ABSTRACT

Title of Dissertation: TECHNOLOGY INTEGRATION BEFORE STUDENT OUTCOMES: FACTORS AFFECTING TEACHER ADOPTION OF TECHNOLOGY IN INDIA

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Since the 1920s, ICTs have been endorsed as solutions to challenges of access and quality in education. Proponents have also supported technology use in education on grounds that it could potentially impact cognitive, affective, and pedagogical outcomes. Based on these perceived benefits, many developed and developing countries have been alarmingly swift at rolling out technology in schools. However, in spite of more than several decades of ICT investment in education, whether it leads to better cognitive, affective, and pedagogical outcomes remains unclear. Amidst the preoccupation with an outcomes-only approach, the notion of technology integration is getting neglected. Prior to determine how technology can impact students and teachers, it is critical we gain clarity on what is being done with technology within the classroom.

This study explored the notion of technology integration and examined the individual and collective role of factors that influence teacher ability to integrate technology in a developing

country context. It also studied the relationship between technology and pedagogy, examining to what extent these tools alters the teaching practices of teachers. Using a convergent/ concurrent mixed methods design, the study answered two broad questions:

1. What are the factors or conditions that either hinder or facilitate a teacher's ability to integrate technology with the classroom curriculum?
2. Are there observable differences between teachers with access to technology and those without in the extent to which they engage in constructivist pedagogy in the classroom?

Data for research question one came from 51 teachers who had access to technology as part of a three-year Computer-Aided Learning (CAL) Program between 2008 and 2011. The study finds that technology integration is a complex process and the ability to use it effectively for teachers, in the sample, depended on the individual and collective impact of four factors: the existing policy climate, personal characteristics of teachers themselves, the school context, and the innovation being implemented. Teacher ability to use technology was especially hampered by the prolonged delay in infrastructure deployment, further exacerbated by faulty and malfunctioning equipment. Teachers also faced tremendous challenges on account of a lack of technical support that rendered most of the malfunctioning equipment unusable for a considerable period of time. Additionally, the parallel introduction of a multi-grade system of education led to time clashes and a wane in teacher enthusiasm to fully explore the efficacy of technology in enhancing the quality of the learning environment. The inability of policymakers and some school principals to be receptive to teacher concerns about the new system meant that teachers felt pressured and forced to implement something they were clearly not in favor of. This had negative implications on teacher motivation, which in turn did not bode well for technology integration.

For research question two, this study compared the teaching practices of the 51 teachers with access to technology with 31 teachers who did not have access to technology. It finds no statistically significant difference in the pedagogical styles of teachers of both groups of teachers. Both groups of teachers display very similar pedagogical styles, and are engaging in as much or as little constructive pedagogy as one another. The question that arises on account of this result is—should we expect technology to alter the pedagogical practices of teachers? From in-depth interviews conducted with eight teachers with access to technology, it emerges that they feel strongly in favor of technology. They allude to benefits like the ability of ICTs to provide visualization to academic concepts to helping students reinforce classroom curriculum in justifying their support for technology. The study closes with a short discussion on the implications of these findings on ICT-based policy and practice.

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By

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Dissertation submitted to the Faculty of the Graduate School of the
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Dedication

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Ma, Bapi, and Dada
– For your limitless love, encouragement, and support

≈

Ashwin
– For your unparalleled patience and faith

≈

Aditya
– For breaking the myth of the eight-hour sleep

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Chapter 1: Introduction

Today, information and communication technologies (ICTs) have become a recurring theme in the development discourse. The premise for their growth, diffusion, and especially endorsement in development is that if implemented appropriately, the integration of ICTs into everyday life can potentially enhance the access to and quality of essential services for the marginalized. Against this premise, one witnesses an increasing push for developing countries to invest in a national information technology infrastructure so that they might also participate in knowledge-based development and reap the intended social, political, and economic benefits of ICTs (Mansell and Wehn, 1998). Donor agencies, clearly impressed by the perceived promise, also endorse a greater role for ICTs in development. Heeks (2002) notes:

> Within that agenda has begun to appear the idea that ICTs lead to the 'death of distance', create a 'level playing field' in which the small and the new compete on equal terms with the large and the well-established, and permit leapfrogging to an 'information economy'. (p.1).

Within ICTs for development, computers[1] have become a permanent fixture in the education reform agenda (Cuban, 2001). Apart from reducing disparities in educational access and quality, the optimism surrounding ICTs in education has also been partly influenced by their potential impact on student's cognitive and affective outcomes, and teachers' pedagogical outcomes.

However, despite several decades of ICT investment in education the verdict on its impact on cognitive, affective, and pedagogical outcomes is unclear (Cuban, 2001; Wenglinsky,

[1] The terms ICTs for education, computers, instructional technologies, computer-based instruction (CBI), and technology for education have been used interchangeably throughout the study

1998; Kozma, 2005; Trucano, 2005; UNESCO, 2009; Russell et al., 2003; Hernandez-Ramos, 2005; O'Dwyer, Russel, & Bebell, 2003; Schrum, 1999). While the outcomes from the innumerable projects are clearly equivocal, the assessments undertaken so far have only demonstrated the complexities associated with ascertaining links between ICT intervention and outcome. For developing countries, the uncertainty is further aggravated by context and socioeconomic realities, which make it difficult to identify the unique contributions of technology. Thus, whether ICTs can meet some of the most pressing educational challenges facing the developing world remain a subject of much debate (Wagner, Day, James, Kozma, Miller, & Unwin, 2005).

Despite the lack of clarity, countries have been alarmingly swift at rolling out technology in schools. Cuban (2001) argues (in the US context) that not only is this enthusiasm misplaced but it brings to the fore some extremely wrong assumptions—the most common one being that more technology will automatically lead to more usage and the rest (better student outcomes) will simply follow. While that has not happened, what is gradually emerging is that amidst the preoccupation with technology and its link to cognitive, affective, and pedagogical outcomes; the issue of technology integration is getting neglected. Clearly, for ICTs to play a substantial role in education, the critical element is to identify how technology plays a role in the classroom? Importantly, how are these tools being used to enhance the learning environment and alter students' learning experiences? Are processes in place, which enable teachers to execute technology for education efforts? In fact, are teachers even being able to use these tools in their teaching endeavors?

Quoting the Office of Technology Assessment, Baylor & Ritchie (2002) caution that "it is becoming increasingly clear that technology, in and of itself, does not directly change teaching or learning. Rather, the critical element is how technology is incorporated into instruction" (p. 410). This aspect of technology integration is critical. Increasingly, a growing body of research on technology integration, claims that the onus of technology use within the classroom rests with the teacher and that the unsatisfactory student outcomes are mainly manifestations of the inability of teachers to integrate technology in their day-to-day teaching (Inan & Lowther, 2010; Baylor and Ritchie 2002; Eteokleous 2008; Russell et al., 2003; Van Braak 2001; Sipila, 2010; Cox, Preston, & Cox, 1999a, 1999b; Hew & Brush, 2007; Bauer & Kenton, 2005).

Through this study, I explore the notion of technology integration and the role of the teacher, in a developing country setting. More specifically, I examine factors that motivate teachers to integrate technology in their day-to-day teaching. While studies conducted in high-income countries have attempted to identify factors that influence technology adoption by teachers, it is somewhat surprising that similar work has not been attempted in underdeveloped countries.

Defining ICTS

Broadly, ICTs allow for the transmission of data and information through digital or electronic means and can be powerful in shrinking distances and enabling access to essential services for the remotest of regions (Marker, McNamara & Wallace, 2002; Duncombe & Heeks, 1999; Hamelink, 1997; Heeks, 2002; Gerster & Zimmermann, 2003). ICT tools include almost every electronic tool that helps in this broad objective of disseminating information. These include televisions, radios, desktops, laptops, mobile phones, the Internet, and other peripherals like CDs, DVDs, smart cards and other digital storage devices. This ability to transmit information across distances has been central to the support for ICT use in development. Recent experiments from around the world have demonstrated that, at the bare minimum, ICTs can facilitate access to fundamental information in the education, health and livelihood arena.

From among the several ICT tools mentioned above, a majority has been explored for their relevance in education. For example, developing countries have used radios and televisions as complements to classroom curriculum. Educational programs have been broadcast into classrooms using these tools as substitutes for teachers. Interactive Radio Instructional (IRI) programs have been implemented in several parts of Latin America (LA), Africa and South Asia. Additionally, broadcasting education content through satellite television has also been widespread in several parts of LA and Asia. While in some parts of LA, televisions have successfully reached out-of-school children, in certain parts of South Asia, underdeveloped and remote villages have also benefited from its usage.

Recently, in addition to radio and television, the use of computers, mobile phones, and the Internet has simply exploded in the education sector. The argument is that with costs diminishing and the computer/ Internet becoming more and more affordable and accessible, it is now possible to reach a much wider student base through these tools. The scope of this dissertation is limited to the use of computers and their overall relevance in education.

ICTs and Development

The harnessing of computers for development emerged predominantly in the latter half of the 20th century. However, in order to understand how computers contribute to development, first, an understanding of development as a concept is necessary. Development in the post-World War II era "was predominantly economic, especially increases in per capita income, and a standard of living comparable to that of advanced nations" (Mansell and Wehn, 1998, p.8). By the 1970s, however, it was obvious that rather than income, people needed to be at the center of development. Criticizing the obsession with income as a proxy for development, the first Human Development Report (1990) stated that "excessive preoccupation with GNP growth and national income accounts had obscured that powerful perspective (human beings as the real end of all activities), supplanting a focus on ends by an obsession with merely the means" (UNDP, 1990, p.9). A critical need emerged—to shift the spotlight from mere gains in income to the ability to gain access to the fundamental essentials of life. Subsequently, human development came to mean enlarging people's choices; the essential ones being access to a healthy life, knowledge, and resources for livelihood creation (UNDP, 1990). Or, the capability to function (Sen, 1987), because "what matters is not the things a person has—or the feelings these provide—but what a person is, or can be, and does, or can do" (Todaro and Smith, 2006, p.17). To the extent that ICTs can improve capabilities and expand choices, one might argue there is a role for technology in development.

Two concepts stand out in the ICTs for development literature—information and knowledge. With the arrival of the information and knowledge age, earlier claims that material possessions alone determined the relationship between society and economic growth are now being questioned. Today information and knowledge are not simply one among several inputs in the path toward development, but critical components. While one can attempt at bettering one's life by judiciously exploiting the resources around them, it is imperative that "human agencies are equipped with the requisite knowledge of socially, economically, and technologically locale-appropriate methods to exploit the resources optimally to expand one's capabilities" (Garai, 2005, p. 13).

Context: ICT use in Education

Education in developing countries is often characterized by limited access and poor quality, while also being confronted by issues of limited resources. The combination of these factors impede the fostering of effective learning environments. In effect, what a child is exposed to is at best objectivist in nature, with an unbalanced emphasis on traditional 'drill and practice' forms of learning that do nothing to encourage critical thinking and cultivate problem-solving ability. Further, limited resources are also manifested in the content that a child is exposed to and even in the inadequate teaching strategies at the teacher's disposal.

The endorsement of ICTs in education is influenced by their potential impact on knowledge creation and information dissemination. In the knowledge society the hope is that every country will value the significance of education in economic and social mobility, both at the micro and macro level. There is a convincing 'access' argument that one can make in favor of ICTs, especially its effectiveness in allowing marginalized children gain access to a quality education. Similarly, for teachers, the Internet can be a repository of best-practices, which can be adapted to context-specific requirements in classrooms to enhance learning environments. Among several advantages, one of the biggest rewards of the Internet is that it allows for differentiated learning, based on the student's cognitive ability.

Of course, caveats exist. Technology tools can at best only complement existing teaching practices. Especially, if the purpose of education is knowledge acquisition, technology is only secondary and cannot substitute for the role of the teacher or facilitator. Likewise, simply introducing technology isn't the magical panacea for sub-standard educational practices. Without a convincing understanding of where technology can be plugged in to better outcomes, more technology will only be tantamount to inducing cognitive chaos (Castells, 1999).

As noted earlier, arguments in favor of ICTs in education are centered around their potential impact on information dissemination and knowledge acquisition, two concepts that are often used synonymously. Some researchers are quick to point out that using this rationale for ICT use in education blurs the lines between information and knowledge. They also warn that using the two terms (information and knowledge) interchangeably would be imprudent, and the failure to recognize dissimilarities between the two, might in the worst-case scenario lead to radicalization, manipulation and large-scale misunderstanding (Frisch, 2006). Here, I first highlight the distinctions between the two concepts, and then explore their connection to technology.

Data, Information, and Knowledge

In the debate between information and knowledge, two distinct points of view emerge—one that argues that all information is knowledge and therefore there exists a proportionate relationship between both (Cowan, David, & Foray, 2000); and the other perspective, which disputes this and asserts a difference exists (Stenmark, 2002). Often, data are understood as context-free facts and figures, which some argue are context-free[2] (Blair, 2002). Information, on the other hand, is context-specific and is likely influenced by relevance and purpose (Drucker, 1988). For instance, prior to seeking information, the user must have a relative understanding of what she is striving to seek. With that understanding begins the pursuit for information. Thus, "information seeking is most often purposive and goal-directed and resembles a problem-solving or decision-making process. The individual identifies possible sources in order to obtain the desired information" (Choo, Detlor, & Turnbull, 2000. p8).

[2] This inferedesnce is debatable, with many arguing that often times data is context-driven.

Knowledge, on the other hand, is defined as the awareness of what one knows through study, reasoning, experience or association, or through various types of learning (McInerney, 2002). Knowledge would ordinarily refer to a person's cognitive ability to process and interpret information. While inherently intangible in perception, it is extremely dynamic in nature, constanty changing as we accumulate more and more of it on account of our experiences and day-to-day functioning. Its elusive nature makes storing it an extremely challenging task. While some researchers argue that it is improbable to separate the knowledge from the knower, and store in datasets, balancesheets, or documents, others argue that given reliable communication channels, it is infact possible that one person's knowledge is communicated as information to another, and thus a separation between knowledge and knower becomes a reality.

The differences between information and knowledge has been a source of dispute for many years. The earliest knowledge management literature does not make a coherent distinction between the two (Stenmark, 2002). The understanding being that all information is knowledge and any increase in the former would automatically augment the latter. That viewpoint has come to question today. Yoguel et al. quoting Lugones et al. (2003) define information as "an array of data, structured and with a certain format but inert and inactive until it is interpreted by those that have the basic capacities to manipulate that data" (2003, p. 7). The ability to interpret information and absorb it is what distinguishes it from knowledge. New information does not necessarily become knowledge. It simply alters the existing knowledge base by either increasing or shifting a person's knowledge base (Stenmark, 2002). Ultimately, information becomes knowledges only when it is cognitively structured to reveal order, pattern, sense, and salience (Choo, Detlor, & Turnbull, 2000).

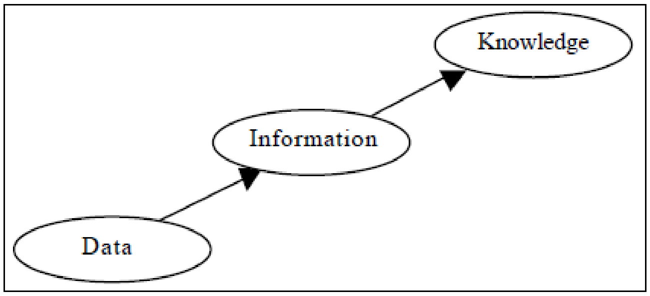

Figure 1: Relationship between data, information, and knowledge
Source: (Stenmark, 2002, p.3)

As depicted in Figure 1, earlier, the understanding was that there exists a linear asymmetrical relationship between data, information and knowledge, with knowledge placed highest on the hierarchy. This model implies that while data can become information, which in turn can become knowledge, a reverse relationship is unlikely. This viewpoint has evolved today. As data becomes information, which become knowledge, a reverse relationship is also possible wherein knowledge becomes information, which in turn becomes data.

The transition of knowledge to information underlines two integral aspects of knowledge. Stenmark (2002) views them through two tracks, namely the commodity (objectivist) view and the constructivist view. The former refers to knowledge as an absolute universal truth, which is explicit. The latter, on the other hand, cannot be defined universally except either in practice, or in the activities and interactions between people. Thus, this form of knowledge, while tacit, is situated and based in the experiences of individuals. While explicit knowledge is easier to formalize and transmit, tacit knowledge is hard to communicate. Given these distinctions some infer that explicit knowledge in actuality is only information and the concept of knowledge is singularly confined to tacit aspects alone.

<u>How do ICTs relate to Knowledge and Information</u>

The argument in favor of ICTs in education is that they contribute significantly to knowledge creation and dissemination. This observation coincides with the changed expectation from education, which is that no more should the end goal of education be limited to skills acquisition alone, but should involve knowledge creation, which in turn entails personality development and how the skills relate to the day-to-day functioning of the one who is being educated. If ICTs facilitate knowledge creation, the very nature of these technology tools can ensure a far greater scope and reach than is traditionally possible.

Before attributing knowledge creation and acquisition to ICT tools, we must understand how technology relates to information and knowledge creation. Intuitively, one might perceive the Internet and computers as a repository of data and information. If one fulfills factors related to access, through computer-assisted learning, teachers and students could gain access to a wealth of data and information, which form the building blocks of knowledge creation. Nevertheless, this expectation is based on the premise that both teachers and students are adequately knowledgeable about how to seek information and utilize it for knowledge creation. This highlights a crucial aspect of learning—the importance of the learning environment in the process of knowledge creation. To hypothesize that technology, as a stand-alone would create knowledge, I would argue, is far-fetched. It is, however, likely that ICT tools can both increase the effectiveness of a learning environment and in conjunction with it contribute to knowledge creation and understanding.

Learning Environments

Powerful learning environments are valuable platforms for constructivist learning—allowing for knowledge creation and transfer, and optimization of the learning processes by allowing the learner to reflect, understand and apply knowledge. One, therefore, must be guarded while making any euphoric claim that simply introducing technology in classrooms would result in knowledge creation. At best, technology tools can create powerful learning environments. Technology is merely a tool in the process of knowledge creation. Whether a student becomes knowledgeable is ultimately influenced by many other criteria.

Like most instructional methods, ICT-based instructions can also be both objectivist and constructivist (Niederhauser & Stoddart, 2001). While the former confines itself to predominantly didactic aspects of learning with the emphasis mainly on mastering and replicating knowledge transmitted to the learner through the computer, the latter provides the learner with the opportunity to discover and re-invent concepts through simulations and interactions. Given the factors that constitute an effective learning environment, ICTs can become valuable enablers based on their following functionalities:

- Access to information: Through computers, students and teachers access multiple information resources and view information from multiple perspectives, thus fostering the authenticity of learning environments (Smeets, 2005).
- Disseminate knowledge about best-practices: These tools compress distances and allow teachers and educators to share best practices with each other. Integrative communication features facilitate constant feedback and dialogue between educators, which makes learning and teaching a very rich experience. Educators can use technology innovatively, especially those tools that are in the form of open, user-friendly, peer-controlled, and interactive virtual communities to structure, organize lesson plans and become familiar with what works and what doesn't in other settings (Hargreaves, 1999).
- Rich text: The integration of text with audio, video and other media makes learning a very engaging experience. Students now have the option to interact with not only peers in class but also counterparts from across the world. Multimedia, especially video-based anchors are more effective than simple verbal discourses in creating authentic learning

situations. Students not only imbibe real problem solving capabilities, but also develop useful knowledge, as opposed to inert knowledge.

- Curriculum differentiation: Classrooms, in their entirety, are not homogeneous entities. They comprise students with varying degrees of intellect and comprehension ability. While customized teaching would be ideal and a requirement in pupil-centric instruction, often times the scarcity of human resource inhibits tailor-made instruction. Through ICTs, it is possible to adapt lesson content and learning activities to the needs and skills of individual pupils, by facilitating co-operation, and by providing rich contexts and tasks that are as authentic as possible (Smeets & Mooij, 2001, p 415).
- Co-operative and collaborative Learning: ICTs make co-operative learning a possibility because it allows students to discuss and reflect upon curriculum, constantly dialogue with each other about concepts and applications, thus resulting in co-operative learning (Susman, 1998). In less developed countries, where the ratio of students to computers is far higher than developed nations, several students huddled around one terminal are a common sight. The knowledge transfer that happens during the course of the session is perhaps some of the richest the children are exposed to.

Technology Integration: The missing link

ICT cheerleaders (Cuban, 2001) have time and again emphasized the arguments mentioned above to justify ICT investments in education. Schools have been wired across countries and regions. But the evidence in support of ICTs is at best equivocal. Research has repeatedly exposed insufficient empirical evidence in support of these claims. As a result, the focus has shifted from what ICTs can do to improve learning outcomes to how ICTs are being used in the classrooms. Some research today suggests that ICT results have been unfavorable because teachers lack the skills and ability to integrate these tools with their teaching.

Larry Cuban (1986, 1993) argues that much of the frenzy surrounding technology use in education is an outcome of a combination of beliefs and assumptions, which are often times not true. His seminal book *Oversold and underused: Computers in the Classroom* on Silicon Valley schools in California exposes the weaknesses of these very assumptions. Based on the premise that Silicon Valley, with its wired schools and technology abundance, should present the best evidence of ICT benefits on education, Cuban argues that not only is there a lack of substantial evidence in support of ICT impact on learning outcomes, there is adequate reason to believe that teachers do not integrate technology in their instructional endeavors. He argues that instructional use of technology is very much an exception than the rule. Numerous factors make teachers resistant to technology: anxiety, cultural norms, increased accountability, lack of requisite technical skills, pressure to cover the syllabus within the academic year, too many students, and technical glitches.

