# ICT in India's elementary schools: The vision and realities

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*India aspires to emerge as the information and communication technology leader among the knowledge-based societies; it does so with the education of children as a primary concern. With the passage and enforcement of the* 2009 Right of Children to Free and Compulsory Education Act, *the Indian government has affirmed its commitment to ensuring universal elementary education for all Indian children. Part of India's rights to education commitment includes the vision of preparing Indian children with 21st century skills, such as learning to operate a computer. Yet, realities exist, including a lack of empirical research on Indian elementary schools, which impedes this vision. The purpose of this literature review is to examine the barriers to and possibilities for information and communication technology programs in India's elementary schools.*

*Keywords: educational technology, elementary education, India, information and communications technology (ICT), Right of Children to Free and Compulsory Education Act (RTE)*

## INTRODUCTION

Over the last decade India has increasingly become defined by two commitments: information and communication technology (ICT), and free and compulsory elementary schooling for all Indian children between 6 and 14 years old. Abroad, India is known for its commitment to ICT, Largely because of its innovative ICT industry, India has enjoyed a period of steady economic growth. Spurred on by the United Nations' Millennium Development Goals (MDGs), India also endeavours to provide a basic education to its children, who make up the largest (and fastest-growing) segment of India's billion plus population (UNESCO, 2009, 2010; World Bank, 2010). Today India aspires to emerge as the ICT leader among the knowledge-based societies and it does so with the education of children as a primary concern. Curiously, though, little is known about how India's commitments converge in the ways that Indian children use ICT in elementary schools. While India's policymakers often expect ICT to usher in promising education changes, there is a limited understanding of how that technology is used and negotiated at the beginning level of Indian schooling: the elementary school classroom. This article describes and reports on research around the vision and realities for ICT programs in India's elementary schools.

With the passage and enforcement of the *2009 Right of Children to Free and Compulsory Education Act* (*RTE*), the Indian government has affirmed its commitment to ensuring universal elementary education for all Indian children. Part of that affirmation includes the mission of preparing Indian children with twenty-first century skills, such as learning to operate a computer. Yet, most of what scholars know about ICT use in India's elementary schools is largely anecdotal. Consider this example of a 2010 New Delhi debate webinar hosted by the World Bank: the debate's motion simply stated, "Most investment in technology in India's schools is wasted. Discuss." The debate was intriguing. While both sides were well represented by Indian educators,

policymakers, and technology leaders, the arguments were mostly anecdotal accounts of wasted ICT investments in school. One discussant shared a story about a small Indian village elementary school that received a dozen computers from a corporate sponsor. The computers were all neatly packed in boxes and shipped to the school. A year later, a corporate representative came to visit the school and found the computers still tucked away in a classroom all neatly packed in their boxes. The boxes were never opened because the school was still waiting for electricity.

While this makes for a compelling story, the debate reflects much of the research on the current state of elementary school-based ICT research in developing nations like India. Like the arguments from the New Delhi debate, too much of the field's research remains anecdotal because of a lack of empirical research about the ways in which India's elementary schools are using computer technology (Light, 2009; Pal, 2008; Walsham, 2010). Thus, while the Indian government desires to match its industrial strength–the ICT sector–with its human capital potential, the illuminating and instructive lens that research offers remains obscure.

Indian policymakers envision computer technology delivering promising educational benefits. Among those benefits are Internet-based teacher training and supporting the delivery of local language curriculum through educational software to enhance the education of India's diverse elementary schoolchild population (MHRD, 2010). While this vision galvanizes ICT's potential in India's schools, realities exist that affect the successful integration of ICT.

Although the empirical research in this field is scarce, the literature does draw attention to the realities of ICT programs in India's elementary schools. Often these realities are discussed as barriers. In this paper, barriers are defined as the factors that restrict or inhibit a technology's use (Ertmer, Addison, Lane, Ross, & Woods, 1999; Hew & Brush, 2007; Rogers, 2000). The literature also sheds light on possibilities, which exist in India for using ICT to support the work of elementary schooling. This article discusses possible strategies to overcome the barriers.

