itself does not do much technology. They do not have the technology expertise to handle a computer-based system, so you will have to bring another stakeholder: a bigger NGO for better things, a technology company or organization." (Project leader)
- **Increasing efforts to develop appropriate technology:** "It [the project's device-mediated communication] should be so simple that it can be used by any farmer. It should be accepted by the farmer. They are very reluctant to use technology; they will not even touch the computer, but slowly they are learning. The basic idea is to give technology and the benefits of technology." (Team member)

The above quote about designing technology that "can be used by any farmer" illustrates one way that the communication-related bridge appropriate technology can mitigate the barrier of human capacity.

Although limited skillsets impeded stakeholders from engaging in some technology-mediated communication, skills were not the only limiting human factor. Communication strategies also affected stakeholder participation, often posing a barrier to project development goals. For example, device-specific communication that required intended beneficiaries to travel to a particular location, such as an Internet kiosk, posed a barrier to participation for some stakeholders:

> "[The] kiosk model will not work, so we have to bring information to the farmer itself. Very few people want to go there [to the Internet kiosk] and put it [i.e., post a question], we found in a survey." (Team member)

Participation was also impeded when stakeholders did not find a particular communication approach to be engaging:

> "There is a downside to the Pico projectors, which is that they're not very bright. So they're not entirely engaging to like a population that might have lots of TV penetration. So in an area like here in [Indian location] where there is higher TV penetration, then they're going to compare the picture quality to what they watch regularly. They're not going to be excited. So in that case where anyway you have the infrastructure, you can continue with the TV/DVD player. But in a place where people have maybe never seen a TV or cinema in the past, where this is like the first projection screen that's been shown, then that case we've found that it's highly useful." (Project leader)

> "As a teacher, I have 32 years in experience, but in a class I cannot convince them by my words, but I can use ICT to explain more convincingly. These photos will impress and be more memorable." (Team member)

The quotes above show an interesting connection among participation, infrastructure, and appropriate technology. Technology is appropriate not only when it accommodates infrastructure gaps but also when it is engaging for stakeholders.

Stakeholder participation may also suffer when stakeholders are unsure whether they can trust the validity of the information they receive through a particular communication channel. For example, the participation of farmers in the technology-mediated agricultural projects required that that those farmers be able to judge the quality of the information they received:

> "To ensure the quality of the answers, what we have done is when the certified experts answer, off to the side of the answers there is a logo saying this is an answer that is coming from a certified expert. So a farmer knows that this answer comes from an expert and this answer comes from a farmer. So it is up to him whether to accept someone's suggestion or not. He is free to choose what he feels like choosing. Secondly, we feel that farmers also have their own indigenous source of knowledge. They have found some very local or simple ways of solving a particular problem in their own field. And there is no reason why we should not bring his particular wisdom and knowledge onto the portal... We said let everybody get a chance to share his own ideas, but farmers should be able to differentiate between advice given by an expert and by a farmer." (Member of partner organization)

> "We were thinking we would have the experts recorded in their own voice, with a mail attached to it, to help farmers see it as more credible." (Project leader)

Because digital media amplified project reach (i.e., enabling large numbers of stakeholders to post and to answer questions) that digital media also complicated stakeholders' ability to judge the validity of information. With non-digital communication like in-person conversations, farmers would have cues regarding an adviser's credibility, cues that draw upon cultural, social, and contextual details that are masked or eliminated in online communication. For example, when engaging in face-to-face communication, farmers could gauge an adviser's age and could make better judgments regarding their social standing and social network connections. In a collectivist society like India (Hofstede, 2001), these factors are particularly important for framing communication. But because online documents like web portals mask many of these cues, the project team members created new cues that would aid farmers in judging the credibility of advisers and, therefore, the advice they post.