Some researchers, however, contend that Cuban's inferences might be outdated. Becker and Ravitz (2001) looked at computer use among 4,100 teachers in the US and concluded that some of Cuban's deductions are today invalid. They conclude that those teachers who have prior technical expertise, a cluster of 5 to 8 computers in their classrooms, and are constructivists in their pedagogical beliefs, would be more likely to integrate technology in the classroom.

However, what must be kept in mind is that the majority of research on technology integration until now has been conducted in high-income nations. While it is true that conditions for technology access and dissemination have progressed tremendously in advanced nations, the lesser developed countries continue to play catch-up. Conditions that were true in rich countries a few decades ago, are a reality for a majority of students in marginalized regions of the world today. With substantial gaps between the north and the south in technology reach, most of the conditions Becker and Ravitz (2001) offer remain unsatisfied.

Overview of Proposed Study

The previous sections have served to lay out the context of this study. While there is optimism surrounding the use of technology in education, there is very little evidence to support that technology can lead to better learning outcomes. While there is agreement that technologies represent a promising strategy to strengthen affective outcomes among learners, its impact on cognitive and pedagogical outcomes remains debatable. What is increasingly emerging, however, is that prior to ascertaining any causality, it is important to explore the notion of technological adoption and integration. Simply deploying technology in schools does not guarantee use.

The discussion above also emphasizes several aspects in the argument for ICTs in education. Firstly, there exists a clear difference between information and knowledge. While information is simply structured data, knowledge necessitates reasoning and contextualizing the information. Given this, if the objective of education is to facilitate knowledge creation and not simply transfer skills, then a learning environment must be cognizant of the fine difference between the two concepts. Further, there are vital factors that augment the effectiveness of a learning environment, namely an open-ended learning environment that encourages peer-to-peer collaborations and interactions; differentiated learning; instilling content that promotes authenticity, and curriculum, which ultimately integrates theory with application. Researchers argue that such favorable environments facilitate ‘constructivist’ learning, which encourage the learner to critically reflect upon content and relate them to day their daily lives.

The above discussion also questions the assumption—if access to ICTs is provided, knowledge creation becomes a natural outcome. ICTs as stand-alone devices or applications can at best complement the effectiveness of a learning environment and thus only facilitate the process of knowledge creation. An individual’s access to ICT cannot create knowledge unless the learning environment encourages its creation. This is where the role of the teacher or facilitator becomes decisive. Given their various uses and applications, the degree to which ICTs are effective in influencing a learning environment depends in principal on the perceptions of a facilitator – who could be the teacher in school, or the parent at home, and/or the student who is at the center of this process. Computers, after all, cannot change existing pedagogy, they can only supplement or support it (Smeets, 2005). While it is true that ICTs can promote constructivist learning by making learning environments more effective, it is also true that the effectiveness of ICTs in achieving that goal would depend a great deal on the teacher or facilitator. In other words, ICTs in education are not being promoted as substitutes for teachers, but as aids.

Research Questions and Setting

For this dissertation I focused on the efforts of the Azim Premji Foundation’s Computer-Aided Learning (CAL) Program in the Indian state of Chhattisgarh. The Azim Premji Foundation is a Bangalore-based not-for-profit organization, which in the recent years has become pivotal in changing the educational landscape of rural India. With a mission to “significantly contribute to achieving quality universal education to facilitate a just, equitable, and humane society," the foundation explores, among other interventions, the use of computers to augment pedagogical practices of rural teachers.

Established in 2002, CAL started with the objective of addressing persistent educational challenges like high-drop-out rates, low achievement, and low affective outcomes among students in rural areas. The basis for the program was that in order to better student outcomes, pedagogical practices, and techniques needed to be changed. To this end, the program equipped teachers with the necessary tools to make learning a playful and fun exercise for all students. It identified six factors critical to the success of the program. These were[3]:

- Teacher involvement and leadership
- Computer Aided Learning to be an integral part of teachers' pedagogy and classroom processes and not a stand-alone activity
- Dedicated Government resource and ownership
- All time availability of the prescribed infrastructure and hardware
- Availability of digital learning material of adequate quality and quantity
- Continuous ongoing dialogue with teachers to explore the strengths of the available technology

The program was holistic to the extent that while it provided teachers training in computer-assisted learning, it also created digital content that supplemented the pedagogical interventions. Most importantly, the program did not sidestep the government as the primary education provider. Collaborations were forged with state governments, with the Foundation's efforts confined to training teachers in ways the computers could enhance their teaching efforts.

Through the program, the Foundation developed and deployed content in schools that had already been equipped by a functional ICT infrastructure by State Governments. Teachers were trained to integrate this content with the day-to-day curriculum such that education could become a fun-exercise for the students.

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[3] APF Documents

In 2008, the Foundation entered into a partnership with the State Government of Chhattisgarh to explore the possibility of using CAL as a pedagogical intervention to address issues of retaining students in school. This intervention comprised two dimensions: first, gauge how the program impacts technology integration within the classroom; and second, show the State Government a model of deploying technology, where infrastructure issues are addressed and teachers are trained to see technology as a pedagogical tool.

In order to examine the first dimension, a three-year research study between 2008 and 2011 was introduced wherein 60 schools were divided into three clusters of two experimental and one control. In the first group of experimental school or E1 schools, teachers were offered both pedagogical and technology training in using ICTs to improve the learning experience of students. In the second cluster of experimental schools or E2 schools, the intervention comprised pedagogical inputs to the teachers alone. The third cluster, which served as control, was devoid of either input.

In the second dimension pertaining to a model of technology deployment, the hope was that through the learnings emerging from CAL, the AP Foundation would offer inputs to the state government on issues ranging from computer-student ratio, ensuring functional equipment, ensuring peripheral essentials like adequate back-up power supply, technology training for teachers, and empowering teachers to create novel curriculum content using technology. This dissertation is focused on examining the efficacy of the first dimension and seeks to explore two research questions:

1. What are the factors or conditions that either hinder or facilitate a teacher's ability to successfully integrate technology with the classroom curriculum?

2. Are there observable differences between E1 and E2 schoolteachers in the extent to which they engage in constructivist pedagogy in the classroom?

Purpose and Significance of the Study

Previous research has demonstrated that often times ICTs for education do not have the desired impact because teachers are either hesitant or resistant to change their pedagogical practices and integrate technology with the day-to-day curriculum (Cox, Preston, & Cox, 1999; Cox, Preston, & Cox, 1999; Cuban, 2001, 1993). Therefore, to assume that use will automatically follow availability "much the same way that night follows the day" (Cuban, 2001, p. 16) is wrong. Deploying technology will not have the desired impact unless teachers adopt and adapt to newer pedagogical practices.

Against this premise, the purpose of this study is two-fold: First, it seeks to identify conditions and factors that influence teacher ability to integrate technology in the classroom; and second, it gauges if there are any significant differences in the pedagogical styles of E1 and E2 teachers, questioning the association between technology and constructivism.

In the past, several studies have attempted to understand what prompts a teacher to adopt and integrate technology within the classroom. While some research has looked at personal characteristics of teachers, cultural contexts, and professional development programs, others have examined teacher attitudes, and beliefs in the technology adoption process. However, most studies that have examined the above relationships have been in have examined these factors in isolation (Inan & Lowther, 2010). Very few have studied the collective impact of these factors on technology integration. In this study, I examine the interrelation of the conditions and how they individually and collectively shape technology integration in the classroom.

Secondly, the majority of the research within this topic has been conducted in high-income nations. While some of these factors might be transferable to developing country settings, to argue that technology integration is culture neutral is far-fetched. In this study, I attempt to show technology integration is determinant on a very complex mix of factors that are not context neutral.

Further, an important contribution of this study is the generation of primary data that will help us understand the pedagogical component in the ICT for education debate. Until now, the success of a project has been gauged through the lens of how it impacts the learner. But as mentioned earlier, leaving teachers out of the equation jeopardizes this goal. We need to know more about the factors that either propel or repel teachers towards or against technology within a developing country context.

Organization of Study

This study is organized as follows: In chapter 2, I review the argument for ICTs in development and education and present the conceptual framework for the study. In chapter 3, I elaborate on the methodological strategies used in the study. Chapter 4 describes the CAL study in detail, including program objectives, training focus, and implementation challenges. Chapter 5 examines factors that influenced E1 teachers' ability to use technology. In chapter 6, I address in detail whether and how E1 and E2 teachers differed in their pedagogical styles. In chapter 7, I conclude the study by summarizing the key findings, making recommendations for policy and practice, and discussing the scope for future research.

Chapter 2: Literature Review

Introduction

Technology integration is a complex issue. Partly, the complexity is compounded by the fact that there is no clear understanding of what technology integration entails. Technology integration has been defined differently by different researchers. To some, technology integration refers to technology for instructional purpose or instructional delivery (Inan & Lowther, 2010; ISTE, 2002). To some others, technology integration encompasses technology for both instructional and non-instructional delivery and as long as the teacher uses some technology, he or she is engaging with technology for educational purposes. Even others argue that technology is fully integrated only when students start using these tools (Becker H. J., 1999). It is imperative that prior to determining the extent to which teachers use technology for their teaching purposes, there is a clear understanding of what technology integration actually means. Otherwise, research studies run the risk of claiming exaggerated outcomes. For instance, OTA (1995) observed substantial differences in reported scores if the definition of integration was changed from "some" technology use to technology used by students (O'Dwyer, Russel, & Bebell, 2003).

Research in the past has concluded that several factors either inhibit or motivate teachers to use computers within the classroom. Broadly, these factors are: personal characteristics like age, gender and years of experience (Inan & Lowther, 2010; Mathews & Guarino, 2000); teacher attitudes, beliefs, and self-efficacy (Cox, Preston, & Cox, 1999a; Cox, Preston, & Cox, 1999b; Baylor & Ritchie, 2002; Chen, 2008; Marcinkiewicz, 1994; Dexter, Anderson, & Becker, 1999; Ravitz, Becker, & Wong, 2000; Ertmer, Evenbeck, Cennamo, & Lehman, 1994; Ertmer P. A., 2005; Zhao & Cziko, 2001); existence of professional development programs (Eteokleous, 2008; Becker & Ravitz, 2001; Ertmer P. A., 1999; Schrum, 1999; Windschitl & Sahl, 2002); adequate infrastructure (Becker & Ravitz, 2001; Ringstaff & Kelly, 2002); and school support (Inan & Lowther, 2010; Baylor & Ritchie, 2002; Hadley & Sheingold, 1993).

The majority of the research examining the relationship between these inputs and integration comes from high-income countries, especially the United States. The literature suggests that some explicit associations exist between the factors mentioned above and the degree to which teachers integrate technology into their teaching practices. Some of the findings are: first, gender matters. Past research has shown that male teachers are more likely to use technology than their female counterparts are. Second, the tendency to integrate technology diminishes with years of experience. Third, the lack of school level support and professional development programs negatively influences a teacher's ability to use technology in his/her day-to-day teaching. Fourth, cultural barriers are negatively associated with technology integration. By cultural barriers, researchers examine power relations within school. If teachers simply view themselves as inconsequential to the reform process, the chances are they will be resistant to experiment with innovation. Finally, teachers who are more inclined toward constructivist modes of teaching are also more likely to use technology to liven up classroom sessions than peers who prefer traditional drill-and-practice forms of education. However, this is not an exhaustive list.

As mentioned earlier, the majority of the research in technology integration has examined these relationships in isolation. Very few studies have looked at the collective impact of these factors on technology integration. It is essential to understand the combined effect of these factors because not only do they influence the degree to which technology is used within the classroom, they also influence each other, which changes the overall relationship between the response and predictor variables.

The absence of similar research in developing countries is conspicuous. This is a critical gap, and warrants greater understanding of whether these same factors affect technology integration in marginalized settings and to what extent. Such a study is integral to unfolding cultural and contextual factors that either hinder or assist teachers in their ability to introduce and use technology in classrooms.

Against this objective, this chapter proceeds as follows. I revisit the rationale behind ICT use in development and examine questions about why, how, and where technology can be plugged in to facilitate development. Shifting the focus to education, I investigate the evidence in its favor. I summarize a brief selection of empirical work that explores the effect of technology on learning and affective outcomes. To reiterate, the verdict, as we know by now, is inconclusive. At this point, I take a step back to probe what the literature says about the association between unfavorable results and the resistance and hesitance among teachers to explore technology within the classroom. There is adequate evidence in the literature to suggest that in the absence of certain critical inputs, teachers will continue to react adversely to any reform that involves technology. I conclude by highlighting important areas for research, focusing on those that this study addresses.

ICTs and Development

Two polar viewpoints emerge in the discourse on ICTs for development: a confident pro-camp that argues significant benefits accrue from the implementation of ICTs in developing countries, and an equally confident opposition, arguing the ICT-promise might be premature because there still is very little empirical evidence that confirms these supposed benefits

(Caspary, 2002). The confidence on one end is severely diluted by marked skepticism on the other. Before the excitement monopolizes developmental efforts, skeptics warn that ICT-programs must be preceded by rigorous analysis of the social and cultural dimensions of these tools because only then will countries be able to harness them for development in their own context (Morales-Gomez & Melesse, 1998). Puryear (1999) cautions any enthusiasm must be prefaced by thorough analysis of the costs associated with implementation and sustenance.

Potential of ICTs

Broadly, the ICT-impact is two-fold—economic and developmental. Revisiting the earlier income-centric concept of development, those in favor argue that declining costs of technology and peripheral applications offer developing countries immense opportunities for growth (Steinmueller, 2001). The efficient exploitation of technology can result in increased industrial productivity, thereby positively impacting the economic growth of the country. The truest advantage for developing countries is that, given the strides already made in technological advancement, they would not have to reinvent the wheel, but simply adopt already existing technology to their best advantage.

Alternately, the human development perspective, which is much more holistic, surmises that often times the marginalized are limited by geographic and economic constraints to gain adequate access to information and services. Moreover, the rare times that access is achieved, the quality of the information and the service itself is dismal. Wresch (1996) characterizes information as any other commodity, arguing that while some have plenty of it (living in the midst of goldmines); others are grossly devoid of it (can barely find coal). He argues that the information gap is extremely pertinent in the context of development because it is expected that those disconnected will fare much worse and if status quo is maintained, the gap between the rich and poor, the knowing and the ignorant will only expand. Therefore, as claims about the relevance of information and knowledge in development emerge, the underlying rationale is that the cause of poverty or the lack of choice and freedom is directly an outcome of the discrepancies in knowledge and information among the information-rich and information-poor. To the extent that this rationale is true, greater communication and information flow must be encouraged to reduce this gap. The perception then is that ICTs could be utilized as potential development tools to facilitate quality access to information. In summary, while ICTs can augment a country's technical know-how and enhance infrastructure, performance and competitiveness, it can also create access to knowledge and information about basic social services (Morales-Gomez & Melesse, 1998) and support human development. The following section concentrates on the latter. ICTs can assist in the information and knowledge delivery of the following:

Agriculture

Most developing countries are predominantly agricultural. Due to the lack of information, small farmers are forced to remain insular in their farming techniques, being confined to primitive modes of production. Additionally, sustained income is often times dependent on factors such as middle-men, weather, market prices, and rigid market structures. Their ability to maneuver the circumstances can be greatly augmented if adequate channels of information are put in place that allow them access to market-related information, crop prices, weather, farming techniques, and better trade opportunities. In that regard, ICTs can become powerful tools for information transfer (Richardson, 1997; Adeya, 2002; Lioa & Liu, 2006). Apart from providing information on all of the above issues and better trade possibilities, ICTs can drastically minimize transaction costs especially on account of the communication needs of farmers (Lioa & Liu, 2006).

Additionally, functional communication channels allow farmers to adapt information to meet specific needs. For instance, given access to technical know-how, farmers might be better trained to alter farming practices or crop preferences depending on weather predictions. They may even gain access to a larger consumer base, and not be forced to resign themselves to the exploits of middlemen or commodity brokers. In all, ICTs can provide small farmers instant information on market prices, customized crop potential in various markets, negotiation, and marketing techniques, all of which can positively impact a farmer’s income credentials.

But the benefits of ICTs on agriculture and its practice is heavily dependent on the acess to basic material needs—the most common of which is ownership to cultivable land and basic raw materials. Information through a technology backbone is of no consequence in the absence of fundamental factors that augment agricultural production.

Government

It is widely believed that governments in most societies are not transparent enough, not accessible enough, and not accountable enough. Given, that the government is an institutional superstructure that society uses to translate politics into policies and legislation (Kettl, 2000), the lack of the above three qualities is detrimental for both the government and its citizens. In many countries, citizens are extremely skeptical of what the government can achieve for them. While some view their governments as bloated, wasteful, and unresponsive to relevant needs, others are grossly unaware of its functionings (PCIP, 2002). Based on these perceptions, the term government is frequently synonymous with words such as redtape and bureaucracy.

In spite of the above perceptions, it is a given that governments and citizens require each other. While it is expected that a government performs certain functions—protecting its citizens, planning and executing projects of social relevance, and making laws and implementing them, it is equally crucial that information about the existence of these services is known to the public it governs and does not remain hidden or almost impossible to access. Often times, the marginalized are either ignorant or apathetic due to the cumbersome procedures that characterize access to government services. Added to that, distance becomes a huge impediment for those marginalized by geography and circumstance.

It is expected that technological communication channels can become relevant and powerful in countering the challenges mentioned above. Given the presence of requisite infrastructure, citizens can have access to government information without having to travel long distances. For instance, if implemented appropriately, ICTs can drastically reduce time and costs factors involved in the procurement of simple legal documents (e.g birth certificate, marriage certificate, etc). The integration of ICTs with the day-to-day functioning of the government has great potential in enhancing and improving efficiency and effectiveness. At the same time, increased government access would, on the one hand, encourage greater citizen participation and, on the other, allow the marginalized access to information needed simply to better their lives.

However, it must be remembered that while ICTs can rebuild existing government processes and simplify them, they can only be supplemental to good governance and not be substitutes for it. Further, while the benefits of ICTs in simplifying the delivery of government services is immense, the extent to which the tools are integrated with the functionings of the government would depend on those running it.

Democracy

The emergence of ICTs have also led to rising optimism that it will strengthen democracy around the world. The claim is that through the Internet, readers will not only gain access to unlimited information, but be able to react and make informed decisions and ultimately participate in governance. Dahlberg (2001) offers that Internet democracy rhetorics fall within the three camps: liberal individualism that allows people to express individual interests; communitarism, which allows communitites to verbalize communal spirits and values; and deliberative democracy that facilitates a rational discourse in the public sphere, which when exploited effectively can transform private individuals into active citizens. However, very central to democracy is talk, the ability to interact with people (Barber, 2003). The Internet's prospects in this regard is immense, where virtual communities offer limitless opportunities for people to communicate without being inhibited by challenges on account of physical location.

The Internet also facilitates the formation of informal networks (Castells, 2004), members of whom are bound by shared interests, ideologies, and objectives. By becoming virtual meeting places for ideas to flourish and evolve, the Internet ultimately fosters a sense of community by encouraging interactions and online deliberations from people all around the global spectrum on common themes and perceptions.

However, the above advantages of the Internet is based on the assumption that it has a free reign in every country. From the examples available worldwide, it is evident that the simple presence of the Internet does not necessarily translate into usage for democractic practices. In China, for instance, "state agencies take new technologies as a means to improve people's living standards but not citizen participation" (Qiu, 2004, p.101). Internet spread and use is often a function of its social construction, which is heavily context and country-specific (Qiu, 2004).

Health

Health is one sector where being knowledge-poor is very obviously detrimental to overall well-being. Here distinctions need to be made between curative and preventive diseases. The argument in favor of ICTs and health is primarily focused on preventive care.

Preventive diseases, the incidence of which is very high among the poor, can be avoided if basic hygiene is adequately propagated. It is common knowledge, however, that the incidence of these diseases is rampant in poor underdeveloped regions of the world because people residing in those areas are ignorant and unaware about basic sanitation practices. For instance, in recent years, one concern that is reaching alarming proportions is HIV/AIDS. The unabated spread of the pandemic has affected millions of people across the developed and developing spectrum. Given the preventive nature of the disease, it is safe to congecture at this point in time that its spread could have been curtailed if a substantial percentage of those affected were aware of basic precautionary measures. However, without legitimate communication channels, the probability of gaining access to basic health information is exponentially diminished, causing untoward outcomes.

Further, for people residing in the underdeveloped regions of the world, sustained access to healthcare is a serious concern. Discrepancies in access force residents to travel huge distances to meet basic healthcare needs. However, the huge opportunity costs involved in availing of such services only deter residents from taking care of their basic healthcare needs.

In the healthcare arena, information and knowledge dissemination of basic healthcare dos and don’ts can significantly impact the vulnerable strata of society. Apart from information, recent advances in technology have resulted in remote medical diagnostic kits that link underdeveloped regions with city-based health care centers. These kits are extremely sophisticated and can, at the bare minimum, record basic parameters such as heart-rate, pulse, blood pressure, weight, and temperature. Remote consultations using these parameters can avert common diseases such as flus and counter the problem of distance that, in the past, have prevented residents from gaining access to quality healthcare.

But as we observed earlier, in the argument on agriculture, information dissemination using technology tools addresses only one aspect of the problem and might even be ineffective in the absence of fundamental material requirements. In the case of healthcare a very similar viewpoint emerges. Through remote consultation, patients can become aware of basic hygiene. But in the event of an illness, consultation alone cannot rid the patient of their health problem. Access to pharmacies and medicines are equally vital for fundamental healthcare needs of the marginalized. Thus, while technology can address some of the issues associated with distance and underdevelopment, it cannot solve the problem in its entirety.