The article is structured as literature review, which synthesizes empirical research on ICT in India's elementary schools. The focus is on elementary schools because of the prominence placed upon this level of education in India. Perhaps the most democratic and comprehensive of all Indian institutions, India's elementary school system, aims to educate the most children (100% enrolment) over the longest consecutive period of education time (8 years). By comparison, Indian secondary schools educate about 60 percent of Indian adolescents in four years (MHRD, 2010). Thus, India's elementary school system is more reflective of the realities of enacting an ICT vision.

The literature review is divided into four sections: discussion of the review's method; description of current research on the *barriers* to ICT or educational technology programs in India–in this part of the paper, a contextual description is provided which relates to India's elementary school system; examination of the *possibilities* of ICT and reporting on programs which address the various barriers; and concluding discussion about the literature review's implications.

## METHOD

The paper focuses on the phenomenon of ICT use in India's elementary schools, centring on the meaning commonly associated with the phrase: *educational technology*. In the literature, educational technology is often synonymous with computer-related tools used for teaching or learning purposes (Law, Pelgrum, & Plomp, 2008; Pelgrum & Law, 2003). It is important to note that other scholars more broadly define education technology as any tool or resource, which can aid and equip a child's learning (Bruce, 1993; Mishra & Koehler, 2006). For the purposes of this

review, though, the paper defines the phenomenon of ICT use in elementary schools according to Law et al.'s (2008) association of educational technology with computer use. Therefore, this literature review includes studies, which explain how India's elementary school teachers or students used computer technology for educative purposes. Studies not meeting the contours of this definition (i.e., research about the instructional use of television or studies on the use of computers for school record keeping) were excluded.

Using the understanding of educational technology as the starting point, candidate studies were searched for using educational databases like JSTOR, ERIC, EBSCO, ProQuest, and the WilsonSelect indexes. Google Scholar was also searched in order to identify policy documents and empirical studies about elementary school based ICT initiatives in India. One limitation of this search was that the English language was the sole language used for searching. The search included a combination of different terms, like "ICT and educational technology" and "primary school and elementary school." Other example search phrases included "ICT," "educational technology," "computer use," "India's elementary schools," and "India's primary schools."

Following Hew and Brush (2007), the paper used the "snowball" method and examined the bibliographies of policy reports and reviewed the references in journal articles for additional empirical studies. While the search included quantitative and qualitative studies, the search dates were confined to roughly the past decade (from 2003–2013). The paper excluded policy reports and articles that pertained only to (a) secondary education, (b) administrative uses of computers, and (c) opinion papers. Most of the empirical research cited is from the last five years.

After extensive searches, the paper identified 14 empirical studies that were specifically related to ICT use and elementary schooling in India (Azim Premji Foundation, 2008; Banerjee, Cole, Duflo, & Linden, 2007; Bharadwaj, 2007; Iyer & Baru, 2008; Kam, Kumar, Jain, Mathur, & Canny, 2010; Karnati, 2008; Light, 2009; Linden & Banerjee, 2003; Mehta, 2005; Pal, 2009; Patra, Pal, Nedevschi, Plauche, & Pawar, 2007; Pawar, Pal, & Toyama, 2006; Thirumurthy & Sundaram, 2003; Umrani-Khan & Iyer, 2008). Of the 14 articles, one study is a dissertation (Karnati, 2008) and four studies are from peer-reviewed journals (Banerjee et al., 2007; Light, 2009; Pal, 2009; Thirumurthy & Sundaram, 2003). The other 10 studies are from conference proceedings or working papers or reports for international organizations. These studies were included because their descriptive data shed light on themes related to ICT use in India's elementary schools.