A final point related to the effects of communication on participation is that stakeholders must find a particular communication strategy to be appropriate for the information context. The quotes below indicate the reluctance of some potential stakeholders to participate in projects because they do not find the communication strategy to be appropriate for the information context. For example, educational content developers hesitated to produce material for mobile platforms because they are not sure that mobile phones are suitable learning devices:

> "I think the challenge is that a lot of these guys are targeting the desktop computer and not mobile phone because they have some reservations about trying to move to the mobile platform. That represents a major shift for them in terms of the expertise they need to develop for learning, and they are not even sure that mobile learning will work. For us the challenge is about trying to grow that whole ecosystem such that people actually see mobile learning as a viable space to be working in." (Project leader)

Similarly, potential employers had little incentive to change their culturally ingrained way of seeking domestic help (i.e., through social networks) and did not find a website to be an appropriate or natural communication channel for achieving their aim:

> "For an employer to get an employee, the part-time workers are got through a social network: the watchman, the neighbors. I will not go to a special site. In India we have a social network that is the way in which people get their workers." (Member of partner organization)

This finding further complicates what "appropriate technology" means: not only usable by stakeholders and able to function in the physical environment but also supporting them in culturally appropriate ways to achieve their own aims.

**Digital and Non-Digital Media (Bridge)**

One communication-related bridge to achieving development goals was using a combination of digital and non-digital communication media. One common communication strategy was using human mediation to supplement digital media:

> "If the farmer is educated, he can log in and do this [engage with agricultural experts online]; if he is uneducated, he can go through a coordinator. They would meet together at the franchise office to use the computer there." (Team member)

> "Without mediation, it [a video illustrating how to perform an agricultural technique] is shown to farmers, and they think it is just a movie-- no impact. If it is mediated, we can clarify doubts farmers have. Even now we need clarification, like if we show medicinal prep, he will ask how to dilute it. This clarification needs to be given by a mediator." (Team member)

The above examples illustrate the value of human mediation for eliminating barriers caused by limited skillsets (the first quote) and the need for customized, relevant information (the second quote). These quotes show how human mediation benefited direct stakeholders (i.e., people directly involved with an ICTD project). In-person communication also supported development goals by extending the reach of information to indirect project stakeholders. Though not directly connected to the project, indirect stakeholders learned from direct project stakeholders who were members of their social network:

> "Information [is] passing from one person to another; there are many ways. This is cost effective. Without much effort from the organization, it can be dispersed to many people." (Team member)

> "When they [students who play mobile-based literacy games] interact with other students, they can be a bridge for [project name]: 'Hey, we have done this great spelling.'" (Member of partner organization)

> "Sometimes what happens is when you provide advice to a farmer in the field, then if the neighboring farmer is also doing the same crop, he can always ask the neighboring farmer what to do, so he can simply take that advice, and he becomes a tutor." (Member of partner organization)

When direct project stakeholders evangelized for a project to members of their social networks, sometimes those indirect stakeholders applied new knowledge without necessarily becoming directly involved with the ICTD project, as indicated in the quotes above, and sometimes they were recruited to direct project involvement. Thus, in-person communication supplemented and supported digital media through recruitment. The success of this strategy corroborates research in distributed teams, which emphasizes the value of initial face-to-face communications to set the stage for successful distributed relationships (Baskerville & Nandhakumar, 2007; Olson & Olson, 2000). Face-to-face communication proved important for recruiting a variety of stakeholder types, including intended beneficiaries and partner organizations:

> "Some partners actually came to our location here in [Indian location] to actually see the system in operation for themselves… They came out here largely to interact with our partner so that they could on a partner-to-partner level interact and say, 'What kind of operations were you guys running before? What kind of value did you see? How well did you guys integrate together?'…Some of it was face-to-face meetings about giving presentations about our research because a lot of the partners were interested in that aspect, about having a clear idea about how this system was set up, what system existed before, and what was the new aspect that was introduced, and what was the inputs provided and what were the outputs. This could be spelled out relatively clearly; then they were relatively receptive." (Project leader)

> "We are moving into China and Kenya because there were local academics there who saw a [project name] presentation at conferences. And they thought this would actually work for them in their own respective regions. So that was how they actually contacted me and asked if we could work together." (Project leader)

> "We do have conversations about promoting our services. The farmers have some mobile phones, so promoting services through SMS and voice. Another could be agriculture fairs and promoting at a stall and distributing pamphlets. And if we know friends who are related to farmers, we can promote." (Team member)

The first two quotes above by leaders of different ICTD projects illustrate the value of in-person presentations for recruiting potential partner organizations like NGOs. The second quote is particularly interesting because it illustrates that, for one project, this outcome (recruiting new partners) was an unanticipated benefit of presenting positive project outcomes at conferences. The third quote identifies a range of ways that another project recruited intended beneficiaries. While voice and SMS messages played a role, in-person communication at public venues like agricultural fairs and through personal connections with farmers played an important role as well. Another common recruiting method that project team members used for recruiting intended beneficiaries was going door to door in apartment complexes, city slums, and rural villages, talking to people about the project.