Concerns about ICTs

The manifestations of the ICT promise, hype, and optimism is obvious in the numerous projects currently underway around the world. At the same time, there is a growing body of literature cautioning these actions as hasty, while urging that comprehensive socio-economic and cultural dimensions of these technologies be analysed before blindly endorsing them as the magic-potion to developmental problems around the world (Morales-Gomez & Melesse, 1998; Klees, 1996). Critics also purport that rapid technological convergence and change tends to add to the complexity of problems (Akhtar, 1995) faced by developing countries. In contrast to this guarded criticism, is the one offered by Heeks' (2002) where he equates the ICT-obsession of consultants, academics, vendors, and development organizations to that of sharks drawn to blood, as these entities are drawn to money. Thus, while many developmental agencies might promote ICTs as developmental tools, most often the end goal is economic with very little cognizance of the social, cultural well-being, political participation, and self-fulfillment of the members of society it aims to serve (Nostbakken & Akhtar, 1994). The arguments against ICTs are as follows:

Costs and Warped Priorities

In order to optimally utilize the promise of ICTs, a country must first have a functional telecommunications infrastructure. Most developing countries are devoid of even basic forms of communication infrastructure. This is evident from the long waitlist of phone/ mobile phone applicants in developing countries. Concentrating on Internet usage patterns alone, the gap between the developed and developing countries is far more alarming. In 2007, less than 5 percent of the population in Africa had Internet access. In contrast, 43 and 44 percent of people in Europe and America were online (ITU, 2009). Evidence, until now, shows that a substantial percentage of poor countries are being left behind by the information revolution. While this is common knowledge, the blanket recommendation has been that poor nations need to invest more on ICTs if they wish to develop.

Clearly, everyone from donor agencies to industry have been echoing the same sentiment. However, what they choose to ignore is that often times the unprecendented levels of investment that arise out of their lobbying is at the expense of alternate development efforts. Thompson quoting Perez (1988) states, “In affecting what funds are available to spend elsewhere and even how they are spent (i.e. often to complement or ‘leverage’ existing ICT investments), it is not just ICT being shaped by developmental requirements - increasingly, the inverse is also true: developmental policy options are becoming linked to the shape of technological evolution” (2004, p. 105).

Such policies aggravate existing challenges. For instance, as mentioned earlier, to put the emphasis on technology-led development, a country must first have a functional technology backbone, which is an extremely expensive proposition. This is evident from the cost estimates Barlow (1995) offers – a full fibre installation in any country costs approximately $1500 per home[4]. At a 100 million homes in a country, that is a huge investment. Barlow estimates that the incremental cost of near universal fiber to every home would be between $20 billion to $ 25 billion.

Some, today, claim that the rapid gains in technology R&D have resulted in diminishing costs of technology. Others contest that and state that the very globalized nature of the merging ICT industries makes them a very expensive proposition (Nostbakken & Akhtar, 1994). With costs being a genuine concern, for most developing countries therefore investment priorities are always a trade-off between sectors. Some critics believe that education, for instance, is a sector that is likely to suffer on account of the push for ICT-led development. The critical question then is, to what extent should public expenditure be used to support the ICT promise? (Nostbakken & Akhtar, 1994).

Content

Content has been an extremely contentious issue in the ICT-for-development debate. While it is generally accepted that the Internet today is perhaps the biggest storehouse of information and data, there are questions about its credibility and validity. Critics argue that while the Internet's capacity as an information warehouse is excellent, it is vital to gauge the quality and source of the information before it is recommended to users.

[4] Costs offered by Barlow might be dated because his paper was written in the mid-90s.

A second concern about Internet content is that most of the information today represents an unbalanced flow from the North to the South. This highlights concerns about culture. The innumerable documents that find their way to the Internet today, are predominantly shaped by Western countries who are the technology leaders and will remain so in the forseable future. This falsifies the cultural pluralism that supporters claim in favor of ICTs (Morales-Gomez & Melesse, 1998). At times, this free tranfer of attitudes, customs, norms, and traditions is extremely detrimental. Nosbakken and Akhtar (1994) quoting Ashok Khosla bring out this concern aptly, saying, "Information Technology brings many good things, but it also brings American soap operas and commercials that encourage the formation of habits that are not sustainable" (p. 12).

Language is an added concern. Morales-Gomez and Melesse (1998) are derisive in their critique of the Internet stating that apart from cultural dimensions, the information on the web is predominantly disseminated in a language other than that of the intended beneficiary in developing countries. They add that countering the problem does not end with simply generating language softwares, because "language is one of the pillars of culture; it reflects not only the ways in which reality is captured and communicated but also the ways in which its meaning is understood and appropriated (p. 7)

Access

In some cases, the gap in Internet access between the high-income and developing countries is close to 40 percentage points. In 2007 when countries of Europe and America had already achieved 14 percent and 11 percent diffusion, in Africa the broadband reach was only 0.2 percent (ITU, 2009). As technology continues to evolve, the poor countries will find it even more difficult to catch up with the advances made in the west. The challenge is further aggravated when new technology obliterates the old. In such a scenario, the technology that developing nations have access to now is either already redundant or outdated in the advanced nations. In effect, instead of a convergence, there is only increased divergence.

Apart from the global divide in technology, a subtantial internal country technology gap is becoming increasingly problematic, both in the rich and poor nations. Critics argue that technology presence does not always translate into technology access and can result in serious equity issues. Katz & Aspden (1997) conducted a random telephonic survey to determine the profile of an Internet user in the US and concluded that they were more likely to be male, younger than average, and better off economically. On the other hand, non-users were more likely to be female, close to average in terms of age, education and income. Similar inferences were drawn from research conducted in Peru, which concluded that the average Internet user is under 25 years of age, well educated, and resides in a high-income neighborhood of Lima (Belejack, 1997). The manifestations of the intra country divide are reflected on age, sex, race, location, education, and most importantly income.

Factors determining usage are predominantly socio-cultural and economic in nature. The economic aspect is evident from the fact that lower the Internet diffusion in a country, the more elite will the online population be (Chen & Wellman, 2004). Further, Internet usage will be proportional to educational level. Users who have a high level of literacy, are more likely to access the Internet and vice versa. Geographic location also is a crucial determinant of Internet usage, as evidenced by more affluent regions having higher Internet penetration rates than poorer ones. Unless these recurring issues are addressed, more technology will not necessarily solve the problem of access. Morales-Gomez & Melesse (1998) summarize the essentials:

> Making ICTs available is not by itself a reliable developmental approach, however noble its intentions may be……. If the villages which house the poor are currently excluded from the benefits of knowledge and information, it is not only because they are removed from modem urban centres where progress takes place, nor simply because they lack the tools to be connected to the modem world of information. The issue is by far more profound. The fact that the "global village" is not global for the majority of the world's poor is not simply because technologies are not available to them. With or without these technologies, the poor are likely to remain marginal to the benefits of society if they are excluded from the benefits of overall development (p. 4).

Revisiting the rationale of ICTs in Education

In 1948, Article 26 of the United Nations (UN) backed Universal Declaration of Human Rights, declared education a human right. It said:

> Everyone has the right to education…. education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms. It shall promote understanding, tolerance and friendship among all nations, racial or religious groups, and shall further the activities of the United Nations for the maintenance of peace" (UN, 1948).

Beyond these benefits chartered in the declaration, there is also consensus today that education is positively related to improved health outcomes (Lleras-Muney, 2002), income-generating opportunities, expanded capabilities (Saito, 2003), enhanced freedom of choice, and overall well-being. However, in spite of more than 60 years since the declaration, education is still not a human right for a majority of the world's population. Challenges continue to exist on several counts—while to most the problem translates to a lack of access to basic education, to many others it has meant access to a system that is severely deficient in quality.

In general, these challenges surrounding access to education have been a concern for the international community. Education for All (EFA) was initiated in 1990 and renewed in 2000, as time-bound goals two and three of the Millennium Development Goals (MDG) in 2000. In the approximately 10 years since the MDGs (UN, 2000), substantial progress has been made on goal two, which relates to ensuring universal primary education for children everywhere by 2015. Between 2000 and 2007, enrolment in primary education in the developing world increased from 83 percent to 88 per cent. However, disaggregating the data by region reveals that more needs to be done, especially in the Sub Saharan African region where primary school enrollment was 74 percent.

As is evident, however, goal three, which pertains to eliminating gender disparity in primary and secondary education preferably by 2005, has not been met. In 2007, for every 100 boys in primary schools in developing countries there were 95 girls. In secondary education, the gap is far greater with 89 girls for every 100 boys enrolled (UN, 2009).

Given these realities, there is quite clearly a need to intensify efforts focused at enabling quality access to education. Over the past few decades, discussions about the role of ICTs as enablers of access have emerged. Some strongly believe that ICTs can be truly transformative, because of their ability to condense distances. In the presence of the appropriate infrastructure, and access to it, it is possible to deliver educational services at the doorstep of children who have been traditionally inhibited by circumstance and geography.

The demand for knowledge today is perhaps far greater than it has ever been in the past. Some researchers, together with the concept of learning, refer to knowledge as “the new battlefields for the evolution of our society and mankind” (Lytras & Sicilia, 2005, p. 2). However, as the demand for knowledge in today’s global economy surges, several countries continue to grapple with fundamental systemic problems that obstruct its creation and dissemination. Educational systems, which are considered seats of knowledge creation, in the greater part of the developing world are replete with access and quality issues. As a result, what we observe are lopsided educational outcomes, which in the long term have very grave consequences for the country and its people in general.

Over several decades, prolonged and sustained efforts by governments, donor agencies, non-governmental organizations, and philanthropists have resulted in commendable progress in primary and secondary school participation. Nevertheless, consistent challenges remain. In highlighting the disparities in education between developed and developing countries, Lockheed (1993) presents an interesting contrast:

> "At the primary level, students in developed countries are likely to go to school in modern well-equipped buildings and have a curriculum that is well thought out in terms of scope and sequence. On average they have 900 hours a year of learning time, $52 a year of non-capital material inputs, and a teacher with sixteen years of formal schooling.....In low-income countries, by comparison, students are likely to go to a shelterless school or have class in a poorly constructed and equipped building, and their curriculum is likely to be poorly designed. On average they have only 500 hours a year of learning time, $1.70 a year of non-capital material inputs, and a teacher with ten years of formal education (p. 20).

Access and quality have been recurring challenges in education for the majority of the developing world. It is obvious that we have made remarkable progress in school enrollment since 1960 (Glewwe & Kremer, 2006). However, in spite of the improvements, discrepancies between the advanced and poor nations remain substantial. From data available for both developed and developing nations, it is evident that while the enrollment gap between the two is shrinking, a gap still exists. The Millennium Development Goals Report (2009) reports that the 2006-2007 adjusted net enrollment ratio (NER) in primary education for developed and developing countries was 96 and 88 percent respectively. Gender disparities are particularly alarming in several parts of Sub-Saharan Africa, where in 2005, for every 100 boys in primary school there were approximately 89 girls. This compared poorly to the global average of 95, Middle East 92, and Latin America 97 (EPDC, 2009).

Likewise, disparities in secondary education between the advanced and poor nations are far greater than what is evident in primary schooling. In 2007, North America's gross enrollment ratio (GER) in secondary education was an impressive 97.7%, compared to 52.1% for the Arab States, 62.6% for East Asia and Pacific, 39.3% for South and West Asia, and 55.6% for Sub-Saharan Africa.

Two primary challenges emerge, as we try to understand the status of education in developing countries. The first pertains to the issue of access. Students in developing countries are constantly challenged by economic, cultural and infrastructural constraints, which limit the number of students who actually enroll into schools. The second relates to concerns about quality. If countries resolve the problem of access to education, does it translate to quality access? In many parts of the developing world, the answer would be no. School systems in developing countries are constantly underfinanced and under-resourced. Ironically, international efforts like EFA, MDGs, and country-specific policies have focused more on enrollment than attainment. As a result, while students have been herded into schools, a corresponding emphasis on what is being taught, how it is being taught, and most importantly, how much is the child learning seems to be missing. Unless these issues are adequately addressed, problems such as grade repetition, inability to absorb grade-specific curriculum, school drop-out, and poor attainment will only perpetuate.

Since the 1990s, ICTs have been proposed as solutions to problems of access and quality. The claim is that given the appropriate infrastructure, quality education can be delivered at the doorstep of a child who was earlier limited by his/her socio-economic realities. Below, we probe the connection a little further.

One defining feature of ICTs is that it transcends time and space (Tinio, 2003). With current ICT tools today children who are traditionally impeded by infrastructural, financial, and cultural reasons, can have access to education. Using videoconferencing technology, students can participate in remote classrooms. Collaborations have been forged between rural and urban schools in several parts of the world, which allow remote students the access to some of the best educators in the country. Several examples exist wherein teachers in neighboring cities or town, who are otherwise averse to traveling to remote regions, can teach students otherwise constrained by geography. The inherent advantage of technology is that it allows both synchronous and asynchronous learning. Live classrooms maybe conducted where the teacher and the students are in two separate geographic locations. Similarly, teachers may develop the course online and offer students the opportunity to access the content and participate in an asynchronous manner. Thus, within stipulated time frames, students have the liberty to access course material, lectures, and complete assessments. The ability of ICTs to enable both synchronous and asynchronous classrooms minimizes the need for mandatory physical presence. Further, it condenses distances by bringing education to the doorstep of the student. In doing so, ICTs can become a viable solution for girls who reside in remote locations and are excluded from educational options due to cultural and safety reasons.

However, in spite of the ‘distance’ argument in favor of ICTs, the reality is that technology is an expensive solution. If the argument in favor of ICTs is that it can enable access to those challenged by financial obstacles, then technology might not necessarily be a feasible option. Online learning is expensive and currently cost effectiveness of computer and the

Internet as technology solutions vis-à-vis traditional brick-and-mortal options or even other ICT forms, such as radios or televisions is difficult to gauge because of the scope of most ongoing efforts. Most of these efforts are either too small or they go under-reported (Tinio, 2003). Besides, one must be mindful of the fact that setting up a technology-based option is not simply a one-time expenditure. Apart from the fixed costs, variable costs, encompassing maintenance and support costs are also substantial. Besides, given the regions these tools are expected to serve, optimal usage necessitates some degree of computer literacy and education, which is insufficient in most parts of the world.

In order to gauge the effectiveness of ICTs in ensuring universal access to education, it is also imperative to analyze its impact on equity. Some critics argue that the nature and costs of these technologies will only worsen existing disparities along gender, economic, social, cultural lines. There are many marginalized populations in the world today who are yet to make their first phone call (Hernes, 2002), while many in the western world already have access to personal computers in their homes. The marginalized have been unable to make such quantum leaps in technology because priorities have simply been of a very varied nature for them. For governments in developing countries, the emphasis is less on state of the art and more on the state of the economy, its system of law, the functioning of its institutions, and the workings of its civil society (Hernes, 2002). The challenge, therefore, is to institute a system which does not aggravate existing inequalities.

For instance, the influx of technology may inversely affect the number of women who actually work in a distance teaching environment. The argument is that if women are traditionally marginalized and denied access to training opportunities in technology usage, it is quite likely that fewer women will be employed as teachers/tutors in institutions that deliver courses through technology. Subsequently, the fewer number of female instructors will adversely impact the number of female students who ultimately enroll in such programmes (Phillips, 1998).

ICTs allow teachers and students the opportunity to supplement classroom curriculum with additional sources of information. While earlier students and teachers had to entirely depend on prescribed textbooks or the school library for material, today it is possible to gain access to a vast and varied resource base that can also be adapted to one's specific course needs. The novelty of technology integration with education is that students and educators have the liberty to access information anytime and anywhere.

Technology can also make education a fun exercise. The gains made in technological advancement allow the integration of audio-video-text, which enhances the richness of the classroom. While electronic data can be integrated with educational cassettes, educational videos, simulations, and games, an entire school library can be mounted on a CD-ROM (Bank, 2003) and played on a computer. To placate concerns about the validity and authenticity of the enormous amount of information available on the Internet, teachers can act as both information filters and dissemination channels for students by guiding their information seeking (Bank, 2003) or by ensuring the legitimacy of the information. Additionally, network technologies allow educators to collaborate on research, teaching, and creation and dissemination of teaching material. The in-built interactivity in technologies allows for the customized sharing of knowledge, materials and databases quickly and cheaply, independent of the physical movement and geographic distances of individuals (World Bank, 2003).

While it is true that the Internet, today, is perhaps the largest repository of information, it is also a very vulnerable source of information. While its immense reach is possibly its most defining characteristic, it is also its principal dilemma. For people unaware of genuine sources of information, sieving through myriad outputs and then ascertaining credibility is extremely arduous. Even though the Internet enhances the length and breadth of what one has access to, it makes depth a very contentious issue.

Constructivists argue that a combination of challenges facing schools in developing countries—lack of infrastructure, lack of trained teachers, huge class sizes, and lack of teaching materials among other factors – has made education less student-centric and more teacher-centric. Most often, the flow of information in the classroom is hierarchical. Due to the sheer size of the classrooms, teachers find it logistically difficult to offer personalized attention to every pupil. Dialogue is mostly missing. In effect, students are simply passive recipients, flaccidly engaging in rote learning to pass tests and advance to higher grades. ICTs make it possible to alter such conventional practices and tilt the balance in favor of a more student-centric learning environment.

Through computers, students and teachers access multiple information resources and view information from multiple perspectives, thus fostering the authenticity of learning environments (Smeets, 2005). These tools also compress distances and allow teachers and educators to share best practices with each other. Integrative communication features facilitate constant feedback and dialogue between educators, which makes learning and teaching a very rich experience. Educators can use technology innovatively, especially those tools that are in the form of open, user-friendly, peer-controlled, and interactive virtual communities to structure, organize lesson plans and become familiar with what works and what doesn't in other settings (Hargreaves, 1999). Further, with ICTs, it is possible to adapt lesson content and learning activities to the needs and skills of individual pupils, by facilitating co-operation, and by providing rich contexts and tasks that are as authentic as possible (Smeets & Mooij, 2001, p 415).

The optimism surrounding the potential of ICTs in fostering an effective learning environment has prompted some very hasty inferences. One claim is that with the advent of ICTs in education, the need for teachers is not as vital to a child's learning experience as it used to be in the past. There is adequate reason to believe that this assumption is false. ICTs, as stand-alone devices, can at best complement the effectiveness of a learning environment and facilitate the learning process. Simply accessing technology tools does not make one learned. The extent to which ICTs are effective in influencing a learning environment depends in principal on the perceptions of a facilitator – who could be the teacher in school, or the parent at home, and/or the student who is at the center of this process. Computers, afterall, cannot change existing pedagogy, they can only supplement or support it (Smeets, 2005). While it is true that ICTs can promote constructivist learning by making learning environments more effective, it is also true that the effectiveness of ICTs in achieving that goal would depend a great deal on the teacher or facilitator. "The general point is this: Educational planners have to consider what a well-rounded education is. The whole point of education as a common human enterprise is that no student can bring out his or her potential if left to the student's own haphazard personal search" (Hernes, 2002, p. 26).

Demonstrated Impact

Learning Outcomes

Of all the causalities one can attribute ICTs to, perhaps the most ambiguous is its impact on cognitive outcomes. In fact, "the most pronounced finding of empirical studies on ICT impact is that there is no consistent relationship between the mere availability or use of ICT and student learning" (Kozma, 2005, p. 21). The National Center for Education Statistics (NCES) administers the National Assessment of Educational Progress (NAEP) in the US reports on the educational progress of students in grades 4, 8, and 12. In 2000, the NAEP conducted a national mathematics assessment of students in the above-mentioned grades. In trying to gauge, whether computers had any positive relationship with learning outcome, the report concluded that the results were different for different grades. Eighth-grade students in schools, which indicated, that computers were available at all times in classrooms on an average scored lower than students in schools that did not indicate a similar level of computer availability. However, twelfth-graders in schools, which had a computer laboratory, on an average, scored higher than students from schools in which computers were not available (Braswell, Lutkus, Grigg, Santapau, Tay-Lim, & Johnson, 2001).

Likewise, Wenglinsky (1998) using 1996 NAEP data found that for eighth graders the frequency of home computer use was positively related to academic achievement in school. On the contrary, however, the frequency of school computer use was negatively related to academic achievement. Fuchs & Woessmann (2004), in determining the impact of home computer use on academic achievement found that on controlling for family-background characteristics the relationship is statistically significantly negative. Similarly, if school characteristics are controlled for, the relationship between technology intervention and educational outcomes is negligible and statistically insignificant.

In India, there is a premium on the ability to read, write, and speak in English because these skills enhance a person's employability and the chances of earning a good income. The reality in most schools is that teachers are not qualified to teach English. Against this pretext, India-based NGO, Pratham, introduced a computer-based program, which involved a hardware called Pictalk. Through these machines, students were taught basic English and grammar.

A randomized trial (He, Linden, & MacLeod, 2007; Linden 2008) to gauge the effectiveness of the PicTalk program revealed that the PicTalk program was effective in improving students' English skills. However, higher-performing students had benefitted more from the sole exposure to PicTalk. Interestingly, lower-performing students who were exposed to a combination of technology intervention and teacher participation were the ones who benefitted from the project.

Randomization was used to evaluate an in-school and out-of-school computer-assisted learning (CAL) program in the Indian state of Gujarat. Researchers observed that students in the in-school CAL treatment group performed worse than the control. The intervention actually lowered the score of the treatment group by 0.57 standard deviations. Interestingly, treatment students in the out-of-school CAL intervention did better than their control by 0.28 standard deviations. These results revealed that the CAL program was perhaps more valuable as a supplement to classroom curriculum and not effective as a substitute.