According to Hatch (2002), data analysis is "a systematic search for meaning" (p. 148). In order to make meaning of the literature's data, the paper analyzed each study using Miles and Huberman's (1994) three-step interpretive approach, and Glaser and Strauss' (1967) constant-comparative method. First, the major findings emerging from the studies were identified. For example, "lack of computer equipment" was one such finding from Bharadwaj (2007). Second, the paper compared the findings across the studies to distinguish patterns. Third, the paper examined the patterns and categorized them into larger themes. The findings were continually analyzed until the themes were "saturated" (Miles & Huberman, 1994). Thus, the paper argues that there are three barriers to elementary school ICT programs in India: (1) lack of resources, (2) lack of teacher preparation and (3) lack of local understandings.

## THEMES EMERGING FROM THE LITERATURE REVIEW

This section starts with a brief contextual description of India's elementary school system. Then the section describes the themes emerging from the review of literature on ICT use in India's elementary schools.

### Context

The Indian government defines elementary school as the period between Classes I to VIII, or the U. S. equivalent of first grade to eighth grade (ASER, 2013; Azim Premji Foundation, 2004). India's elementary school system serves the world's largest child population; there are almost two million elementary schools spread across 35 Indian states and union territories (MHRD, 2010). Since Indian Independence in 1947, the Indian Government has attempted to address the challenge of providing education for all children in India (Govinda, 2007). In 2000, the Indian legislature instituted a national campaign called the Universalization of Elementary Education (UEE) campaign, also known as *Sarva Shiksha Abhiyan*, to increase enrolment and retention of India's elementary school children.

Indian policymakers have viewed UEE as a way to modernize elementary schools and to prepare India's children with the knowledge and skills necessary for the future. The government identifies ICT and the computer technology industry as contributing to the transformation of most every sector of India's economy, including education (Balakrishnan, 2004; Bhagwati, 2004; Bhasin, 2010). Bhasin (2010) asserts that ICT is a multi-billion dollar industry that contributes to India's high-growth economy. Economists believe that one key to maintaining India's ICT lead is the education and development of human capital–namely the country's youth (Balakrishnan, 2004; Bhagwati, 2004; Bhasin, 2010; Jhurreev, 2005). Yet, despite the promises of increased ICT investment, barriers exist.

### Barrier 1: Lack of resources

India's National Curriculum Framework 2005 states: "the significance of ICT has been widely recognized, but the detailed guidelines and strategies for its educationally optimum use has not yet been worked out" (NCERT, 2005, p. 92). NCERT (2005) further points out the irony of India's ICT prowess, but the dismal lack of ICT resources in India's elementary schools. Only 13 percent of India's government-run elementary schools have computers (Azim Premji Foundation, 2008; Thirumurthy & Sundaram, 2003). The Azim Premji Foundation (2004) found that educational technology in India's rural elementary schools continues to be almost non-existent and having access to even *one* computer would be considered lavish in most rural schools.

Mehta (2005) found that Indian urban elementary schools were four times more likely to have ICT compared to rural schools. Bharadwaj's (2007) study of 1,000 ICT equipped elementary schools revealed fewer than six computers per school or about one computer for every 72 students. Less than 9 percent of the teachers in the schools surveyed had access to the Internet, whether at school or outside (Bharadwaj, 2007). Where computers are available in India's elementary schools, the emphasis is largely on acquiring computer literacy skills (Iyer & Baru, 2008). ICT is commonly taught as a separate class rather than being integrated into the subject matter (Iyer & Baru, 2008).

Thirumurthy and Sundaram (2003) compared how teachers used ICT in six different elementary schools. There were no computers in the classrooms in any of the schools; instead children were taken to a computer lab, arranged in groups of three or four, and took turns playing drill and practice games on the computer. Umrani-Khan and Iyer (2009) reported that sharing computer

hardware is a common occurrence in India's elementary school computer labs. Thus, at ICT-equipped elementary schools, there tends to be not enough resources for all the children. Whether it be cell phones (Kam et al., 2010), computer mice (Pawar et al., 2006), or software (Azim Premji Foundation, 2008; Banerjee et al., 2007; Linden & Banerjee, 2003; Pal, 2009; Patra et al., 2007), it is common for large groups of elementary students in India to share technology resources.