The above examples show how a combination of digital and non-digital communication can increase the reach of ICTD projects to new stakeholders (whether indirect or newly recruited). Combining new and old communication approaches is also useful for increasing the capacity for information access among existing stakeholders. This strategy creates multiple paths to the same information—for example, SMS messages, paper reports, and human intermediaries. Providing multiple paths to the same information has benefits identified in literature on planning for flexible operations (Suchman, 2007). As Suchman describes, every detail of an interaction—particularly human-machine interaction—cannot be anticipated in enough detail to identify all possible paths and outcomes. Thus, flexible planning which focuses on error recovery is often more beneficial than attempting to anticipate and plan for every possible outcome (Suchman, 2007). This approach to planning is ideal for ICTD environments, which are so dynamic that multiple communication channels are often necessary to provide flexibility in information paths:

> "It [agricultural information] goes through SMS. It can go through printout. We are also trying to add the voice connection now." (Project leader)

> "Initially [the primary communication channel] was web, but if we want to get more farmers in, let's try SMS based on the number of mobiles verses PCs. Then SMS had limitations that we could not address; we could not help that. Then we thought let's do voice. That is old; let us bring it back." (Team member)

> "I think a combination of Internet, mobile, and offline is best of all worlds." (Project leader)

The above quotes from stakeholders of three projects illustrate that offering multiple paths to the same information was a common strategy among projects to meet development goals.

**Amplification (Bridge)**

Technology's effect as an amplifier of human intent and capacity emerged as a clear bridge to achieving project development goals. Certain modes such as video amplified the ability of projects to clearly convey development-related information such as agricultural processes (first quote) and educational content (second quote):

> "In a slide show we can't show the whole process, only photos. By photos they [farmers] can't understand; by video they can understand. This makes a big difference... Like compost, only one or two people would adopt. After seeing video, many people adopted for themselves." (Member of partner organization)

> "Blackboard and chalk is the key tool. Once you come out of the class, you have done the operation. But these additional programs with [project name] are a major add-on material for better understanding." (Member of partner organization)

A particularly common theme of amplification was that the technology-mediated communication developed by project team members could be used by other organizations to support those organizations' development goals. In other words, partner organizations could do what they do better by adopting and adapting technology-mediated communication strategies. Quotes below from stakeholders of three projects illustrate this approach to amplification:

> "We thought these partners were doing good work, and our job was really to build tools to support those organizations' development goals or missions." (Project leader)

> "What we want to see is that there is other organizations that are able to take the aspects of this model and use it without having to overinvest especially upfront, because that's the largest struggle, and for them to realize the value as quickly as possible into the existing systems that they already have." (Project leader)

> "We are looking to create games that can support existing curriculum objectives, wherever they might be." (Team member)

Another common theme is that conveying messages through digital media amplified existing human capacity, allowing projects to engage with greater numbers of intended beneficiaries and to increase the productivity and reach of domain experts:

> "For each district, there is one [regional government organization] to support agriculture, people with expertise in this area. They do research and come up with practices about what people should do. They are covering a whole district, and a farmer may not want to come so far. The director is very enthusiastic. She said if you want to cover whole district, ecommunication is the only way." (Team member)

> "[Project name] worked with [partner organization] activities to quicken more coverage of farmers. Eight to ten people could cover 50-60 farmers, but with the TV we can over more than 100 in a day. More people will get benefit of whatever they are disseminating--more coverage." (Team member)

> "What we're also trying to do as the government is also trying to promote using information communication technology in agriculture. Because, you know, 60% of our population, more than 60% of our population is into agriculture. It is a big challenge how to reach this many number of farmers." (Member of partner organization)