<u>Teacher Training and Student Attitudes</u>

Kozma (2006) used mixed methods to determine the effectiveness of the World Links[5] Program in Jordan. Some of the significant findings were that the World Links Program was contributing strongly to the objectives of the educational reform undertaken by the Jordanian government. The combination of quantitative and qualitative data revealed that ICTs facilitated the integration of innovative practices within classroom teaching. He observed that teachers and

[5] http://www.world-links.org/en/countries/arab-region/

principals in World Links schools were more likely to integrate a variety of software packages, search engines and the Internet into their teaching than their non World Link peers. It also emerged that teachers in World Link schools were more likely to encourage a collaborative environment within the classrooms. Snippets from the program evaluation offered interesting insights into the willingness with which teachers were integrating technology with classroom instruction. Many teachers felt that, as a result of the intervention, their role becomes more of a facilitator than a lecturer. Principals also confirmed this by adding that the role of the teacher had gradually evolved from the primary source of knowledge to a facilitator of knowledge creation.

Likewise, Gaible (2008) found similar results while evaluating the World Links Program in Syria. Perhaps the two areas with the greatest impact were improvements in student-teacher relationships and the act of knowledge-building inside the classroom, as reported by both teachers and students. Responses during focus groups, revealed that teachers wanted to be better liked by students and break away from traditional teaching practices.

The program also had a positive impact on the learning environment as evidenced from the data collected through student focus groups. Overall, most students felt that the program had greatly impacted certain areas, such as computer skills, English-language skills, ability to communicate, curriculum comprehension, ability to learn independently, and the ability to search and sieve relevant information. Teachers, on the other hand, expressed satisfaction at being able to integrate innovative technology components with classroom sessions. This way, many teachers felt that they could liberate themselves of conventional teaching practices, which did little to improve relations with students.

The framing of targets as evidenced by the MDGs and EFA has reiterated the importance education plays in human development. The international community's commitment toward ensuring that every child has access to quality education has shifted the spotlight to innovative measures that can make this vision a reality. It is in this light that ICTs are increasingly being promoted as enablers of quality access to education. It comes as no surprise therefore that a majority of developing countries today, encouraged by advanced nations and international donor agencies, are proactively pursuing and testing the development and dissemination of ICTs and related technologies in education. Nevertheless, given the proliferation of ICT projects worldwide, there is very little known about the demonstrated impacts of these technologies. Without the knowledge about impact, it is very difficult to discern whether roll-outs are an outcome of international pressure or good programmatic choices.

Teachers and Technology Integration

Gradually, more and more researchers have come to agree that the lack of evidence surrounding the role of technology on positive student outcomes is partly due to teacher inability to integrate technology into the classroom (Eteokleous, 2008; Baylor & Ritchie, 2002; Marcinkiewicz, 1994; Inan & Lowther, 2010; Mumtaz, 2000; Cox, Preston, & Cox, 1999a; Hew & Brush, 2007; Zhao & Cziko, 2001; Hennessy, Ruthven, & Brindley, 2005). Research also agrees that teachers must be at the center of every innovation within the classroom (Chen, 2008; Bitner & Bitner, 2002; OTA, 1995; Zhao & Cziko, 2001; Levin & Wadmany, 2008). After all, to what extent technology is exploited within the classroom remains the teacher's prerogative. There is a growing body of literature that argues that technology integration is an extremely complex process. Different teachers react differently to educational change. While some are averse to the prospect of educational change within the classroom, others feel fear and anxiety (Bitner & Bitner, 2002).

Generally speaking, teachers go through a five-stage process in their quest to combine technology with teaching. These are: entry, adoption, adaptation, appropriation, and invention. Quoting Sandholz, Ringstaff, & Dwyer (1997) Mills and Tincher argue that in passing through these five stages, the learning process inside the classroom transforms from a traditional objectivist process to a constructivist process. Whereas at the entry-level, teachers use manuals to explore ways to use technology in their day-to-day teaching, at the invention stage students become central to the learning process (2003).

<u>What is technology integration?</u>

Much the same way that ICTs do not have an agreed upon definition and comprise several technical tools, technology integration has been defined differently by different researchers (Bebell, Russell, & O'Dwyer, 2004). Broadly, the literature views technology integration through three lenses: technology for instructional, non-instructional, and as a learning tool. Instructional use of technology encompasses activities such as lesson planning, lecture presentation, research, and peer-to-peer collaborations (Bebell, Russell, & O'Dwyer, 2004). Non-instructional technology use usually refers to ICT use for record-keeping, such as grades and attendance, administrative activities, and communication with parents. However, technology use as a learning tool is perhaps distinct from these two in that it puts children at the center of the learning process, as opposed to teachers. When children start using ICTs to improve their understanding of coursework, enhance their critical and higher-order thinking, and problem-solving abilities, technology becomes useful as a learning device (Cuban, Kirkpatrick, & Peck, 2001; Becker H. J., 1999) and that to some teachers is the ideal definition of technology integration. Thus, in making inferences about the degree to which teachers integrate technology inside the classroom, one must be cautious about the 'kind' of integration being measured. Does the integration refer to teachers using technology for administrative purposes, or is the emphasis on technology use for curriculum enhancement, or better still is the focus on students exploiting technology for their learning needs?

Factors affecting technology integration

Technology was widely expected to transform education. However, after decades of investment, there is little evidence that teachers are radically altering their teaching practices (Hennessy, Ruthven, & Brindley, 2005). Cuban (2001), in investigating technology use among Silicon Valley schools, challenges the assumptions surrounding technology use in education. Particularly, he questions the theory that access will automatically lead to use, which in turn will automatically leads to better student outcomes. Not only are the outcomes evasive, teachers, for the most part, have been slow in adopting these tools. Apart from the teachers, the onus of the underutilization is also on policymakers who have introduced school reforms without sufficient buy-in from teachers who are ultimately responsible for implementation (Cuban, Kirkpatrick, & Peck, 2001).

A growing literature has improved our understanding of barriers that prevent teachers from exploring technology in their daily teaching practices. These barriers can be broadly classified into personal, infrastructural, cultural, and institutional factors.

Personal Characteristics

Past studies have concluded that personal demographics and teacher attitudes have statistically significant explanatory power on technology use within the classroom. Mathews and Guarino (2000), using path analysis to explore this link concluded that while personal characteristics of teachers had a direct impact on computer usage, years of experience had a direct impact on computer proficiency of teachers. General findings suggest that male teachers are more inclined to use computers than their female peers. van Braak (2001) surveyed 236 secondary schools teachers to explore whether personal characteristics explained differences in computer use. Using a combination of quantitative methods, he deduced that while male teachers were more involved in computer use in class than female teachers, gender did not explain variations in computer use. Inan and Lowther (2010) used a path model to examine, among other things, the impact of age and experience on computer use of 1,382 Tennessee public school teachers. They found a statistically significantly negative relationship between the two predictors and technology integration. As teachers grew older, the results showed that they were less likely to experiment with innovation inside the classroom. Simultaneously, increases in the years of experience on the job also negatively impacted computer use for teaching purposes.

Conversely, however, teacher willingness to improve teaching practices through the use of computers had statistically significant explanatory power on technology use. Using a combination of path analysis and logistic regression, van Braak (2001) concluded that teacher attitudes and beliefs were critical predictors of technology use inside the classroom. The empirical literature exploring this link is unanimous in the assosiation between positive attitudes and techology integreation. Time and again, it has shown that positive attitudes correlate favorably with technology use (van Braak, Tondeur, & Valcke, 2004; Cox, Preston, & Cox, 1999b; Cox, Preston, & Cox, 1999a; Inan & Lowther, 2010; Drent & Meelissen, 2008; van Braak, Tondeur, & Valcke, 2004; Baylor & Ritchie, 2002). However, attitudes are in turn correlated with teacher's perceived usefullness of the innovation, ease of use, and intention. If the innovation causes anxiety and fear, which research has shown to be the most common reaction of teachers toward technology, usage will be limited. Intuitively, prior technical knowledge correlates positively with perceived usefullness, and ease of use (Cox, Preston, & Cox, 1999a, 1999b), which in turn impacts teacher attitudes favorably.

However, Cuban, Kirkpatrick, and Peck's (2001) study contradicts the associations between gender, and years of experience, and prior technical knowledge. In their study of two schools in the Silicon Valley, they found no evidence of differences between "veteran and novice" teachers, male and female teachers, and teachers with and without past technical experience (p. 826).

Infrastructural factors

Research has established that the degree to which technology-based reforms can work in schools depend largely on the availability of adequate infrastructure. The lack of access to technology, and unavailability of technical training, and technical support are cited as tremendous impediments to the implementation and continuity of technology-based reforms in schools. This is perhaps particularly pertinent in a developing country setting, where teacher-to-student ratio and computer-to-student ratio remains a major concern. Without access to adequate infrastructure, teachers find little opportunity to experiment with technology for their teaching purposes (Hew & Brush, 2007).

The lack of ready access and support can create significant barriers for teachers. Pelgrum (2001) analyzed worldwide survey data from 26 countries to determine the main obstacles to technology implementation in schools. The most frequently voiced problem, according to this study, was the lack of sufficient computers. Unavailability of other technology peripherals, like softwares and CDs were also cited as hindrances to unconstrained use. Further, while the use of technology is functional on the availability of adequate infrastructure, constant technical support and maintenance are vital to unobstructed use. Cuban, Kirkpatrick, and Peck (2001), during their study, heard teachers and school administrators repeatedly complain about the unreliability of technology amidst recurring breakdowns. Issues such as servers crashing, inadequate wiring, and obsolete software compounded the ambivalence teachers expressed toward technology. While some might argue that Cuban's assessment are relatively dated and might not apply in today's day and setting due to increased access, I argue that to a large extent these technical issues are still valid in developing countries. Frequent power outages, insufficient wiring, Internet inaccessibility, low bandwidth, are still concerns that have not been fully addressed and countered in developing countries. In the presence of constant technological glitches, the literature claims that teachers' confidence toward technology-based educational reforms erode, thereby affecting use.

Within the broad focus on access, an interesting aspect emphasized in the literature is the relationship between placement (Cuban, Kirkpatrick, & Peck, 2001; Becker & Ravitz, 2001) of technology—in a classroom versus a computer laboratory versus media centers like libraries—and use. Becker and Ravitz (2001), in their research, found that teachers with 5 to 8 computers in the classroom were more likely to engage in teaching practices that allowed students frequent use of computers than peers who would have to depend on computer laboratories. They argue, administrative challenges, for instance reserving the laboratory one week in advance and lesson planning around this agenda prevent teachers from integrating technology with the curriculum. These findings, however, contradict those of Cuban, Kirkpatrick, and Peck (2001) who observed that teachers in their sample were more inclined to use media laboratories, where there were sufficient computers to accommodate an entire class.

The majority of early integration efforts viewed lack of resources and technology access as the predominant barrier to technology use within the classroom. Solutions, therefore, focused on enhancing the adequacy of resources. There were two underlying assumptions supporting this solution (Ertmer, 1999). First, adequate resources would lead to integration. Second, implementation would not start unless the resources were in place. While there is an argument to be made in favor of technology availability and use, Cuban (1993, 2001) has repeatedly cautioned against blind acceptance of these assumptions. Because, inspite of the investments supporting the rhetoric, there is very little evidence that teachers have combined technology with their teaching practices.

Cultural Contexts

Cultural obstacles, according to Cuban (1993), pertain to ".....cultural beliefs about what teaching is, how learning occurs, what knowledge is proper in schools, and the student-teachers (not student-machine) relationship dominate popular views of proper schooling" (p. 186). Any form of innovation within the classroom that challenges traditional teaching practices and disturbs conventional student-teacher relationships and teachers experience is what Ertmer (1999) calls a "cultural incompatibility" (p. 51). There is a great deal of overlap between cultural contexts surrounding technology use and teacher beliefs as predictors of technology use. At the very core, both concepts underscore the critical role teachers play in the execution of educational innovation. Zhao and Cziko (2001), use a Perceptual Control Theory (PCT) framework to lay out three conditions for technology use: a teacher will use technology only when she or he is convinced that it will enable them to meet a higher-goal; it wll not disturb any existing higher-level goal; and finally, when they have enough resources to use it (p. 6). Their analysis gets to the heart of the question—why must teachers use technology? The authors argue that amidst all the assumptions surrounding technology integration in schools, what is fundamentally missing is the fact that teachers are driven by their own goals. Unless there is a strong synergy between the reform process established by the school and their own individual goals, teachers will remain antagonistic to change. Their study also provides an insightful view on matters such as computer phobia, lack of confidence in front of students, reversed flow of knowledge (students teaching the teacher), and teacher concern about students accessing "indecent material" on the Internet, which diminish a teacher's perceived usefullness of technology within the classroom.

Along similar lines, Lim and Chai (2008) argue that even though teachers might perceive that computers are useful, their "pedagogical beliefs, competencies and socio-cultural contexts, and objectives of the lesson may prevent that affordance from being attended or taken up" (p. 809). The researchers observed six teachers in two Singaporean primary schools that were supposedly achieving high levels of technology integration within the classroom. In spite of the availability of adequate technology, and teachers expressing a tendency for constructivist practices, the researchers found that the information flow within the classroom still had strong hierarchical underpinnings. Such results confirm that if the innovation contributes to a sense of loss of control inside the classroom, teachers are hesitant to invest in its implementation (Cox, Preston, & Cox, 1999b).

Institutional barriers

A very strong impediment to technology use in schools is the presence of institutional barriers that are functional either at the school-level, district-level, or national level. Institutional barriers relate to a multitude of issues, ranging from a lack of consensus on broader educational goals, school support, leadership issues, to scheduling, and curriculum. Alluding to Fullan (1991), Cox, Preston, and Cox argue that the extent to which a technology-based reform process is successful depends to a large extent on the forms of school support teachers are offered (1999a, 1999b). Often times, the expectation is for teachers to alter their pedagogical priorities to align with goals established through a prescriptive process. But researchers argue that in order for teachers to adopt technology, they must be made equal stakeholders in the decision-making process. In its absence, teacher frustration on account of issues such as loss of control and forceful adjustment to an alien reform manifests itself as barriers to technology integration.

One can safely deduce that several times educational reforms fail because the overall objective is ambiguous. Policy-makers have been quick to construe teacher hesitance as a refusal to reform process, but Cox et al. (1999a, 1999b) argue that often times that is a wrong diagnosis. The fact of the matter is that teachers do not reject change. However, if the onus of change is on them, then they need to be adequately informed on how to implement it.

Other issues impeding technology adoption relate to a lack of time and clash between objectives (Hew & Brush, 2007). Teachers express often feeling a sense of saturation by having to pursue too many goals simultaneously. For instance, Fox and Henri (2005) investigating factors influencing technology use within the classroom in Hong Kong schools, heard teachers complain that there were too many parallel objectives to meet leaving them with very little time to experiment with innovation. According to teachers, the school management's unspoken decree was for them to focus on ensuring students performed well in exams. Against such established priorities, additional efforts meant additional time. These results correspond with Cuban's (2001), who argues that often teachers do not have the time to pursue innovation because they have to function within established school priorities. As a result, teachers need longer hours to meet innovation goals of the school, work additional time to do online research and prepare for class sessions (Karagiorgi, 2005). Those teachers who make such consessions on the job, either suffer a burn out or exit the school system (Hew & Brush, 2007), unable to cope with the pressure.

Conversely, at a very macro level, these challenges are a direct outcome of the lack of clarity on the part of policymakers—be it at the school-level, district-level or national-level—about what ultimately defines innovation? Is the focus on introduction of technology as the means or the end? Cox et al. (1999b) surmise that in cases where schools are backed by the head teacher and the school supports ICT integration into teaching, teachers have been successful in introducing innovative practices.

Another challenge that manifests itself as an institutional barrier is the lack of professional development opportunities and technical support for teachers following the introduction of technology in schools. This follows directly from the need for clarity on overarching goals and objectives. If schools are clear on how to exploit technology for the educational needs of students, teachers must be adequately trained, while on the job, to meet that purpose. In order for teachers to engage in innovative pedagogical practices, training and professional development programs need to be offered in the use of computers (Mumtaz, 2000).

A professional development program can also be instrumental in changing teachers' negative perceptions about technology efficacy and use. Revisiting the link between teacher beliefs and technology use, given the same resources, researchers note, different teachers react differently to technology. Partly, their beliefs about technology mediate the extent to which they are willing to invest in change (Windschitl & Sahl, 2002). However, for technology-based innovation to succeed, a professional development program must identify and be cognizant of this belief system and ultimately align them with the overarching goals in a manner such that teachers feel invested in the reform process.

Here, there is a need to differentiate between professional development for computer literacy and the use of technology as a learning tool. The purpose of professional development has to be more about improving a teacher's critical understanding of where technology can be plugged into the learning environment and less about computer literacy and proficiency in computer applications (Mullen, 2001). In fact, rather than an emphasis on imparting simple computer skills like word-processing, data entry, spreadsheets, and presentations, a professional development program must train the teacher in ways to integrate technology with the curriculum (Eteokleous, 2008; Popp, Augustine, & Peck, 2003) such that its true potential as a learning tool is achieved.

In summary, Ertmer (2003) posits that every form of technology adoption must be supported by significant organizational changes. In its absense, the reform will not result in favorable outcomes. "If new technologies are to successfully transform education, significant changes will be needed not just in terms of roles, rules, and relationships, but also in terms of the very purpose of the entire educational enterprise" (p. 125). Finally, schools must be aware that technology uptake on the part of teachers goes through a gestation period. Although there is no rule of thumb regarding how long it would take for a teacher to adopt technology and innovate pedagogical practices, some researchers argue that it could take upto 5 years for such goals to actualize (Becker, 1994).

Conceptual Framework

Gradually, more and more researchers have come to agree that the weak link between technology use and positive student outcomes is partly due to teacher inability to integrate ICTs with the curriculum. This argument might be construed in two ways—first, that it lays the onus of the lack of success in integrating technology on teachers while grossly ignoring that as players, teachers are but a small cog in the large wheel of the school system; and second, that teachers must be at the center of every innovation for it to succeed.

The extent to which technology is successfully exploited within the classroom, however, is the interplay of several factors. As a growing body of literature on ICTs for education suggests, technology integration is an extremely complex process. Factors such as personal characteristics of teachers, institutional factors, cultural norms, and policy are crucial in determining the extent and existence of technology integration in the classroom. While individually, each of these factors is crucial, some of their impacts are also mediated through their interaction with one another.

In this section, I elaborate on the conceptual framework for the challenges to successful technology integration within the classroom. Based on the review of the literature, the conceptual framework for this study borrows predominantly from two sets of research: Zhao, Pugh, Sheldon, and Byers' (2002) *Model for Conditions for Classroom Technology Innovations* and Groff and Mouza's (2008) *i^5 Framework*. These two models are particularly pertinent to this study for two reasons. First, educational technology research, for the most part until now, has been fixated on outcomes. While ascertaining the impact of technology on student outcomes is clearly essential, research has demonstrated relatively weak links thus far. Prior to determining the impact of technology, perhaps what needs to be further developed and examined are specific ways in which technology is being utilized within the classroom to result in those desired student outcomes. Research needs to establish whether educational technologies are being suitably matched to students' educational needs, while also identifying factors that make it easier for teachers to explore their use. Unless there is clarity on how educational technologies can be plugged in to enhance the quality of a student's learning environment, the arguments endorsing their use will lack credence. Second, while some research has focused on identifying factors affecting teacher ability to integrate technology, it is incomplete because it views the factors in a fragmentary, piecemeal basis. The complexity of technology integration is intensified by the interplay of a multitude of factors. There is clearly a need to understand how factors individually and collectively impact technology integration within the classroom.

Zhao et al. (2002) and Groff and Mouza (2008) address both these gaps. Both models are based on the now ceaseless premise that if education technologies, primarily computers, are being hyped as truly transformative for the purposes of education and the educational experience of millions of children across the world, then why has usage been disappointingly low? The models are guided by the principle that unless research takes a step back to address issues surrounding the notion of technology integration, any claims in favor of educational technologies will remain premature. Both explanations acknowledge a necessary link of a set of factors with teacher ability to successfully integrate technology with the curriculum. The merit for both models lay in the fact that their import may offer policymakers and practitioners some desperately needed suggestions on how large-scale technology integration efforts can succeed.

There exists a substantial overlap between the two models. Both models highlight the significance of the innovator (teacher), innovation (project being implemented), and the school context in determining the extent to which technology is adequately used in educational settings. The Groff and Mouza's (2008) model, however, expands on the Zhao et al. (2002), model by emphasizing the vital role factors like policy and students play in determining the success or failure of educational technologies. Ultimately, the most critical aspect both models highlight is that often times, ICT-based projects fail because the complexity of the process is aggravated by the lack of control innovators can exercise on the innovation. I will now apply some aspects from both models to build a conceptual framework for this study.

In designing the conceptual framework to determine factors affecting teacher ability to integrate technology, I allude to Cassidy's (1982) definition of instructional technology, which he says must concern itself with "improving the effectiveness and efficiency of learning in educational contexts" (p. 75). The theoretical model for successful technology integration comprises four components: innovator, innovation, policy, and context.