### Barrier 2: Lack of teacher preparation

While Indian parents view student ICT use as positive, the perceptions held by Indian elementary teachers of computer technology are more nebulous (Azim Premji Foundation, 2008; Iyer & Baru, 2008; Thirumurthy & Sundaram, 2003). Many elementary teachers perceive ICT as motivating for students (Iyer & Baru, 2008); some perceive computer technology apprehensively and focus on the challenges (Azim Premji Foundation, 2008; Thirumurthy & Sundaram, 2003). One such challenge is the perceived lack of computer training.

This echoes what Law et al. (2008) reported from their large scale, multi-country SITES study of ICT and pedagogy. Law et al. identified factors that affect teachers' computer technology perceptions. One factor is support; teachers who feel supported, technically and administratively, are more likely to have a positive perception of computer technology. Generally, the literature reveals that computer equipment issues, scarcity of resources, and lack of training are factors that leave many of India's elementary teacher feeling indifferent about ICT (Azim Premji Foundation, 2008; Bharadwaj, 2007; Iyer & Baru, 2008; Thirumurthy & Sundaram, 2003).

For example, Thirumurthy and Sundaram (2003) found that "teachers often express a stream of concerns about ICT and curriculum integration, namely: misuse, overuse, and overstimulation" (p. 309). While some teachers believe that children will benefit the most only when curriculum is integrated with ICT, most teachers interviewed by Thirumurthy and Sundaram felt stifled by ICT and believed it was "additional work" (p. 309). Some teachers noted they did not feel competent to use ICT and were not satisfied with the minimal ICT training and preparation they received when in college. The Azim Premji Foundation (2008) study had similar findings. They found that the elementary teachers in their study believed that ICT meant extra work and required additional training to be able to use ICT effectively.

### Barrier 3: Lack of local understanding

Most research on ICT use in elementary schools comes from developed nations (UNDP, 2003, 2010; World Bank, 2003). Generally, there is a lack of research on educational institutions in developing nations (Light, 2009; Pal, 2003, 2008; Patra et al., 2007; Walsham, 2010). While Indian policymakers expect ICT to usher in promising education changes, they have a limited understanding of how that technology is negotiated in elementary school classrooms. Patra et al. (2007) identify this as an outcome of attempting to squeeze macro-level policy expectations into micro-level contexts.

At the local school level, there is also a lack of research about the meanings Indian teachers and students assign to computer technology (Light, 2009; Pal, 2008; Patra et al., 2007; Walsham, 2010). Researchers have yet to analyze the differences in Indian teachers' and students' interpretations regarding ICT's educational purposes (Pal, 2008, 2009). Consequently, it remains unclear how and why computer technology is negotiated in India's most basic schooling unit: the elementary school classroom. Identifying and analyzing this discourse addresses the need to develop frames of reference (Pal, 2008) towards a deeper and more collaborative understanding for elementary school computer use (MHRD, 2009b).

## ADDRESSING THE BARRIERS: ICT POSSIBILITIES IN INDIA'S ELEMENTARY SCHOOLS

In this section, the paper describes studies that address the barriers. The literature reviewed below highlights the possibilities and innovative ways in which ICT can be used to help support the education of India's children.

### Possibility 1: Sharing ICT resources

There can be social benefits from sharing resources. Under this theme, the paper discusses studies that address ways in which elementary school ICT resources are shared among Indian students. One study (Pawar et al., 2006) investigates the use of multiple computer mice at a computer station in order for multiple children to have access to a computer. Two other studies (Azim Premji Foundation, 2008; Pal, 2009) investigate a Public Private Partnership (PPP) program called Computer Assisted Learning (CAL).

Pawar et al. (2006) describe a typical scene in Indian elementary schools: "It is not unusual to see more than five children crowding around a single display, as schools are rarely funded to afford one PC per child in a classroom. One child controls the mouse, while others are passive onlookers, without operational control of the computer" (p. 1). Thus, learning benefits increase for the child who has control of the mouse while the children who are onlookers lose out on potential gains in learning. In order to remedy the problem, Pawar et al. experimented with five computer mice, one for each child, at each computer station. They found that while each child's time on a task increased, one or two students still tended to dominate the activity direction while the other students in the group remained passive. Overcrowded computer stations are an example of ICT resource scarcity in India's elementary schools.