One of the key ways that digital media amplified existing manpower was by reducing or eliminating travel. Travel has traditionally been a barrier for people in developing countries to receive information and services (Anderson et al., 2009), and transportation is becoming increasingly difficult, slow, and expensive in developing regions (Gakenheimer, 1999). Therefore, reducing the travel necessary for stakeholders to send and receive development-related information is an important bridge for meeting project goals:

> "So what we're really trying to do is transformative change by introducing new paradigms like using mobile technology to take school to the kids, rather than trying to get kids to go to school, which is really not feasible sometimes." (Project leader)

> "ICT can bridge that gap by bringing virtual farms to the lab, and professionals can look at variable situations in a single place at any day or time." (Team member)

> "In the future ICT will provide a big role in agriculture. It can only be delayed; it cannot be denied. Agriculture has not professionalized and formalized because of location. Plants cannot move; experts have to do [it] except that that constraint is addressed by ICTs." (Team member)

**Appropriate Technology (Bridge)**

Ensuring that technology was appropriate for stakeholders' lives was an important communication-related bridge to meeting development goals. One aspect of this appropriateness was how well technology usage fit into the current routines of project stakeholders—particularly intended beneficiaries. For example, when considering which features to build into a hardware device, project leaders and team members conducted field research and reflected on potential uses that built upon existing practice:

> "A postman would have a [project name device]. The postman could carry on a variety of transactions, and he is in touch with everybody often every day. He is a hub and can reach out to these people. In these villages, the men would go searching for jobs in nearby towns, and once a week they would send back money to their family. Middlemen would charge exorbitantly to carry it. We could do this through the postman for a small fee." (Team member)

> "We had a deal where a person has a smart card. All details about the family including health indicators would be on the card so if someone from the family wanted to visit the doctor, if the doctor is not in the local clinic, then people all queue up in front of the doctor's office. And what could be done is that the person puts his smart card in the postman's [project name device] and asks for an appointment at the doctor's office." (Team member)

In addition to providing benefit within the context of people's current routines, other projects pursued appropriate technology by leveraging existing hardware as much as possible—particularly mobile phones:

> "When we launched in 2003, the Internet we thought was going to boom through kiosks. It happened in the beginning, but then after that, the movement was replaced by mobile phones. And so it was a question of waiting for the Internet kiosks to catch up or capitalizing on the mobile cell phone momentum. Now the kiosks are slowly coming back, but still I think it will be a

> long way to catch up on the millions of new customers coming onboard with mobiles. So if we didn't do what we did for the mobile, we'd be lagging behind in the reach." (Project leader)
>
> "Now the cell phone is so common in the rural area, you know, like using that for a central location from where they can ask questions and get the answers back." (Member of partner organization)
>
> "We started with kiosks to let farmers directly interact, but to increase reach we need to use mobile technology and also the broad reach of the Internet." (Team member)
>
> "Earlier in 2004-2005, it was a time where mobile phones started coming… Then [project leader] realized that programming can be done and publications can be linked up with mobile phones. Then we found out that mobile phones will be reached soon to all the people. The penetration will be very high... Then we came up that we should focus on this application." (Member of partner organization)

Project technologists sought to leverage communication devices that were already available to many stakeholders, including intended beneficiaries. Particularly when mobile devices were paired with human mediation, this strategy created a bridge that mitigated barriers related to equipment access and the skills to use that equipment.

Another way that projects addressed the barrier of limited technology skills was to focus on making technology-mediated communication easy to use:

> "[My role in the project is] improving the GUI [graphic user interface], making it easier. Farmers who have a background with nothing related to technology, making them an interface that lets them think in their natural way. Putting the interface where whatever they want, they get in a single step." (Team member)
>
> "Changes come based on feedback from farmers. Farmers gave us feedback on how they want information in workshops and other places." (Team member)
>
> "People don't get one kind of learning. Different people learn in different ways. So we will put things in text, audio, video, so they can go with any of the possible things." (Team member)
>
> "You have to think of human-centered design and make sure they are comfortable with it. Children can take my phone and play the game with no instruction. That is powerful." (Team member)
>
> "Why TV? TV is the operating system. Computer is not suitable for farmers… TV level is a very popular instrument. Anyone can use and operate." (Member of partner organization)

Several strategies to making technology easy to use are described in the above quotes. Some projects employed hardware already used by stakeholders, hardware like mobile phones and televisions. Some projects offered several paths to the same information, enabling stakeholders to select whatever communication channel suited them and their environment. All seven projects conducted extensive user testing and invited feedback from stakeholders to enable iterative development. All of these efforts are strategies to mitigate communication-related barriers to development goals through the bridge of appropriate technology.