The Innovator

The innovator essentially refers to the teacher, whose impact on the extent to which technology is integrated with the curriculum is perhaps the greatest (Chen, 2008; Bitner & Bitner, 2002; OTA, 1995; Zhao & Cziko, 2001; Levin & Wadmany, 2008). Several factors, both endogenous and exogenous to the teacher himself/ herself, influence the extent to which they engage in technology integration. Typically, these factors include teachers' personal characteristics like: (1) technical proficiency (Cox, Preston, & Cox, 1999a, 1999b); (2) attitudes toward technology (Inan & Lowther, 2010; Drent & Meelissen, 2008; van Braak, Tondeur, & Valcke, 2004; Baylor & Ritchie, 2002), (3) the extent to which technologies align with their pedagogical beliefs (Zhao & Cziko 2001), and (4) social awareness (Zhao et al., 2002).

An increase in technical proficiency and teacher attitudes toward technology is associated with a greater likelihood of technology integration. For instance, the more technologically proficient a teacher is, the more likely he/she is to integrate technology with the curriculum. Often times, ambitious efforts at technology uses for the classroom fail because teachers do not possess the requisite knowledge or skills to bring their ideas to full fruition.

The relationship between technology integration and a teacher's pedagogical objectives is critical and tricky. Since, technology is not "functionally neutral," (Zhao et al., p. 492) teachers will use technology only when it is consistent with their pedagogical orientation. Clearly, if technology is at cross purposes with what teachers envisage for their class, success will remain elusive. Added to this is also the requirement that teachers must attain clarity on how technology can be plugged in to further their vision. Any ambiguity only serves to defeat the goal.

Social awareness may also have lasting implications on teacher ability to explore technology in the classroom. It expresses itself through teacher ability to maneuver the school system to meet their pedagogical goals. This manifests in the form of knowing clearly who to approach for constant technical needs, and involves establishing working relationships with technicians and administrators, two groups of people teachers are not traditionally close to. Contextually, however, these groups of people might not necessarily function within the confines of the school. Often times, they could be players who function either at the district or state level. In such circumstances, if teachers want to succeed in their endeavors, it is critical they possess some degree of awareness as to who these players (technicians and administrators who can make or break a project) are and how they might be approached for classroom needs.

Sometimes, however, being socially savvy also requires being astute and judicious about the needs of other colleagues in the school system. This is especially pertinent in the case of developing countries, where there is a constant scarcity of resources. In such situations, one computer laboratory meets the needs of several grades and teachers. Then, success becomes a function of a teacher's ability to adequately use the resources for their own goals, while being sensitive to the needs of other teachers. Challenges begin to emerge when one teacher attempts to monopolize resources for their own classroom needs with very little regard to the needs of others. A fall-out of such a practice might even lead to a lack of cooperation among educators and ultimately result in the failure of the project.

Zhao et al. (2002) place these factors within the broader umbrella of the domain they call "innovator" or teacher. While individually, each of these factors affects the degree to which educational technologies are utilized for curricular purposes, they also interact with one another to mediate the direct impacts of each other. For instance, positive attitudes toward technology will influence the extent of proficiency a teacher is able to acquire and vice versa. Likewise, attitudes and proficiency are closely tied with teacher perception about the role of technology to further their educational goals. One can argue that if teachers believe educational technologies align with their educational beliefs, quite likely they will make the effort to obtain the necessary skills to become dexterous at it.

The Innovation

The second domain affecting technology integration is what Zhao et al. (2002) term "innovation," or the actual educational technology project being implemented. Affecting the success of any ICT-based educational project (innovation) are two sub-domains: distance and dependence. Distance, in turn, consists of three components: distance from the school culture; distance from existing practice; and distance from available technological resources. The first two factors slightly overlap with the innovator domain, in that success of any innovation depends substantially on the extent to which the goals of the innovation align with the pedagogical goals of teachers. With distance, therefore, the likelihood that an innovation will succeed or fail will depend first, on whether it deviates or conforms to the dominant set of pedagogical practices of teachers and administrators in the school; and second, prior pedagogical practices of those teachers directly invested in the innovation.

Extending the above logic, an innovation typically fails due to a disconnect between the overall objectives established for a project and the fundamental pedagogical goals of the stakeholders involved (Ertmer, 1999; Lim & Chai, 2008). For instance, let us assume a scenario where an innovation requires the participation and cooperation of several teachers within a school. For the project to succeed, one presupposes there must exist sufficient buy-in and a cohesive strategy among teachers to bring the innovation to fruition.

Another critical factor within the distance sub-domain affecting success and failure of projects is a teacher's prior background and involvement in the innovation in question. Most successful projects are those which are a variation of something that the teacher has been previously involved with. Using technology to facilitate the extension or enhancement of an existing project, rather than getting engagement in something altogether new, improves the chances of success.

The third element within the distance component comprises the adequacy of technical infrastructure. ICT-based educational projects thrive on the existence of necessary infrastructure. In developing countries, this is perhaps the single most important factor affecting the success or failure of educational technology projects. However, apart from fundamental physical infrastructural requirements of projects, it is also critical that all the processes associated with the smooth uptake of a technological project are in place prior to take-of. This includes peripheral infrastructure and the existence of a competent team that can address impromptu technical issues in a timely and suitable manner. When such factors are missing, what starts thereof is a never-ending cycle of glitches and hurdles that make success almost unattainable.

Zhao et al. (2002) describe the second sub-domain within innovation, dependency, as the degree of reliance on tools and people not directly under the control of the innovator. Logically, projects that are largely self-contained and have minimal reliance on outside resources tend to do remarkably well in comparison to others that rely on the support of outside parties. Greater dependency on outside players results in challenges that result from realigning priorities among the various stakeholders. This is extremely tricky because often times those directly invested in the innovation have very little control over others, and thus maneuvering such divulging interests into one common path is both difficult and demanding.

School Context

The third domain that can be applied to the framework is the school context, which is the seat of the innovation. Within the school context, the three factors that determine the success of a project are: human, technological infrastructure, and social support. The relationship between technology integration and adequate availability of human and technological infrastructure is well known. Human infrastructure goes beyond the minimal requirement of a trained teaching force. It involves the availability of responsive technical staff, and support personnel who can guide innovators in their efforts. Likewise, any ICT-based educational project requires functional and accessible infrastructure. Time is wasted when technological tools stop working. Accessibility is also critical because schools do not want situations to arise wherein there is a resource conflict between teachers.

In highlighting the significance of social support, Zhao et al. (2002) refer to the importance of peer support among teachers for projects to succeed. This criterion ties back into the innovator and innovation domains, which highlight the interdependency between the realms for success. If projects require peer support, then innovators must gather sufficient buy-in. However, the fall-out from a great deal of dependency on outside resources is there is very little control that the innovator can exercise, which jeopardizes the chances of success.

As already highlighted above, while the individual significance of these domains and their relationship to technology integration is fairly pronounced, the inter-relationship between the components of each domain and the domains themselves also impact the degree to which an ICT-based project is successfully implemented. Among the three domains, Zhao, et al.'s (2002) research concluded that innovators had the greatest explanatory power in determining success or failure of ICT-based educational projects.

Policy

Expanding on the Zhao et al. (2002) model, Groff and Mouza's (2008) Individualized Inventory for Integrating Instructional Innovations (i^5) framework adds three other domains as vital in affecting the success or failure of instructional technology projects. These are: legislative factors or policy, student-centric factors, and technology, making allusion to problems arising out of hardware and software issues that result in implementation delays. As noted above, the two domains of innovation and context already include technological factors that explain how and to what extent teachers engage in techno-centric practices in the classroom. As a result, singling out technology as a separate domain, in my opinion, is repetitive. Further, since this study attempts to understand technology integration solely from a teacher's point of view, student-centric factors have been consciously left out of the model.

The fourth domain that is applied to the conceptual framework is policy. Groff and Mouza's (2008) argue that in the past few decades, policies in general have justified the use of technology in education on the basis of three rationales: (1) it will address existing challenges in teaching and learning; (2) it will lead to changes in content and quality of teaching; and (3) it will prepare children for a more technology-savvy world. But what has been conspicuously missing is a clear articulation of how these will be achieved. The lack of a clear action plan also ties back to the challenges of whether innovators, on whom the majority of the burden of implementing the innovation lie, are equipped and trained to create ICT-based educational content for their students. Such a situation brings to the fore issues of teacher training and adequate infrastructure, matters that must be dealt with at the policy level.

However, policy, in this study, is defined differently than used in Groff & Mouza's research. More broadly, this factor concerns itself with the policy climate as it exists in the research setting where CAL was implemented. This, directly, relates to how abrupt policies such as multi-grade multi-level (MGML) learning inundate teachers with additional workload that often throws them off-track from pursuing any one education intervention in its entirety. As will be discussed later, the state government of Chhattisgarh's decision to suddenly expand MGML to include more grades not only had negative implications on teacher time, it also necessitated overhauls in content creation and delivery. Although, one might argue that policy-level changes impact teachers equally across the different schools being studied, the argument that this research tries to make is that its impact can be mitigated by the level of independence exercised by school principals in lessening the stringency he or she might impose on their teachers to implement such changes.

Resulting Conceptual Framework

The four domains described above: innovator, innovation, context, and policy, together create a theoretical framework for understanding factors that affect the process of technology integration. The model, depicted in Figure 2, assumes that while each of the domains individually explain the degree of technology integration occurring in classrooms, there also exists a point of intersection between the domains that mediates each of the individual impacts.

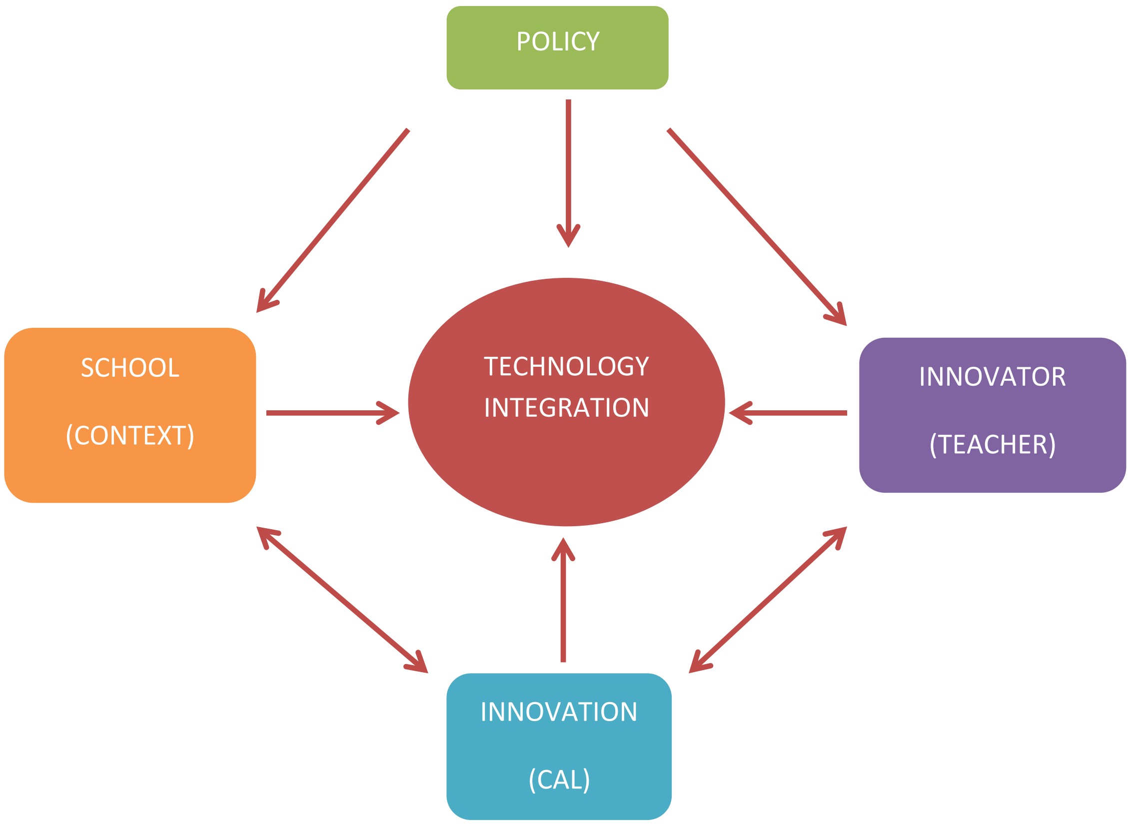

Figure 2: Conceptual Framework for factors affecting Technology Integration

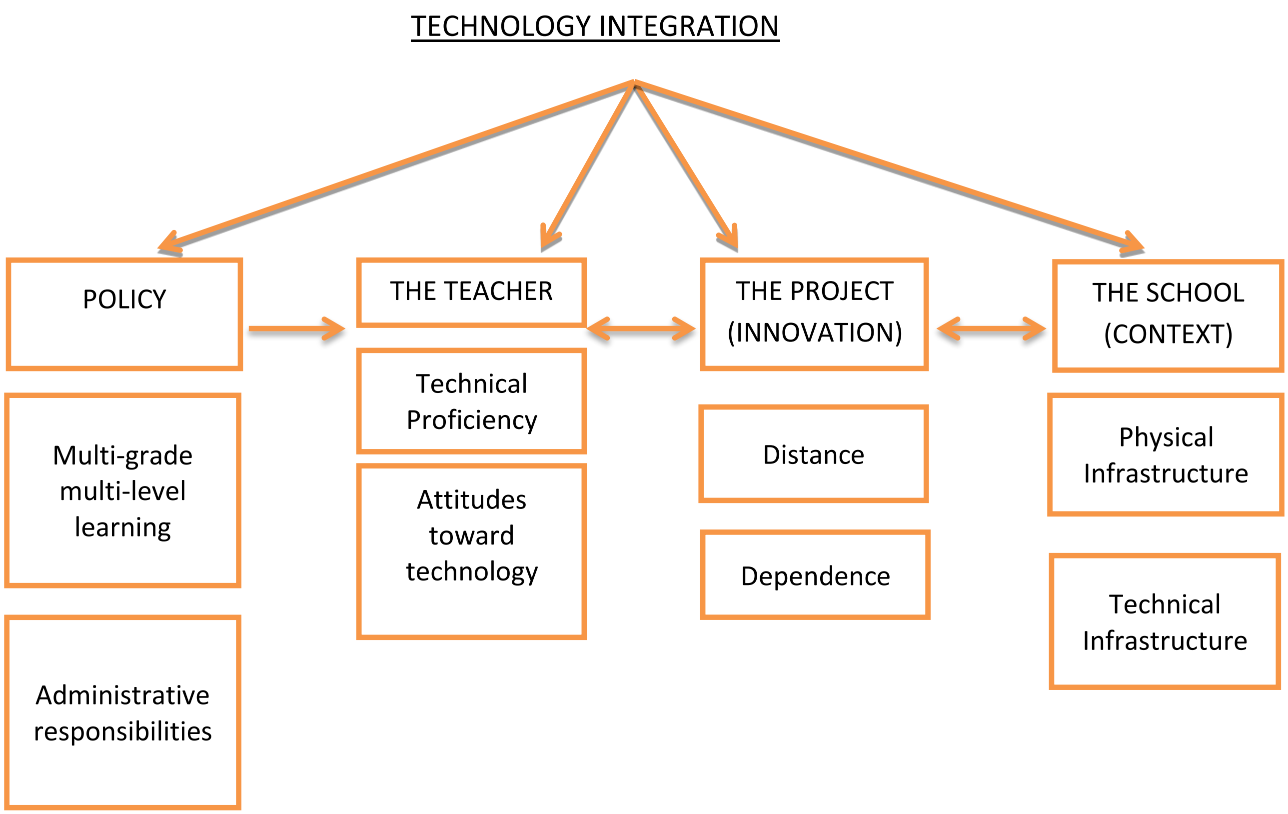

Figure 3: Sub-domains of Factors Affecting Technology Integration

In summary, the various components described in the model above are: policy, school context, innovation, and innovator. As depicted in Figure 3, each factor comprises several nuances that affect technology integration on the whole. In retaining the relationship between policy and technology integration, this study investigates whether a lack of clarity at the policy level jeopardizes a teacher's chances of innovating with technology in the classroom. An absence of clarity often manifests in the form of several simultaneous interventions that policymakers enforce on school administrators and teachers, often unaccompanied by a clear sense of objectives and directions. The innovator, on the other hand, determines the relationship between teacher attitudes and technical proficiency on technology integration. It also explores how technology aligns with teachers' pedagogical beliefs to influence their commitment to the process of technology integration. The third domain pertains to the innovation. As suggested in the literature, an innovation is likely to succeed when it aligns with the broader goals of the school where it is being implemented. Additionally, success is also functional on teachers' ability to exercise some degree of autonomy and self-sufficiency in innovating with ICTs within the classroom. This follows the logic that an increase in teacher dependency on project personnel is detrimental to the success of a project. Lastly, factors associated with the school are vital to the process of technology integration. Whether a teacher is able to innovate with technology depends to a great deal on the kind of support he/ she enjoys from the school administration and his/ her peers. Also critical in the level of preparedness the school enjoys with respect to physical and technical infrastructure.

Chapter 3: Methodology

In this chapter, I present the research design, program focus, unit of analysis, and survey tools used to collect data. Subsequently, I also elaborate on the pre-testing mechanisms, data collection, and analyses used in this study. Finally, I address issues of validity, credibility, transferability, and research ethics as pertinent to this study.

Purpose

As stated earlier, the purpose of the study is to examine the conditions necessary for technology integration within the classroom, highlighting infrastructural, social, cultural, and policy-relevant nuances that either aid or constrain the process. Further, the aim is also to engage in a debate around the overarching question of whether technology fosters more exploratory or constructivist practices on teachers? This study scrutinizes these two issues through two core research questions:

1. What are the factors or conditions that either hinder or facilitate a teacher's ability to successfully integrate technology with the classroom curriculum?
2. Are there observable differences between E1 and E2 schoolteachers in the extent to which they engage in constructivist pedagogy in the classroom?

The first research question serves to highlight challenges that hinder the creation of effective technology-based learning environments. This is especially relevant at a time and age when technology-based educational reforms have become ubiquitous. What has been disheartening, however, is that despite the enormous strides made in making technology accessible to schools around the world, usage has been disappointingly low. Such a trend begs the question, "What are the issues that prevent teachers from using technology more frequently and regularly?"

The second research question examines the efficacy of technology in encouraging teachers to engage in student-centered teaching practices. This question directly builds upon the literature on constructivism and technology and examines the claim that teachers with a strong constructivist bend of mind are more likely to use technology in the classroom. It slightly reverses this relationship to examine if the teaching styles of teachers, who have access to technology, are more likely to be associated with constructivist pedagogy than their peers who do not have access to similar tools?

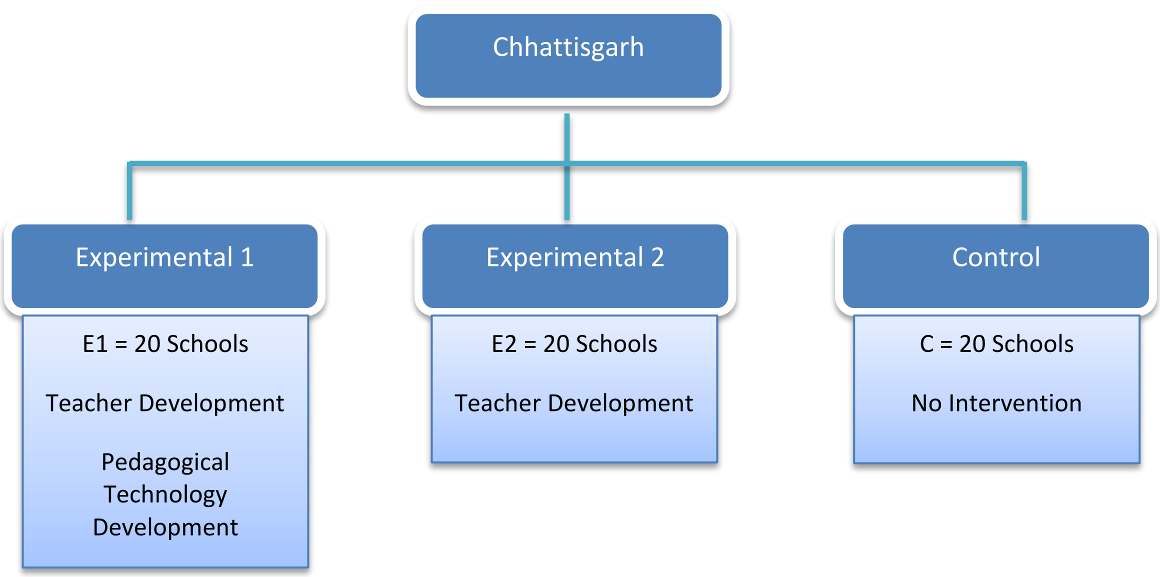

Figure 4: Computer-Aided Learning Program research Design in Chhattisgarh

Between 2008 and 2011, Kurud Block in Chhattisgarh was the setting for a three-year educational intervention program called Computer Aided Learning (CAL) Program, ending in March 2011. The intervention had two components: first, a computer-based component that would supplement a teacher's efforts in the classroom while also allowing students to engage in active learning processes; second, a pedagogy component that empowered teachers to invest in learner-centric processes in the classroom.

In 2008, CAL was initiated as a research study, wherein 60 schools were selected as research participants (see Figure 4). These schools were randomly divided into three groups of 20 schools each. In the first group of experimental schools (called E1), teachers were offered both teacher development and pedagogical technology development. In the second group of experimental schools (called E2), teachers were only offered teacher development tools. The remaining 20 schools or C served as control, devoid of either input. For the purposes of this study, the data collection was confined to teachers in E1 and E2 schools.