While computer equipment and hardware are scarce, the Indian government makes a considerable investment in educational software through a partnership program called CAL. In this program non-governmental organizations (NGOs), such as the Azim Premji Foundation, provide computer hardware and educational software CDs to government-run public elementary schools. In exchange, the elementary school provides or creates space in their school for a computer lab, called a Computer Aided Learning Center (CALC). Outside of school hours, the CALC becomes a computer centre, where community residents can pay a small fee and have access to the computers.

Each week, during the regular school hours, each teacher is required to take her students to the CALC where the students learn computer literacy skills through an integrated, educational software series designed by the NGO. The software, called CDs, contain playful lessons aligned with the Indian National Curriculum. Most of the CDs are written in English, some are also produced in local languages (Karnati, 2008).

Pal (2009) reports that, "CAL projects are active in over 20,000 public primary schools in India. CAL aids the curricular program in schools and typically includes a computer centre with three to five machines set up per primary school of about 200 to 400 children in a rough 1:50 machine/child ratio" (p. 1387). Pal's (2009) qualitative study included an analysis of stake-holders' perceptions to CAL projects. Findings from the study suggest that, even though students had to share the ICT equipment, they were still eager to learn with the aid of the computer.

Similarly, in Pal's study, parents viewed ICT as a public good that should be in schools rather than at homes. Interestingly, parents perceived ICT as something that serves best when it is shared by all the children (Pal, 2009; Pawar et al., 2007). Parents further believed that ICT was

effectively utilized when used with a group of children who are learning together. In addition, parents viewed teachers as better equipped than parents to guide and supervise children in ICT use (Pal, 2009).

Other findings about CAL projects were reported by Banerjee et al. (2007). Their quantitative analysis of the cost-effectiveness of CAL programs revealed that CALS are most beneficial when providing remedial skills in math and literacy. Banerjee et al. found that at a cost of about $0.67 per standard deviation of improvement on the reading test, CAL programs have the potential to increase the quality of education in India. An important unanswered question their study is: "Given the evidence of decay in gains a year after the CALs end – are these effects only experienced in the short term, or can they be sustained several years after the program ends, making a long-lasting difference in these children's lives?" (Banerjee et al., 2007, p. 1264).

Additional findings (Azim Premji Foundation, 2008; Banerjee et al., 2007; Linden & Banerjee, 2003; Pal, 2009; Pawar et al., 2007) related to CAL suggests that while there is a lack of ICT hardware and equipment, India's education stakeholders, mostly parents, have a positive view about any kind of technology which their child gets to use, even if means the child has to share. The CAL findings offer a glimpse into an important distinction related to ICT investment in Indian elementary schools: ICT software, rather than equipment and hardware, is prioritized by the Indian government for addressing the resources' scarcity. The idea is that software can be designed in a way to enable multiple learners to access a single computer. Similarly, an investment in software is more likely to be based on building remedial skills in math and literacy.

### Possibility 2: Teacher Training Initiatives

While there is not a lot of empirical research on how Indian elementary teachers are being prepared to use ICT, the literature indicates that there are several corporate-sponsored projects focused on preparing India's elementary teachers to teach with technology. Many of such projects are spearheaded by private ICT companies, such as Dell Computers, Intel, and Microsoft (Aggarwal, 2010; Light, 2009; Mathur, 2007; Suckow, 2010). Dell's program, called the "connected classroom," invests in low cost notebook computers for Indian elementary teacher and students to use in the classroom. Part of this program includes an online training module for preparing teachers to use the laptops in a "connected classroom" (Aggarwal, 2010).