## Conclusions

This study has identified patterns regarding the effects of communication mode, medium, and device on ICTD projects' abilities to meet development goals. As discussed throughout the Findings subsections, communication-related bridges and barriers interrelate in complex ways, and not all of the effects of bridges are positive. In the complex system of ICTD, desired outcomes can directly compete, and achieving a positive effect can directly trigger negative effects. For example, particularly in India, amplifying the number of people who can be reached with development information (good) also amplifies the number of languages spoken by information recipients (bad, or at least more complicated). Reaching more people also complicates the ability to convey useful information. Intended beneficiaries seek specific, actionable information that will help them meet their own goals. If ICTD projects do not provide that, not only will projects lose stakeholders but, more importantly, projects will not meet development goals: i.e., people's wellbeing will not be improved. Therefore, this study has important implications for communicators working in ICTD environments: carefully weigh the tradeoffs involved in scaling up projects, particularly through technology-based communication modalities. Scalability is a widely sought criterion for success in ICTD (Heeks, 2008; Marais, 2011) for good reason: it amplifies the positive outcomes of the early exploratory work involved in designing an effective project. Thus, scalability should not be eliminated as a consideration in ICTD work but should be considered in light of these findings. Amplifying the reach of development information through technology-based modalities may be more likely to be effective where stakeholders (project team members, domain experts, and intended beneficiaries) share a single language and where beneficiaries seek similar information-- for example, regional market prices for agricultural goods or weather information.

Another implication for ICTD stakeholders, particularly for technical communicators working in resource-constrained environments, is the value and importance of human mediation. When working with stakeholders who lack technology skills and are members of collectivist cultures, human mediation can be an even more effective and appropriate bridge than training. From a Western, individualist standpoint, training provides an individual with skills to accomplish tasks. But in resource-constrained environments with collectivist cultures, communication devices are more likely to be shared among users (Parikh, 2006) and used less frequently (Walton, Yaaqoubi, & Kolko, 2012). Users may well forget training when they go for long periods without applying those skills. Therefore, mitigating limited stakeholder skills through human intermediaries is a promising communication-related bridge for supporting development goals. Further, digital media are better suited to displaying data than to generating knowledge (Davenport, 1997). (Knowledge is defined in this context as data that is contextualized and supports decision making, as per Davenport.) Digital media can play a useful role in compiling and conveying data, but human mediation is often necessary to change that data into knowledge that supports development goals. Although human mediation offers support for meeting development goals, it can be a resource-intensive strategy. However, not all mediation must be provided and coordinated by domain experts and project team members. This study found that when intended beneficiaries *did* benefit from the knowledge they gained, they often shared it through their social networks.

A final implication of this research for communicators working in resource-constrained environments is to focus on using appropriate communication technologies, with "appropriate" broadly defined to include not only environmental considerations like access to electricity but also human, social considerations like effects on willingness to participate. The relationship between communication strategy and stakeholder participation varies: some stakeholders found novel technologies engaging and appealing, but other stakeholders found novel technologies intimidating or unusable. Engaging with local stakeholders is an important strategy for identifying engaging, appropriate technology. One

consideration when deciding between novel versus established technologies is the availability of human mediation. Where human mediation is limited, using existing communication devices such as mobile phones, radios, or televisions can mitigate barriers related to limited skills and motivation. In addition, communication strategies that reduce or eliminate the need for physical travel offer important benefits in terms of increased productivity for domain experts and ability of intended beneficiaries to participate. In conclusion, communication modes, media, and devices had significant effects on ICTD projects' abilities to achieve development goals.

## Acknowledgements

The author would like to thank Tony Walton, Ashish Raj, and H.M. Basavaraj, who made such valuable contributions to the visual aspects of this webtext. The author also thanks the project stakeholders who participated in the research reported here, as well as the Microsoft Research Technology for Emerging Markets research group, M. Haselkorn, B. Kolko, C. Lee, and K. Toyama for their support of this work.

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