The primary participants for this study were teachers in grades 3, 4, and 5 in nineteen E1 and eighteen E2 schools. The control group of schools was deliberately left out of my study because the focus was on teachers' ability to integrate technology in the classroom and its association with constructivist pedagogy. Since student outcomes were not the focus, the study only examined teachers and their teaching styles in the E1 and E2 group of schools. While overall, the program trained 220 teachers between 2008 and 2011, the data collection for my study was limited to only those teachers who had been in the CAL program for its entire duration. This resulted in a sample size of 94 teachers, of whom 82 responded favorably to the survey. As will be explained later in this chapter, two survey instruments were developed, one administered to E1 teachers and the other to E2 teachers. At the outset, an extensive review of the literature had served to identify factors and conditions necessary for successful utilization of technology and its integration in the classroom. The first survey was administered to E1 (technology and pedagogy) to gauge factors that aided or inhibited them in their efforts at technology integration. The second research question was focused on classroom teaching practices. The survey consisted of items that captured teacher views on traditional and constructivist pedagogy. This was administered to both E1 and E2 teachers to gauge if they differed in the extent to which they engaged in either traditional or constructivist pedagogy. Since E2 teachers did not undergo technology training, they were not administered the first survey.

Research Design

For several decades, positivist/empiricists and constructivists have engaged in debates regarding the superiority of quantitative or qualitative methods over one another. Positivists or those engaged in quantitative enquiry argued that research had to be objective, in order to allow for context-free generalizations, while also enhancing the validity and reliability of data. Qualitative researchers or constructivists countered the positivist argument by positing that research was constantly value-bound and therefore objectivity, in a pure sense, could never truly be achieved. Additionally, reality, they argued, was multiple and subjective. As these debates raged, there were calls for reconciliation between the paradigms. Eventually, many positivists and constructivists have reconciled on issues like:

> "(a) the relativity of the "light of reason" (i.e., what appears reasonable can vary across persons); (b) theory-laden perception of the theory ladenness of facts (i.e., what we notice and observe is affected by our background knowledge, theories and experiences; in short, observation is not a perfect and direct window into "reality"); (c) underdetermination of theory by evidence (i.e., it is possible for more than one theory to fit a single set of empirical data); (d) the Duhem-Quine thesis or idea of auxiliary assumptions (i.e., a hypothesis cannot be fully tested in isolation because to make the test we also must make various assumptions; the hypothesis is embedded in a holistic network of beliefs; and alternative explanations will continue to exist); (e) the problem of induction (i.e., the recognition that we only obtain probabilistic evidence, not final proof in empirical research; in short, we agree that the future may not resemble the past; (f) the social nature of the research enterprise (i.e., researchers are embedded in communities and they clearly have and are affected by their attitudes, values, and beliefs); and (g) the value-ladenness of inquiry (i.e., human beings can never be completely value free, and that values affect what we choose to investigate, what we see, and how we interpret what we see)." (Johnson & Onwuegbuzie, 2004, p. 16)

Gradually, mixed methods emerged as the third research paradigm following a long history spanning several decades. Creswell and Clark (2007) divide the history of mixed methods research into four, overlapping time periods. During the formative years, spanning the 1950s up until the 1980s, the issue of merging paradigms emerged, gaining gradual momentum as many researchers questioned the possibility of mixing both forms of data. With the 1970s and 1980s, also termed as the "Paradigm Debate Period" (p. 15), qualitative researchers like Guba and Lincoln, argued that both quantitative and qualitative research were driven by very separate sets of assumptions. Thus, merging of the two was untenable. This point of view formed the basis for the incompatibility thesis (Tashakkori & Teddlie, 1998). While debates continued, especially about which method was the foundation for mixed methods research, by the 1980s attention shifted on issues such as procedures and methods for designing such mixed methods studies. Several researchers like Creswell (1994) and Tashakkori and Teddlie (1998) created typologies of different kinds of mixed methods designs and provided illustrative examples. By the turn of the millennium, interest in mixed methods research was perhaps at its highest and that surge has continued.

Today, contrary to the purist point-of view, the perception that has evolved is that quantitative and qualitative paradigms are mutually compatible and mixing of the two is indeed possible. Mixed methods research is defined as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (Johnson & Onwuegbuzie, 2004, p. 17)

Although purists, averse to mixing paradigms, exist to this day, there also exists "situationalists" (Creswell & Clark, 2007, p. 15) and "pragmatists" (Tashakkori & Teddlie, 1998, p. 5) who either adapt their research methods or believe that paradigms can indeed be merged to study a research question. Johnson and Onwuegbuzie (2004) even argue that there is a stronger need for pragmatists and a harmony between paradigms because that will lead to greater communication between researchers, ultimately essential for advancement of knowledge. Advocates also argue that the appeal of mixed methods lies in its ability to offer an "intuitive way of doing research that is constantly being displayed through our everyday lives" (Creswell & Clark, 2011, p. 1).

The overall research design for this study was a convergent concurrent mixed methods design. Onwuegbuzie and Johnson (2006) summarize that the concurrent mixed methods design comprises four basic steps: (a) the quantitative and qualitative data are collected separately but simultaneously, (b) one source of data (e.g., quantitative) does not build on the other source of data (e.g., qualitative) as it would in a sequential design (c) both sets of data are analyzed separately, and (d) the interpretation from the quantitative and qualitative components is merged at the integration stage. A prototypical version of the convergent parallel design is presented in Figure 5.

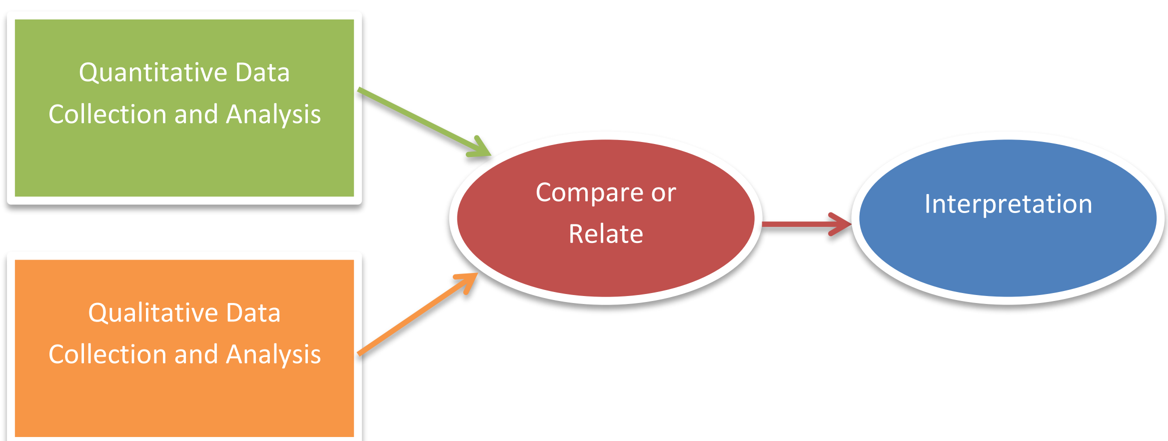

Figure 5: Prototype of Convergent Parallel Mixed Methods Design (Creswell & Clark, Designing and Conducting Mixed Methods Research, 2011, p. 69)

During the data collection phase for this study, the quantitative and qualitative strands were implemented simultaneously but separately. A survey instrument was developed to collect quantitative data, which was subsequently pretested on the field prior to being scaled up to 37 villages in Kurud Block[6]. Simultaneously, a series of interviews was conducted with eight E1 teachers to gauge and understand implementation challenges, and how CAL had impacted their teaching endeavors on a daily basis. While the level of interaction between the two strands was kept independent during the collection and analysis phase, the mixing or "point of interface" occurred at the inference stage.

The advantages of a convergent parallel study lay in its ability to make efficient use of time. A study of this nature is most suitable when time is limited and the researcher must collect both strands of data in one field visit, as was the case with this study. Additional advantages pertain to the fact that it is extremely intuitive, and allows the researcher to collect and analyze data separately thereby utilizing the techniques traditionally associated with each strand (Creswell & Clark, 2011).

Data Collection and Analysis

Since this study utilizes mixed methods inquiry to explore the above-stated research questions, both qualitative and quantitative data were collected. Quantitative data was obtained through the administration of a survey instrument developed to capture factors affecting technology in the classroom as well as teaching practices of E1 and E2 teachers. Subsequently, eight E1 teachers were selected for in-depth interviews and observations with the purpose of

[6] Block is a sub-division of a district in India

complementing and explaining the quantitative findings. The interviews were structured around six issues: 1) how did they [teachers] define CAL; 2) what, according to them, was CAL's biggest contribution; 3) how were they using computers; 4) how did they define teaching and learning; 5) had their views on teaching changed during the duration of CAL; and 6) concerns surrounding the implementation of CAL. The interviews were 30 to 90 minutes long and were recorded using an audio recorder. During my school visits to schools, I also observed students in the classroom and computer laboratory.

Quantitative Data

Two survey instruments were designed for the purposes of this study. While the first (Survey 1) was designed to capture conditions and factors influencing a teacher's ability to integrate technology in the classroom, the second (Survey 2) aimed to measure the extent to which teachers were investing in traditional or constructivist pedagogies in their day-to-day teaching endeavors. The typologies used in both surveys were identified after an extensive review of the literature on technology integration and instructional teaching strategies. Below, I elaborate on both.

My review of the literature produced five critical factors that influenced technology integration in the classroom. On that basis, the original Survey 1 consisted of 90 questions, divided into five subscales, designed to measure the five constructs identified in the literature as significant conditions. These were: personal characteristics, technology proficiency, attitudes toward technology, infrastructural factors, and school-level factors.

Under personal characteristics, items on Survey 1 consisted of both endogenous (external) and exogenous (internal) components. The exogenous composition of teacher characteristics included basic demographic information, such as age, sex, educational background, professional experience, and past experience in the use of computers. Apart from these, two subscales were designed to capture endogenous elements measuring teachers' proficiency and confidence, and beliefs and attitudes toward computers.

The subscale on infrastructural barriers referred to school-level factors that facilitated the technology integration process. The majority of the literature has until now defined institutional support as school assistance in technical and administrative issues as well as providing adequate infrastructure. In India's context, a functional ICT-based educational program should also involve attention to matters such as power back-up to ensure uninterrupted usage. To capture this and more, Survey 1 measured availability of and access to functional technology tools, availability of technical support and training both inside and outside the school, student to computer ratio, power availability and back-up, and constant maintenance in case of technical breakdowns. In including items measuring school-level conditions, the purpose was also to capture the school environment and context within which the program was being implemented. The descriptive phrases and items were so developed to capture school policy and legislative factors that were perceived by teachers to be either supportive or hindering to their ability to engage in technology-based educational practices.

A sixth subscale, included in the survey, captured the outcome variable of interest, which was technology integration. As evidenced in Table 1, technology integration has three principal dimensions. The first refers to the use of technology for non- instructional purposes. In this category, teachers use technology primarily for administrative and communication purposes. Examples of such activities would include using technology for grade-keeping, attendance, communication with peers, and maintaining one's itinerary. The second category involves technology use for instructional purposes. Within this, activities such as using technology to prepare class lectures, Internet-based research, using the projector, using applications such as Word, Excel, and Powerpoint, sieving through educational CDs and identifying content that supplements classroom curriculum would be some of the examples.

Table 1: Different uses of technology

Type of Technology Integration	Activities involved
Instructional use of technology	Encompasses activities such as: • Lesson planning • Lecture presentation • Research for lesson planning • Peer-to-peer collaborations within and outside of the school
Non-instructional use of technology	Using technology for: • Record-keeping, such as grades, and attendance • Performing administrative duties • Communicating with parents
Technology as a learning tool	When children start using ICTs to: • Collaborate with peers • Engage in group work for classroom assignments • Use technology to enhance their critical and higher-order thinking, and problem-solving abilities

Technology use as a learning tool is distinct from instructional and non-instructional use, in that it puts children at the center of the learning process, as opposed to teachers. When children start using ICTs to improve their understanding of coursework, enhance their critical and higher-order thinking, and problem-solving abilities, technology becomes useful as a learning device. Within this category are included activities that enhance a student's learning through the use of technology.

Apart from questions on background characteristics, the majority of the survey instrument consisted of behavioral and attitudinal questions. For behavioral questions, I used both frequency scales and vague quantifiers to measure “how much” and/ or “how often” teachers engaged in a certain activity. Frequency scales were used because they are better than simple yes/no options as they offer a relatively accurate measure to respondents in reporting behavioral frequencies on a numeric scale. Further, approximate ranges were used—for instance, once a month and once a week instead of actual numbers on a numeric scale. While from a respondent’s perspective, the frequency scales would be faster and easier to complete, from a researcher’s perspective, they were beneficial at the coding and data analysis stage.

As is known, in order to minimize errors, the literature on survey research and methodology endorses the use of a reference period against the behavior that the researcher is trying to measure. Most importantly, reference periods stimulate recall. For questions gauging frequency of computer use, the initial draft of Survey 1 contained ‘the past month’ as the reference period. Fowler (1995) advises caution in the use of different types of reference periods. For example, in using two reference periods—day versus a week—he argues that there were advantages and disadvantages for both, and the efficacy of each strategy had to be tied into the overall research question. Thus, while a reference period of one-day might result in more accurate recall, if the purpose of the survey was to gauge behavior patterns, then data on one day was not a very good way to characterize an individual. I used this logic when using the one-month reference frame because the purpose here was to gauge patterns of computer use among E1 teachers. However, during pre-testing and actual scaling up of the instrument, it became evident that the majority of the participants had stopped using computers in the current academic period. Therefore, to understand their prior computer usage, the survey was modified to encourage teachers to recall their activities in the previous academic year.

Overall, the survey consisted of a series of positive and negative statements to capture teacher attitudes towards technology, technical proficiency level, and school-level support. I used verbal rating scores on a 5-point Likert scale as response options. Although, the literature on survey methods suggests a 7-point scale is the best in terms of reliability, a seven plus or minus two is what is generally recommended (Schwarz, Knauper, Hippler, Noelle-Neumann, & Clark, 1991).

In designing Survey 2, the primary purpose was to capture the teaching practices of both E1 and E2 teachers. This survey comprised descriptive phrases for both traditional and constructivist teaching strategies, which were developed after a careful examination of the literature on instructional teaching strategies. Items for both subscales were interspersed equally in the survey. The objective was to ensure consistency in teacher responses, the premise being that teachers who scored high on items measuring traditionalism would correspondingly score low on items measuring constructivism. By mixing these items, the goal was also to ensure that teachers read the survey carefully and were cognizant of the contrasting objectives of each of the phrases.

Content Validity of the Survey Instruments

Prior to piloting the surveys, both instruments were discussed in meetings with an APF official in Bangalore and field officials in Chhattisgarh. The purpose of both these meetings was to revise the instruments, as needed, to reflect the context within which CAL had been implemented, while also clarifying any misconstructions in the instrument, including word choice and relevance of typologies. Some modifications were suggested to accommodate the changing policy climate that made some of the items on the survey either redundant or unclear.

These changes arose predominantly due to the introduction of the multi-grade multi-level learning program (MGML), a state-led parallel intervention that suddenly complicated the purpose of certain items on the survey capturing demographic characteristics of the respondents. Multi-grade schooling, in many parts of the developing world, is frequently proposed as a solution to problems associated with educational access. Often, schools challenged by geographic isolation, low student enrolment, and very high teacher absenteeism cannot justify the need for one teacher per grade level. In such schools, teachers are forced to have a responsibility for two or more curricular grades simultaneously. It is roughly estimated that approximately 180 million children around the world go to multi-grade classrooms (Little, 2009).

E1 and E2 schools have implemented MGML by collapsing grades 1 through to 4 into one grade. However, to guarantee that teachers are left with manageable class sizes, the schools have followed one of two options for the actual implementation of the program. In the first scenario, the entire pool of children is divided into four sections and each teacher is made responsible for a particular section and is required to teach all four subjects: Hindi, Math, Environment Science, and English. In the alternate scenario, teachers are responsible for a particular subject. As a result, during the course of the day, the teacher moves from one classroom to another teaching that specific subject.

The challenges that arose due to MGML and specifically for the purposes of the data collection was that items like “subject taught,” “grade taught,” and “number of students in class” became fluid. In adhering to the first option, teachers were teaching all subjects, while in the second scenario, teachers were teaching a varied number of students as the day progressed. The second issue proved more problematic because in the current situation, it was unlikely that the survey would be able to gauge the true pupil-teacher ratio. In spite of the challenge, it was decided that these items would be retained in the surveys just to make sense of the school context teachers were exposed to on a daily basis.

The initial draft of Survey 1 contained an entire section on computer skills and expertise both from the teacher's perspective as well at the student's. This section was modified to include all the technical tools imparted as part of CAL, and also altered for the terminologies used to measure the respondent's technical competency. For instance, items like "using computer to make presentation" was simply altered to "use Powerpoint" because it was felt that teachers would relate to the latter.

For the items measuring teacher attitudes, technical proficiency, technology integration, and pedagogical methods, the staff concurred that the items used in both surveys were worded correctly and properly classified as descriptive of the constructs that were being measured. Additionally, the field staff also suggested some additions to the section on pedagogical practices, especially to incorporate some of the language-based pedagogical training that was offered to teachers in both groups of schools.

Pre-testing Survey 1 and Survey 2

Having incorporated the feedback from both meetings, the surveys were pre-tested on three E1 teachers. Pretests are useful in examining validity of survey items and identifying the reasons that cause response errors. While many methods exist to gauge the veracity of question items, I chose to conduct cognitive interviews to pre-test the survey instruments. The advantage of cognitive interviewing lies in its ability to allow for detailed analysis of individual items on the survey (Desimone & Le Floch, 2004). The process offers the researcher an opportunity to understand respondents' thought-process as they decode the questions on the survey. Further, in using the process on several respondents, the researcher is able to identify whether there exists a shared or conflicted understanding of items being asked on the survey.

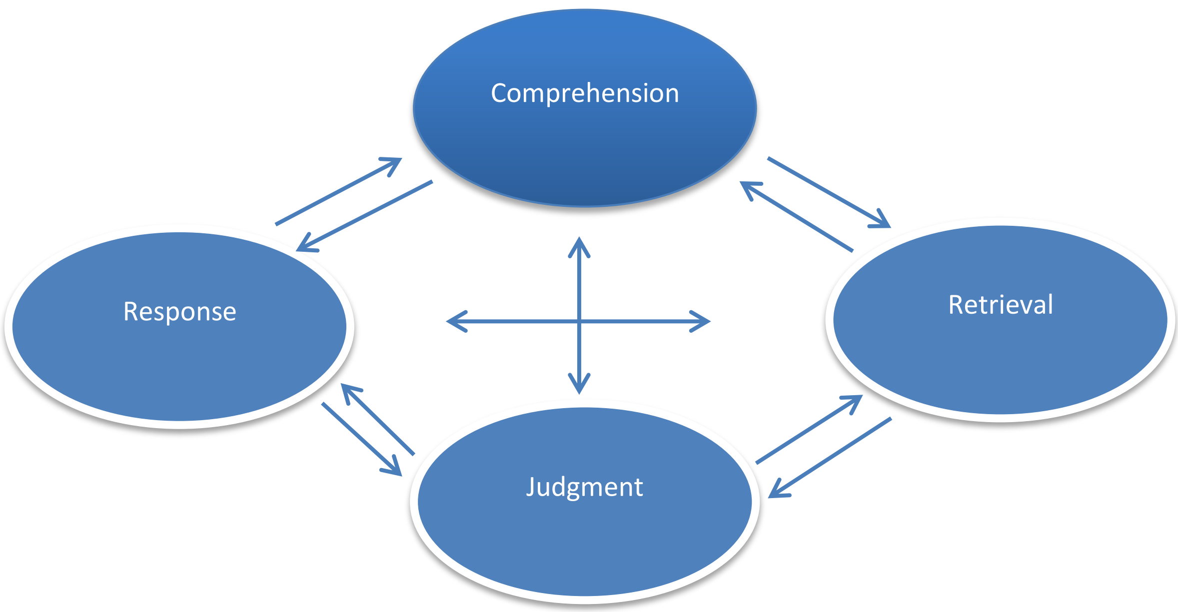

Figure 6: Elaborated Question-and-Answer Model (Collins, 2003, p. 232)

The theoretical underpinning of cognitive interviewing suggests that the respondent goes through a four-stage response process to answer a question. Broadly, these are: comprehending the question, retrieving the information required to answer the question, making a judgment based upon recall, and finally responding to the question. Collins (2003) argues that this process is not necessarily linear and goes through several iterations between the stages as depicted in Figure 6.

Cognitive interviewing allows the researcher to identify at what stage or stages the respondent faces a roadblock and how, therefore, the items must be modified to ensure uniform comprehension across the respondent base. Desimone and Le Floch (2004) posit that findings drawn from the process can enhance the validity of the instrument by "identifying those response errors that the respondent may commit by misinterpreting the question, forgetting crucial information, making erroneous inferences by mapping irrelevant memories, or reporting with social desirability response bias" (p. 7).

Three teachers from E1 schools were selected as interviewees during the pre-testing of the survey instruments. The decision to test the survey on E1 teachers alone was based on the premise that Survey 1 was more comprehensive of the two surveys and already included the demographic and pedagogical subscales that Survey 2 contained. Of the three interviewees, one was a veteran teacher, Kumar, who was also the principal of his school, while the other two: Veena and Banu, had spent less than 3 years in the profession. The interviews took place in their respective schools, where each participant participated in an hour-long session, engaging in "thinking aloud" while responding to the survey items and follow-up questions. Special attention was given to how the respondent comprehended the questions, the kind of recall strategy used, and whether his/her response matched with the response categories provided on the survey. The respondents offered significant comments by verbalizing their though process while reading the items on the survey.