Intel's initiative is called "Teach to the Future Program". The program supports Indian elementary teachers with both face-to-face and online instructions for how to teach with technology (Light, 2009; Suckow, 2010). The training emphasizes strategies for effectively using ICT in the classroom, how to increase productivity through email, and ways of collaborating as a faculty. Intel also touts that teachers are better equipped to make decisions about when to incorporate technology in their lesson plans in order to increase students' critical thinking skills (Suckow, 2010). One other unique aspect about Intel's program is the Train the Trainer Model. In this model, expert teachers with a sophisticated knowledge of ICT are identified by the school's administration. These "experts" take part in further comprehensive training and then train other teachers in their respective schools. A certificate is awarded to all teachers who complete the program (Light, 2009; Suckow, 2010).

Microsoft's "Project Shiksha", also called "Empowering the Future" project, began in 2002 (Suckow, 2010). The project is run in tandem with Indian states in order to equip and advance digital literacy among government-run elementary school teachers and students (Mathur, 2007; Suckow, 2010). Through Project Shiksha, Microsoft also provides inexpensive software, in depth training, and a packaged ICT curriculum. Currently, the "Empowering the Future" project has

reached over 100,000 teachers and five million elementary students in India (Chawak & Dutta, 2014).

While these programs seem to contribute to the preparation of Indian elementary teachers to teach with technology, there is a lack of empirical studies about each program's effectiveness – though the merits of these programs are heralded by many websites and news services, which print the occasional, and often celebratory, press release. Actual research-based findings, however, are scant. Thus, it is difficult to measure or begin to posit what kind of impact the programs can have in relation to elementary school teacher education in India. The best that this paper can conclude is that these programs do exist and represent the strong interest and investment that large, multi-national ICT companies are making into training elementary school teachers in India.

### Possibility 3: Moving toward contextual understanding

Patra et al. identify that socio-cultural contextual knowledge is missing in much of the empirical research on ICT use in India's elementary schools. Along with Pal (2008), they recommend that researchers in developing nations include detailed descriptions of their study's context. Patra et al. provide examples of such description in their study on the different types of computer usage models across India. Several researchers also made calls for more research on ICT use in India's elementary schools, recommending case study research design as a way to address the lack of local understanding (Hew & Brush, 2007; Light, 2009; Pal, 2003, 2009; Patra et al., 2007, Wilson, 2002).

## DISCUSSION AND IMPLICATIONS

This article reviewed 14 studies and identified the barriers and possibilities defining India's elementary school ICT programs. An extensive search of the literature found no previous literature reviews related to this topic, making the discussion in this paper unique.

Although the paper discussed the barriers to implementation of ICT programs separately, in reality these barriers are interrelated. Thirumurthy and Sundaram (2003) explained how the scarcity of ICT resources affected teachers' attitude about using such resources. Likewise the gap in literature regarding local understanding of teachers' ICT knowledge and skills correlates with the theme that teachers are ill-prepared to use ICT because it is difficult to tailor teacher ICT training without the wisdom which local contextual understanding offers. In sum, this literature review suggests that there is a relationship among the barriers: ICT resource scarcity, lack of teacher preparation, and a deficit in localized contextual understandings which act together to explain the nature of India's elementary school-based ICT programs. In spite of the barriers, there is an array of possibilities for use of school-based ICT programs in India. These possibilities are manifested as innovative ways to address and overcome the barriers.

As with all research findings, there are caveats. This review does not speak to all the complexities that define ICT use in India's elementary schools. Other factors, such as class size, school infrastructure, and administrative support, are also likely barriers. Additionally, the review cannot begin to capture all the complex realities of the life in classrooms and schools across Indian. UNESCO (2005, 2006, 2008, 2009, and 2010) reported that the Indian public elementary school system is plagued by an inconsistent quality of education. Overcrowded classrooms and a lack of proper facilities pose not only a learning risk, but also a health risk. In the government-run public schools in India, UNESCO estimated that seven percent of the schools do not even have one functional blackboard, 16 percent are without drinking water, and 51 percent are without a toilet. GESCI (2008) also cited that a consistent source of electrical power was a luxury that only India's

elite private schools enjoy. When faced with these kinds of barriers, perhaps a pertinent question to ask is: How is it possible for elementary school-based ICT programs in India to succeed?

## IMPLICATIONS

Nevertheless, this literature review of ICT in India's elementary schools offers three interesting implications for future research. First, the literature review sheds light on the issue of ICT resource scarcity in India's elementary schools. Having the world's second largest population, resource scarcity is already a political and economic issue in India. Scarcity affects all aspects of Indian society. More independent research is needed about the types of Public Private Partnerships that exist in India, as well as the kind of impact these programs have on elementary schooling. Additionally, expanding understanding about creative solutions to share educational technology resources, like Patra et al.'s (2007) multiple-mice project, will become increasingly important as India emerges as a leader in the knowledge society. Such understanding is developed through more empirical research.

Second, the literature review has implications related to preparing India's teachers to use ICT in their practice. Staples, Pugach, and Himes (2005) argue that successful use of ICT in elementary schools is more than just access to computers, it is mainly about teachers. They posit three factors necessary for ICT to be integrated. First, the ICT must be aligned with the curriculum and the school's mission. Second, teachers must "buy in" and be properly trained in how to use ICT. Third, recognition and praise must be given for students and teachers engaged with educational technology. So what does teacher preparation and "buy in" look like in India, where there are estimated to be a million teacher vacancies within the next five years?

Indian policymakers are currently exploring ways in which teacher education programs can utilize ICT to help address the realities of preparing India's elementary teachers (NCTE, 2009). Policymakers would be wise to look at not only the types of ICT hardware and software that can assist in this preparation, but also to consider the technological mindset being developed by a future crop of elementary teachers.

Perhaps a model like Mishra and Koehler's (2006, 2007) technological, pedagogical, and content (TPACK) framework could prove to be instructive and fruitful for preparing so many teachers to meet the challenge of using technology. TPACK explains the relationship among the following three types of knowledge for teaching with technology: content, pedagogy, and technology. TPACK is useful for identifying the knowledge required by teachers for connecting instructional technology to teaching and content. Preparing India's future elementary teachers requires not only ICT resources but also a mindset for how to integrate ICT with subject matter content and pedagogical practice for educationally profitable outcomes.

Third, and perhaps most pressing, is the implication this review has regarding the quality and quantity of empirical research on ICT use in India's elementary schools. India's future is buttressed by its dual commitment to its ICT industry and the development of its human capital potential: elementary school aged children. As important as both these commitments are to India, there is a dismal lack of empirical research on ICT use in India's education system. This implication also speaks to the kind of scholarship represented in much of the literature on school-based ICT programs in developing nations (Light, 2009 Pal, 2008; Walsham, 2010): not only is there a lack of research on ICT in India's elementary school context but the existing scholarship is inconsistent in its rigor.

The empirical research reviewed in this paper reflects the lack of consistency in research rigor. Many studies did not include a complete description of methodology or even research questions. Only two of the thirteen studies actually grounded the research in a stated theoretical framework (Pal, 2009; Patra et al., 2007). Few of the studies included a description of the research design. Research methods ranged from large-scale surveys (e.g., Azim Premji Foundation, 2008; Bharadwaj, 2007) to quasi-experimental design (e.g., Banerjee et al., 2007; Iyer & Baru, 2008; Kam et al., 2008; Patra et al., 2007; Pawar et al., 2006). The remaining studies had vague method descriptions such as: "data collected from field observations at several schools" (Thirumurthy & Sundaram, 2003, p. 311) or "data gathered from a 52 item survey" (Umrani-Khan & Iyer, 2009, p. 2). While there are a number of research designs, such as case study (see Hew & Brush, 2007, for a fuller explanation of the potential of using case study to investigate ICT programs in elementary schools) that could help a researcher systematically investigate local understanding of ICT; what would be most helpful to the larger field is if future research conforms to a disciplined inquiry (Shulman, 1998). As Indian policymakers and government leaders continue to imagine and inquire about the role of ICT in their ever-important elementary school system, more research, based on a systemic inquiry will expose the realities and, potentially, help transform the barriers into possibilities.

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