The two subscales that resulted in the maximum number of feedback were pedagogical practices and school environment. Some items on the pedagogical subscale highlighted a certain degree of complexity in comprehension. For instance, on the item asking: "I encourage my students to memorize course material," Kumar offered:

> I suppose it would depend on the content I was teaching. I would expect my students to memorize certain things. For instance, when I am teaching environmental science, I would expect my students to memorize the names of plants. Those names are just there. You cannot call a plant by a different name. But when I am teaching Math, tables more particularly, I would expect them to understand how multiplication works. You can easily memorize 2 times 2. But it gets a little complicated when you have larger numbers. For such instances, it’s always better to understand. So I would say it really depends on what I’m teaching.

Based on this feedback, it was decided that the items on pedagogical practices would be simplified by specifying the subject on which changes in pedagogical behavior was being measured, notably language and math the two subjects on which the CAL intervention was introduced.

The section on pedagogy also exposed challenges arising out of social desirability bias. Through the CAL intervention, it was obvious that teachers had been exposed to the dissimilarities between traditional and constructivist teaching and therefore were aware of what was socially desirable behavior in the classroom. This became more apparent when during follow-up probes I asked them to give tangible examples for items like “I encourage group activity among my students”, “There can only be a single interpretation of mathematical concepts”, “While lesson building teachers must keep their student’s background in mind” etc. Their inability to provide examples was problematic and it was decided that during the scaling up process of the actual survey, teachers would be randomly selected to qualify their responses on the pedagogical subscale.

A critical feedback received during the interviewing was that teachers made very clear distinctions between school-level support, as evidenced by how their principal or head teacher backed them and government support, which was often viewed as prescriptive and authoritarian. The two teachers expressed contrasting views, especially in MGML’s context, which underscored the need to revise parts of the school environment subscale to accommodate these contradictions.

> The problem is, they (the government) suddenly introduce something like MGML and expect us to follow. They conduct regular checks, sending one person at regular intervals to enquire if the policy is being implemented. It is not always easy to follow what they ask of us because we are severely deficient in the kind of infrastructure needed to implement MGML. So I complain to my head teacher and he understands. He gives me the liberty to teach the way I want to and takes care of the situation when someone from the government comes enquiring. This way, he encourages me to perform better. I get the time to explore how the computer can be used to make learning more fun for my students. I do not feel rushed for time and I also don't feel pressurized in my job. So the support that you ask of can come from my head teacher or the government. I personally feel that my head teacher is extremely supportive of me. I don't feel that way about the government. (Veena)

> In any given day, there are several things that I am required to do. Apart from teaching, I am also expected to perform administrative tasks. In addition to that, I have to use the computers for my teaching. Then, the government suddenly comes up with MGML. There is a radio-English program that I am supposed to play to students during noon. Not to mention that if my name comes up, I need to collect census data for the government. And if I complain to my principal, he says that these are requirements that I must fulfill. If I complain to the master trainers, they simply nod. There is absolutely no support. They don't understand what I go through and it is extremely frustrating. (Banu)

The initial draft of Survey 1 asked respondents to respond to phrases descriptive of support in general, inclusive of both school-level and government-level provisions. However, following the pre-testing, it became essential to capture the merits of both as separate from each other and for the survey items to distinguish between school-level support and legislative support, both of which could collectively and individually have a bearing on a teacher's ability to integrate technology. The descriptive phrases on the school environment subscale were subsequently revised to separate these two factors by specifically asking about school support and legislative support.

Scaling up Survey Distribution

After incorporating the feedback following the two meetings with APF staff and pre-testing of the instrument, the survey was scaled up for distribution to 20 E1 and 20 E2 schools. As mentioned earlier, only those teachers who had participated in CAL through its entirety were selected as respondents. Between July and September, 2011, I traveled to the 40 school locations to self-administer the survey to 82 teachers.

To minimize classroom disruption, APF officials in Bangalore initially suggested that having formulated a travel plan based on proximity of schools, the surveys be dropped off at the respective schools and collected a day later. However, field personnel rejected this plan on grounds that teachers might either forget to complete the survey, or simply copy their answers from their peers. Based on this feedback, APF field personnel identified a travel plan for me, wherein a cluster of schools, selected on the basis of geographic proximity, were targeted for data collection each day. In devising the plan thus, I also had the scope to revisit those schools where respondents may have been absent on the day the first survey administration had been conducted. In addition, the majority of the visits were planned either prior to the start of the school day or during lunch break to ensure that teachers did not lose class time.

The teachers were asked to complete the survey recalling their teaching habits in the previous academic year (2010-2011). This was essentially done because CAL, as an intervention, officially ended in March 2011, although teachers were offered on-site support until the very end of the academic year.

Survey Responses: Challenges

A severe challenge to the survey administration was widespread teacher absenteeism among respondents in both E1 and E2 schools. There was some pattern to the absenteeism observed among female teachers. The majority of female teachers were absent on account of impending due dates on their pregnancies. The Chhattisgarh government grants maternity leave to female government employees for a period of 135 days, if she has fewer than two surviving children. In case of medical emergencies and irrespective of the number of surviving children, maternity leave is also offered to women for the duration stipulated necessary by their care provider. However, according to several male teachers, schools are not offered substitutes for the female teachers who are on maternity leave. Instead, the responsibility is borne by other teachers on the staff for the time that the female teacher is absent. Clearly, this issue was a cause for concern among male teachers who complained of time constraints such a situation posed on them.

Absenteeism among male teachers, on the other hand, was more random and it was often observed that their absence during the time I visited the schools was either due to them running personal errands or traveling to the district for official work on behalf of the school. In this case, female teachers raised concerns on the matter, saying that the head teacher often showed favoritism toward his male employees in allowing them to take time off during work hours to fulfill personal obligations. If female teachers did the same, one respondent complained, there were repercussions.

However, a third aspect that emerged was that often times teachers were absent because there was very little clarity about what constituted an official holidays. The time I traveled to the 40 schools to collect data, coincided with several Hindu festivals. Although not all occasions were designated official holidays, some schools either declared impromptu leave or teachers simply did not come to school. Unfortunately, these decisions were not always conveyed to students. During two occasions, I observed students present in class while the teachers had taken an unarranged leave. There was no one to substitute for the absent teacher. As a result, children sat in class either chatting or playing. Such situations, according to the principal, were not out of the ordinary. However, parents still preferred their children stayed back in school because they would at least receive free lunch as part of the mid-day meal scheme.

To maximize the response rate, I arranged for school revisits to meet the teachers who were absent on the original day the instrument was administered. The head teachers were also asked to notify the teachers and convey to them that I would be visiting on a later date to self-administer the survey instrument. In doing so, the study was able to counter some of the challenges posed by absenteeism.

During certain occasions, some school teachers were unavailable because the day of the data collection coincided with mandatory in-service teacher training program at the block headquarter. In order to reach out to this segment, the survey instruments were sent to the block office and teachers were asked to fill them out during breaks in the training program. The completed surveys were collected at the end of the day.

Of the 40 schools visited, 37 responded favorably (19 E1 and 18 E2 schools agreed to participate in the survey). While teachers in one E1 school refused to participate in the study citing a lack of time, data from two E2 schools could not be collected because the selected respondents were unavailable during the two attempts made to reach out to them. Overall, it was possible to elicit a substantial response from the schools, partly because prior to the actual administration of the survey, school head teachers were informed about the study being conducted. Additionally, in self-administering the survey, it was possible to convey to the teachers the need for such an assessment, while also ensuring that the respondents filled out the survey during the time that I was visiting. In doing so, responses were not lost on account of teachers either forgetting to fill out the responses or misplacing the survey instrument.

Table 2: Summary of Response Rates

School Type	Response	Number
Overall	Participation	82
	Non-Participation	12
	Total	94
E1	Participation	51
	Non-Participation	4
	Total	55
E2	Participation	31
	Non-Participation	8
	Total	39

Quantitative Data Analysis

I used a combination of descriptive analysis and interview data to explore what factors inhibit a teacher's ability to integrate technology in the classroom. Descriptive statistics was used to provide summaries about technology use among E1 teachers. This was supplemented with interview data that delved deeper into obstacles teachers faced that impeded their continuous use of technology. The results of the analysis are presented in Chapter 5.

To gauge group differences between E1 and E2 teachers, particularly on their ability to engage in constructivist pedagogy, I used exploratory factor analysis (EFA) and analysis of variance (ANOVA). As explained in detail in Chapter 6, two measures of pedagogy were created: first, a composite measuring constructivism was developed with the 8-item scale using a 5-point response format where 1 = “never” and 5 = “always”; and second, a composite measuring traditionalism was developed with the remaining 8-item scale using a 5-point response format where 1 = “never” and 5 = “always”. Both measures were tested for internal reliability using Cronbach’s Alpha. Having ascertained the reliability of the two scales, two separate composites were created by summing the values of the variables for each scale. Further, in order to determine whether a pattern had emerged between the two groups of teachers and their tendency toward constructivism or traditionalism, the averages for both constructs was disaggregated by assignment (E1 or E2). Subsequently, I used ANOVA to determine if E1 and E2 teachers differed in their scores on constructivism and traditionalism. Additionally, I used interview data to examine the teaching practices of E1 and E2 teachers. The purpose was to gauge if teachers had altered their teaching style and if yes, were those changes associated with CAL or other factors at play. The results of the analysis are presented in Chapter 6.

<u>Representativeness of Sample</u>

A total of 82 out of 94 teachers filled out their responses to the survey questionnaire, of which 51 belonged to E1 schools and 31 were E2 teachers. The response rate was 88 percent. The majority of the non-respondents were teachers who were absent during the time that the school visits were conducted. For a summary of the response rates, see Table 2 above.

Teachers were asked to respond to questions on demography, educational background, and years of teaching experience. Once a demographic profile of the teachers was established on the basis of the survey responses, it was critical to determine the representativeness of the sample data. This was predominantly done to ascertain whether there was concern for bias on account of non-representation of any participant population, while also to express the extent to which the sample accurately represented the population characteristics. The sample was compared against state-level data and national-level data on rural teachers to establish whether the sample characteristics were proportional to what is observed at the state and national level. Three criteria were used to make these comparisons: sex, age, and educational background. As is illustrated in Figure 7, the sex composition observed in the sample (male=62 percent, female=38 percent) was relatively proportional to both state (male=67 percent, female=33 percent) and national (male=59 percent, female=41 percent) data, with male teachers outnumbering female teachers in all three.

A lack of proportional representation was observed when the three datasets were compared on educational background and age composition of teachers. While the majority of teachers in the study's sample were high school graduates, a characteristic that was also observed in the data on rural Chhattisgarh, nationally, rural teachers are almost equally dispersed between high school and undergraduate[7] groups. Further, for both state and national-level data, teachers with a graduate degree constitute a minority, which is not the case in the study's sample.

[7] In India, an undergraduate degree comprises three or four years of education. Students pursuing a degree in the arts, commerce, and social sciences enroll for three years of undergraduate study, while those in the fields of technology engineering, and pharmaceutical sciences enroll for four years. Post graduate studies are an additional two years after the undergraduate degree.

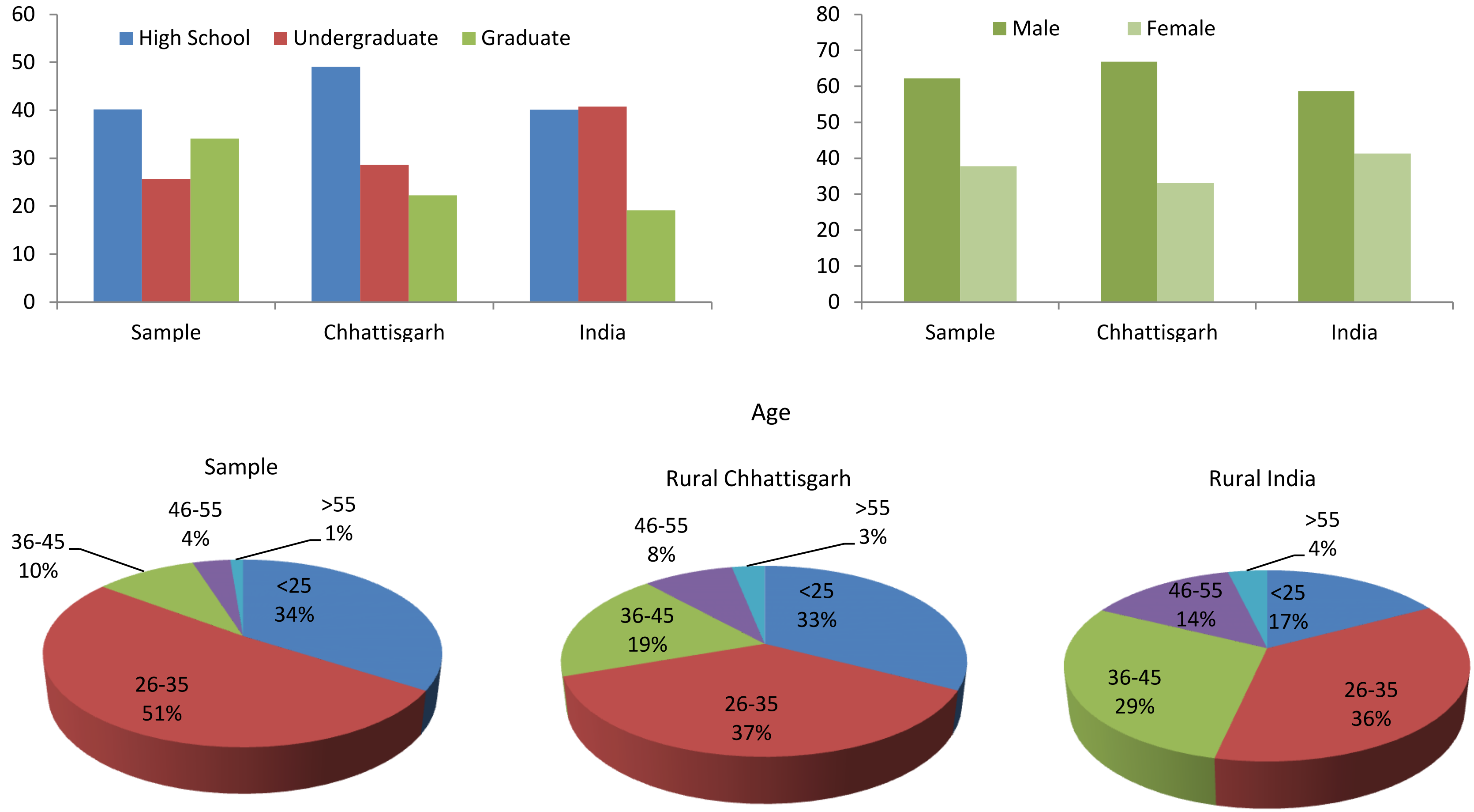

Figure 7: Representativeness of data: Comparison of Sample versus rural Chhattisgarh versus rural India by Educational Qualification, Sex, and Age of Teacher (in %)
Source: NUEPA. (2010-2011). Elementary Education in Rural India: Where do we stand? New Delhi: National University of Educational Planning and Administration

Some similarity was evident in the age composition of teachers in the three datasets. The majority of the teachers in the sample, state and national-level data belonged to the 26-35 age group. However, the sample is less-representative of the national-level data hereafter. While the second largest group of teachers in the sample is teachers who are below the age of 25 years, nationally, they are third largest group. The sample, however, is more reflective of the state-level data which comprises mainly of teachers in the age group of 26-35 years followed by the youngest segment of teachers who are of less than 25 years of age. While the lack of representation is recognized as a limitation of the study, it is also acknowledged that the issue was not completely unavoidable given the nature of the research question. This study's sample was specific to a particular group of teachers who had been recipients of a focused intervention.

Overall, the sample contained 51 male (62 percent) and 31 female (38 percent) teachers. In determining the profile of teachers in both groups of schools, the data revealed that while there was substantial variation in educational background of the teachers between the two schools, they were relatively similar in age, sex, and professional experience. As observed for the overall sample, the majority of E1 and E2 teachers belonged to the 26-35 age group followed by those who were less than 25 years of age. On examining the study's sample further, it was observed that E1 and E2 teachers similar in the number of years spent in the teaching profession. Most of the teachers from both groups of schools had spent less than 5 years in the teaching profession. The anomaly between age and years of professional experience exists because for several respondents teaching was a new career move, having formerly pursued different jobs in the private and public sector. On further examining the educational qualification of teachers, an issue that emerged was that nobody in the sample had any formal degree or training in education. The lack of trained teachers and the high number of teachers with only a high school diploma shed light on issues such as high teacher absenteeism, and at a more basic level the inadequacy of teaching staff in rural areas. In order to address the conflict presented by the growing number of students in rural areas without a corresponding increase in the number of teachers, Chhattisgarh and several other states in India, are encouraging the system of "para" teachers.

"Para teachers"[8] is a very fluid term and covers an entire gamut of teacher recruitment possibilities in schools and alternative learning centers. Broadly, para teachers are full time teachers working in regular schools but on a contract basis and are paid monthly wages much lower than what a regular teacher would get (Govinda & Josephine, 2004). This is simply done to meet the demand for basic education, while functioning within constrained financial resources. The government justifies such a system because in its opinion it offers the opportunity for universal primary education for children who would otherwise have to forego formal schooling altogether. Detractors, on the other hand, disapprove of this system because in their opinion it lowers the standards of educational quality by lowering professional training and educational qualifications of such teachers. They also criticize the dual salary structure, wherein the system pays these teachers much less than regular teachers within the same schools (Kingdon & Sipahimalani-Rao, 2010).

In Kurud block, many schools have hired para teachers. As is the system in other parts of the country, interested applicants take a test. Having secured the minimum requirement, they then undergo training and are offered tenure for a certain period of time, which can be further extended on expiry. Although on paper, the renewal of tenure is performance-based, 95 percent of para teachers in India are offered an extension (Govinda & Josephine, 2004). What is critical

[8] According to official accounts, there were approximately 514,000 para-teachers throughout India in 2006-07 (Mehta, 2007), and that number is steadily rising because of endorsement by the political leadership; i.e., teaching jobs are being used for election purposes

here is that by the teachers' own admission, the training is severely lacking in quality. This observation reiterated findings from past research on para teachers, which has concluded that often the training of para teachers is insufficient and saturated with traditional pedagogy. Pandey's (2006) research found that training programs for para teachers were focused less on quality and more driven by an emphasis on supply. Teachers in this sample reiterated this viewpoint and complained of a complete disconnect between what is presented to them at the training sessions and the reality of the classroom. I elaborate on the issue of para teachers in Chapter 4.

Qualitative Data

Qualitative data collection for the study relied on three methods: in-depth interviewing, direct observations, and review of documents (Marshall & Rossman, 1999). Eight E1 teachers were selected for in-depth semi-structured interviews to predominantly explore: what were the barriers to technology integration in E1 schools; and what type of pedagogy were teachers engaged in within the classroom. A snowballing strategy was utilized to identify key informants, who would provide the most information-rich cases. As a first attempt, I asked APF field staff to refer me to teachers who would constitute polar ends of the spectrum. This involved identifying participants who were successful in meeting CAL objectives and also others who had demonstrated shortcomings. The reasoning behind identifying key informants this way was to capture the reasons for both success and failure. Additionally, during school visits I requested survey respondents to suggest names of colleagues who had either exemplified in the implementation of CAL or faced particular challenges that inhibited their ability to execute the program.

In all, eight teachers were selected for an interview, based primarily on 1) continued participation in CAL and2) level of success or failure in implementing CAL. During the process of identifying interview participants, I requested APF personnel to suggest names of teachers whose school environment also exposed this diversity. The diversity, in my opinion, manifested in the kinds of school-support accorded to the teachers from principals and colleagues. Further, diversity in the type of school would also shed light on the link between infrastructural support and readiness and technology integration. As with survey respondents, interviews were conducted with only those teachers who were engaged with CAL during its entirety. This was essential to strengthen the grounds for attribution of teachers' outcomes to CAL training.

Constant dialogue with APF field staff helped establish the challenges they encountered during the implementation phase of CAL. While the majority of the concerns highlighted infrastructural, policy-level, and school-related issues, teacher attitudes were also clearly symptomatic of the extent to which there was enthusiasm or unwillingness to implement reforms. During the administration of the survey instruments, several teachers exhibited either of these tendencies which were captured in subsequent interviews.

Overall, the interviews were 30 to 90 minutes long and audio-recorded. After the 8 interviews, it was felt that the data collected was becoming repetitive and had reached a point of saturation. Following that, no more interviews were conducted.

The interview protocol was drawn up in a manner to ensure consistency between interviews. This process also entailed providing each of the interviewees with the same set of instructions prior to each session. Notably, the interview protocol comprised questions that were open-ended, neutral, and worded clearly. Probes were used, as needed, to allow participants to either elaborate on an answer, or substantiate their claims with examples.

Broadly, the teacher interviews were structured around six issues that directly addressed the factors identified in the theoretical framework as integral to technological integration. Further, questions on pedagogical practices were also incorporated in the interview protocol to gauge the extent to which teachers' teaching practices had evolved during the course of the program. The interview structure encompassed the following issues: 1) how did they [teachers] define CAL; 2) what, according to them, was CAL's biggest contribution; 3) how were they using computers; 4) how did they define teaching and learning; 5) had their views on teaching changed during the duration of CAL; and 6) concerns surrounding the implementation of CAL. Within concerns, a whole range of factors were targeted, encompassing infrastructural, legislative, school-level, and teacher-level issues.

As mentioned above, the interview questions were structured around themes drawn from an extensive review the literature and the theoretical framework against which the data was to be analyzed. The interviews were designed to complement the survey data, while allowing for a holistic examination of both research questions, in addition to triangulating the findings from the study. The five issues in the interview protocol addressed three main themes: 1) general perception about factors that affected a teacher's ability to integrate technology in the school; 2) teachers' views on pedagogy and how that might have evolved; and 3) teacher's views on CAL. As the interviews progressed, themes one and two were more elaborately probed since they formed the foundation for research questions one and two.

In addition to interviews, I also conducted passive observations (Mertens, 1998), where I was present in classrooms and computer laboratories mainly to witness the kinds of pedagogy teachers engaged in with the students, or how children maneuvered the CAL tutorials. While watching students and teachers, I mostly played the part of an unobtrusive observer without directly engaging with the participants. Everything I witnessed was systematically noted and recorded as extensive field notes. Marshall and Rossman (1999) define field notes as “detailed, non-judgmental, concrete descriptions of what has been observed” (p. 107). This process proved especially useful in studying classroom dynamics between teachers and students. The observations also highlighted some challenges associated with access and use of the CAL tutorials from the students’ perspective.

Lastly, I also reviewed APF documents, concept notes, field notes, research papers, newsletters, and evaluation studies to develop a deeper understanding of CAL’s objectives, operation, and implementation (see Table 3). An in-depth analysis of documents also enabled a greater grasp of how the program was conceptualized, content identified, and most importantly, training conducted. I studied logs, and minutes from training sessions to gauge the manner in which CAL was conveyed to teachers and how they responded to the intervention.

Table 3: Summary of Data Collection Procedure

Data Collection Procedure	Purpose
Surveys	To collect data on participant demographics, school support, teacher attitudes toward technology, teacher perception of pedagogy
Interviews	To understand teacher perspectives on CAL, especially the issues and challenges surrounding the implementation
Observations	To understand how students maneuvered the CAL tutorials, as well as gauge the kinds of teaching strategies employed by teachers in the classroom
Documents	This included studying CAL concept notes, field notes, minutes from training sessions, on-site interactions with teachers, and information on current projects or activities, research documents, and other related information. While some were shared by APF personnel, others were available on the organization’s website

Qualitative Data Analysis

Researchers posit that there are two ways to commence the data analysis phase in qualitative research. In the first, the analysis evolves constantly, beginning as soon as the first interview is over, and continuing until the study ends. In the second, the analysis waits until the entire data collection is complete. Maxwell (1996) argues that the latter is perhaps appropriate when "there is little need to allow for flexibility of design" (p. 77). Else, the benefits of conducting data analysis as the study progresses far outweigh the risks associated with the process. The data analysis for my study proceeded simultaneously with the data collection, primarily to lend flexibility into the process, as well as build coherence and structure.

At the analytical stage, Ritchie and Spencer (1994) theorize that qualitative data analysis is essentially about detection, and encompasses tasks such as defining, categorizing, theorizing, explaining, exploring, and mapping. Ultimately, however, the types of tasks performed to analyze the data would depend on the research question being examined. The plan for the data analysis for this study comprized a six stage process: 1) organizing the data; 2) generating categories, themes, and patterns; 3) coding the data; 4) testing for emergent understandings; 5) searching for alternative explanations; and 6) writing the report (Marshall & Rossman, 1999, p. 152).

As I have mentioned above, the data collection involved activities like interviews, observations, and review of documents. Different techniques were used to record the different kinds of data collected. While each of the interviews with CAL teachers was digitally recorded, the documents were either shared by APF staff or retrieved from the organization's website. The data management was done by creating digital files of the transcribed data as well as observer comments, which were stored in my computer. Throughout this process, personal information like teachers' names and schools were coded with pseudonyms to shield the actual identity of the interview participants.

After reading through the interview transcripts, field notes, and reviewing organizational documents, I developed memos highlighting tentative ideas about categories and themes. These themes were directly drawn from the theoretical framework identified for the study. For instance, in ascertaining factors that challenge or limit a teacher's ability to integrate technology, the framework emphasizes the role of 1) research and policy; 2) the school; 3) the teacher; and 4) the project. During the categorization of the data, these themes were sorted through the data. Thereon, the task involved rearranging the data and placing them into these established categories in a manner that would ensure that while there was internal consistency between the themes, the different categories were distinct from one another to warrant comparisons (Maxwell J. A., 1996). This was achieved by "identifying salient themes, recurring ideas or language, and patterns of belief that link people and settings together" (Marshall & Rossman, 1999, p. 154)

Subsequently, I applied a hand-coded coding scheme to highlight passages and text that were unique to each broad theme and category identified, and which could then be related back to the theoretical framework. Researchers recommend the use of key words, symbols, or colors to code the data, a process than simplifies the data organization and streamlines the eventual analyses. I used key words and a color scheme to code the data. In doing so, I identified common themes relevant for analyzing the two overarching questions.

Sub-categories of these themes were also created to focus on the different dimensions and perspectives that each of these categories represented. Within school-related factors, for instance, I looked for organizational culture, infrastructural readiness, human support, and the technical setup in general. While broadly these were all grouped within school-specific causes of a lack of technology integration, each sub dimension enabled an individual and collective understanding of the degree and impact they had on the outcome variable of interest.

After concluding both analyses separately, the focus shifted on merging the qualitative and quantitative results by exploring how both the data converged. In merging the findings, I used the side-by-side comparison for merged data analysis (Creswell & Clark, 2011). The format involved presenting the quantitative results, followed by the qualitative results. Then I made comparisons between both the data to ascertain whether they complemented or contradicted one another. Ultimately, I used the observational data to triangulate the findings. Results from the analyses have been discussed in the subsequent chapters.

Research Ethics

Mertens (1998) advises that ethical considerations in research should be an integral part of the planning and implementation, and not an add-on or an afterthought. Prior to the actual data collection, I completed the basic required modules of the web-based Collaborative IRB Training Initiative Course. Subsequently, I secured approval from the University of Maryland Institutional Review Board to conduct my research in India by self-administering the survey instruments and interviewing CAL teachers.

During the school visits, each of the research participants was debriefed on the real purpose and use of my study. Survey respondents were informed that confidentiality would be ensured by assigning codes to them. Additionally, pseudonyms would be assigned to and used in all recorded information, which included the one-to-one interviews with the 8 teachers. Only after obtaining fully informed consent, were the participants asked to fill out the survey or respond to interview questions.

Additional privacy and condifentiality measures were also put in place by doing the following: 1) Survey responses and transcripts of interviews were password protected and kept only on my computer; 2) All handwritten notes were stored in a locked file cabinet in my residence; 3) I used an identification key to identify respondents; and 4) knowledge of the identification key remained only with me.

Validity, Credibility, and Transferability

Researchers argue that discussions of validity in mixed methods research are still at their infancy (Onwuegbuzie & Johnson, 2006). Those who address validity in mixed methods research offer that one way of approaching it is to focus on addressing specific validity issues as they relate to quantitative and qualitative research individually (Creswell & Clark, 2011). Addressing validity issues at the data collection, analysis, and interpretation stage, Creswell and Clark (2011) highlight potential issues or threats to validity and also offer strategies to minimize them. In Table 4 below I address the different mechanisms that were put in place for my study to minimize the validity threats the authors talk about.

In addition to the strategies listed below, I used triangulation techniques, peer reviews, and member checks to ensure the validity and credibility. Triangulation was achieved by exploring multiple sources of data using qualitative and quantitative measures. Further, as mentioned above, multiple sources of qualitative data were collected including interviews, observations, and documents. The overarching purpose behind the exercise was to gain a holistic

Table 4: Validity Threats and Strategies used to address them

Potential Threats to Validity	Mechanism to address those threats
Data Collection Stage	
Selecting inappropriate individuals for the qualitative and quantitative data collection	Both survey respondents and interview participants were drawn from the same population of CAL teachers. I also ensured that only those teachers who had been with CAL through its entirety were recruited for the study
Introducing potential bias through one data collection on the other data collection	Two separate data collection procedures were put in place for the quantitative and qualitative components. Survey were used to collect quantitative data and interviews, observations, and review of documents were strategies employed to collect qualitative data. Both sets of data were collected after CAL had officially ended in Chhattisgarh
Collecting two types of data that do not address the same topics	The Surveys and Interview Protocol were designed to address the two broad research questions identified at the beginning of the study. The interview allowed a more detailed understanding of survey responses. In effect, both tools addressed the same topic and were complementary
Data Analysis Stage	
Using inadequate approaches to converge the data	I used the side-by-side comparison for merged data analysis, wherein I presented the quantitative results, followed by the qualitative results in a manner that highlighted the complementarity of the data
Making illogical comparisons of the two results of analysis	To highlight the similarity of the inferences, direct quotes from interview participants were used to match the statistical inferences
Data Interpretation Stage	
Not discussing the mixed methods questions	Each mixed methods question has been discussed in detail in the study
Giving more weight to one form of data than the other	At the analysis stage it was apparent that the inferences drawn from both sets of data were more complementary than contradictory. I addressed this threat by juxtapositioning both analyses in a manner that bestowed equal importance to both the quantitative and qualitative data

Adapted from Creswell & Clark, Designing and Conducting Mixed Methods Research, 2011, p. 240

understanding of CAL, explore factors that inhibited or aided its implementation, and the implications it had on the pedagogical orientation of teachers.

To gain clarity and ensure that there was no misrepresentation of the interview data, I conducted member checks and peer debriefings. Interview participants were asked to clarify any position that was considered ambiguous or confusing. Additionally, I conducted peer debriefings with APF field personnel and sought their feedback on the data collected. This exercise proved extremely useful, especially in understanding the social context within which CAL had been implemented, appreciate the background and experiences of teachers, and the impact that had on their efforts at technology integration.

Mertens (1998) describes transferability as the ability to generalize research findings to other settings. This concern is relatively acute within the international development community, where projects are rolled out amidst the hope that the learnings from one setting might apply to others afflicted with similar circumstances. One way of ensuring that, researchers argue, is to provide a thick description of the research setting, including that of the "time, place, context, and culture" (Mertens, 1998, p. 183). I applied these strategies in my study by highlighting the detailed context within which CAL was introduced and implemented. Through the thick descriptions, I emphasized the multiple and unique scenarios that the different schools presented. Further, I explored the complex relationships between teachers, school management, and government officials , which in turn explained the variations in teachers' ability to implement technology-based change in their respective schools.

Limitations

Although this study presents important findings on factors that affect technology integration, especially in the context of developing countries, it has limitations. Its primary limitation lay in its small sample size. Inferences drawn from the analysis of 82 survey responses and 8 in-depth interviews will not generalize to a large population. The results will likely generalize to a similar sample in a very similar but different setting. Given the pace at which many states in India are responding to teacher shortages in rural areas by hiring more and more para teachers, the findings of my study will generalize to those various settings.

The small sample size also limited the kind of quantitative analysis that could be afforded to the data. A larger sample size would have allowed for more sophisticated pretesting mechanisms to determine whether the survey items were correctly measuring the traditionalism and constructivism constructs. However, to overcome the limitations arising out of the small sample size, I conducted in-depth interviews with three E1 teachers using cognitive interviewing techniques to understand respondents' thought processes. The feedback from the exercise was incorporated to make the requisite changes to the instrument so that the survey items would convey the same consistent meaning to all teachers once it was scaled up.

Further, since the study focused only on those teachers who participated in the program for its entirety, there is a bias in the choice of research participants. However, one cannot establish with certainty the direction of this bias. The study also suffers from some degree of recall bias. Because CAL ended by the time the data collection for this study started, and most schools had stopped using computers by then, to gain a sense of how teachers used technology the survey instrument was modified to encourage respondents to recall their behavior from the previous academic year. This, unfortunately, was unavoidable due to the status of the program and its official closure at the time of the data collection. However, it is hoped that since teachers were asked to recall their computer usage behavior during the past academic year, which was not too distant in the past, their ability to remember would not be significantly accurate and not too affected.

The quantitative data analysis predominantly relied on teachers' self-reported scores on technology use. While this increases the possibility of issues such as social desirability bias, the in-depth qualitative data moderates the bias by delving deeper into the responses provided by the teachers.

Nevertheless, despite the methodological limitations, the research findings are vital and valuable to the ICTs-for-development community. In recent decades, both developed and developing countries have pledged substantial investments in ICTs for education. As mentioned above, the arguments in favor of ICTs in education is essentially one of access and quality. As the reasoning goes—not only will these tools provide educational access to children who have been devoid of an education thus far, it will provide them with a learning experience that is engaging, constructive, and non-traditional. This is an extremely attractive possibility for countries who have been struggling to meet basic educational goals either set by them or the international community.

But, in spite of several decades of ICT investments in education, gaps continue to exist between what works and what doesn't. This is partly due to the fact that there is very little homogeneity between the various settings where such interventions are introduced. As this field continues to evolve, these findings enhance policy-relevant understanding of conditions that need to exist for teachers to be able to use technology in their day-to-day endeavors.

Chapter 4: The Computer-Aided Learning Program

In this chapter, I describe the Computer-Aided Learning Program—its premise, structure, training programs, and implementation strategy. However, prior to describing CAL in detail, I first present a macro picture of education in rural India, followed by a local depiction of conditions in Chhattisgarh, the research setting for the study. These descriptions offer the reader the context of the CAL intervention, including the participants, and policy environment. In doing so, the purpose of this chapter is to present to the reader the social milieu and familiarize them to the existing conditions in which CAL was introduced and implemented.

Overview

In the year 2002, the Azim Premji Foundation (APF), a Bangalore-based non-profit group, initiated the Computer-Aided Learning Program (CAL). The purpose of the program was to explore the use of computers in improving educational quality in rural areas of India. The program identified as its objective the need to make learning a fun and engaging exercise for children, while also addressing issues of equity and equality in knowledge creation and dissemination. To do so, the Foundation created school syllabus-based bi/trilingual multimedia content that supplemented existing classroom curriculum. In Chhattisgarh, training sessions were conducted for the teachers to train them in the use of digital content, especially focusing on avenues and ways in which the content could be integrated with the curriculum to enhance student understanding of academic concepts. These sessions ranged from a one-day introduction to the CAL program to a 10-day in-house training focusing on instructional technologies in math education. Simultaneously, the program also comprised a pedagogical component, which introduced teachers to constructivist and learner-centric teaching practices. However, in order to appreciate CAL's foci, it is imperative to understand the context of elementary education in rural India. I begin by presenting this milieu and subsequently, elaborate on the program in the rest of the chapter.

Elementary Education in Rural India: The debate between access and quality

Although India had identified universalization of elementary education as a national goal as early as 1950, three years after its independence from the British, this commitment remained by and large undelivered for several decades. In 1986, the National Policy on Education (NPE) stated that access to primary education would be a national priority. It also emphasized the need to reduce drop-out rates among school-going children while improving their overall attainment levels. Subsequently, a plethora of policies followed suit, including Operation Blackboard (1986), Non-formal Education Scheme (1986), the *Shiksha Karmi Project* (1987), and *Mahila Samakya* (1989).

In the meantime, the issue of educational access at the primary level gained international traction with the adoption of the World Declaration of Education for All, at the 1990 World Conference on Education in Jomtien, Thailand. At this conference, 155 country delegates and 150 governmental and non-governmental representatives[9] agreed that more needed to be done to universalize primary education.

With very little progress made on the issue of educational access, India's Program of Action (POA) in 1992, once again reaffirmed access to primary education as a national priority. Yet again, the POA was joined by a number of policies, which included *Lok Jumbish* (1992), the District Primary Education Programme (1994), the Mid Day Meal scheme (1995), and the *Sarva*

[9] http://www.unesco.org/en/efa/the-efa-movement/jomtien-1990/

Shiksha Abhigyan (2001), which aimed at completion of eight years of schooling by all children between 6-14 years, by 2020 (Azim Premji Foundation, 2004).

A very clear outcome of all of these policies combined has been that primary enrollment in rural India has improved. Today, as a result, critics and scholars argue that national dialogue on education needs to shift from one of access to that of quality (Muralidharan, 2011; Little, 2010). Figure 8, highlights this urgency. Data for Figure 8 comes from the 2011 Annual Status of Education Report (ASER), facilitated by Pratham, an Indian NGO. Since 2005, Pratham has tracked enrolment and student ability in reading and mathematics by facilitating this annual survey in every rural district in India. Primarily a citizen effort, the survey is by and large administered by more than 25,000 volunteers and covers over 700,000 children in 15,000 villages each year.

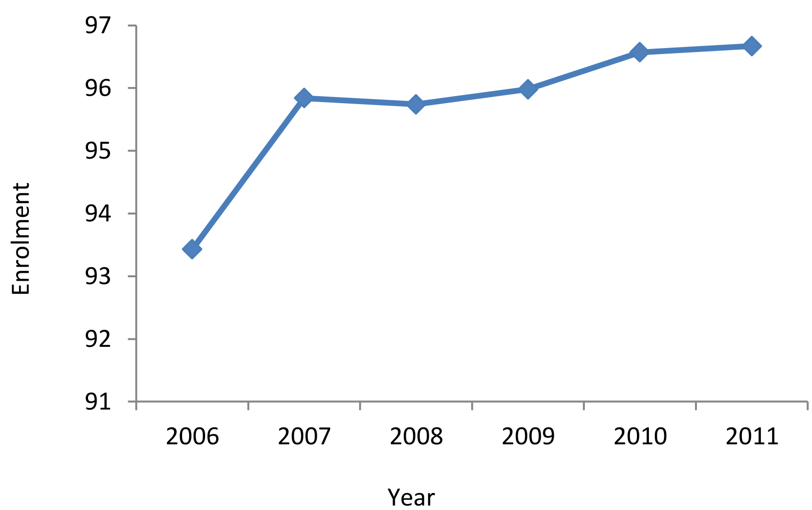

Figure 8: Enrolment percentage in Rural India between 2006 and 2011 (age range 6-14)
Source: 2011 ASER

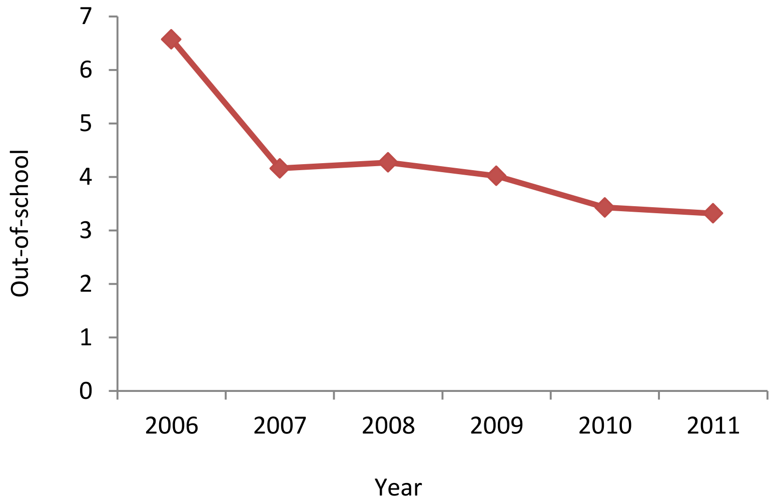

Figure 9: Percentage of children out-of-school between 2006 and 2011 (age range 6-14)
Source: 2011 ASER

As is evident, enrolment reached 96.67% in 2011. This coincided with declines in the percentage of children who are out-of-school. Between 2006 and 2011, out-of-school children reduced by 3.25 percentage points (Figure 9).

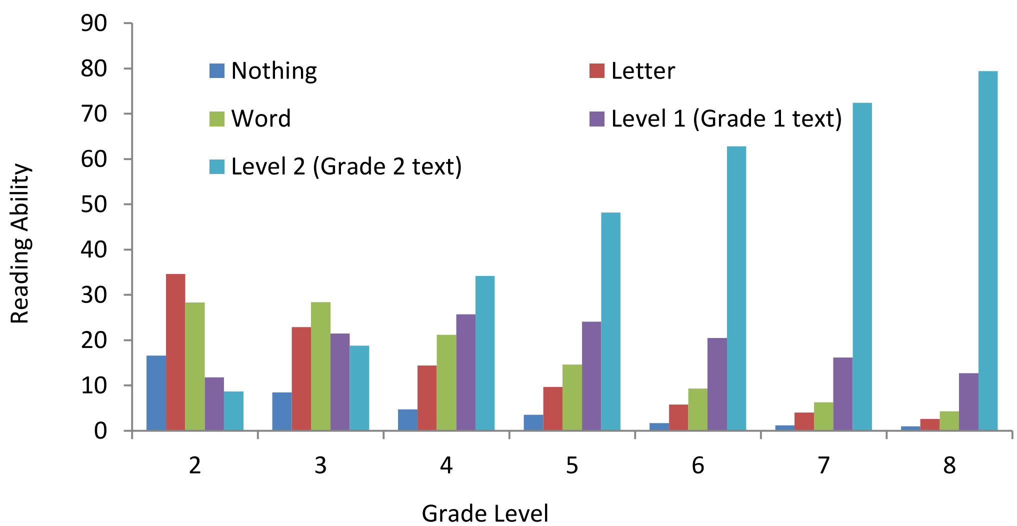

Figure 10: Reading Ability of Children in grades 2 to 8 (All schools 2011)
Source: 2011 ASER

However, when we juxtapose attainment with enrolment, the picture that emerges is very disappointing. Figure 10 shows the highest level of reading achieved by a child by grade. When we consider students in grade 4, 4.7 percent of the children cannot read letters, 14.4 percent can read letters but nothing more, 21.2 percent can read words but not grade 1 level text or higher, 25.7 percent can read grade 1-level text but not grade 2-level text, and only 34.2 percent can read grade 2-level text.

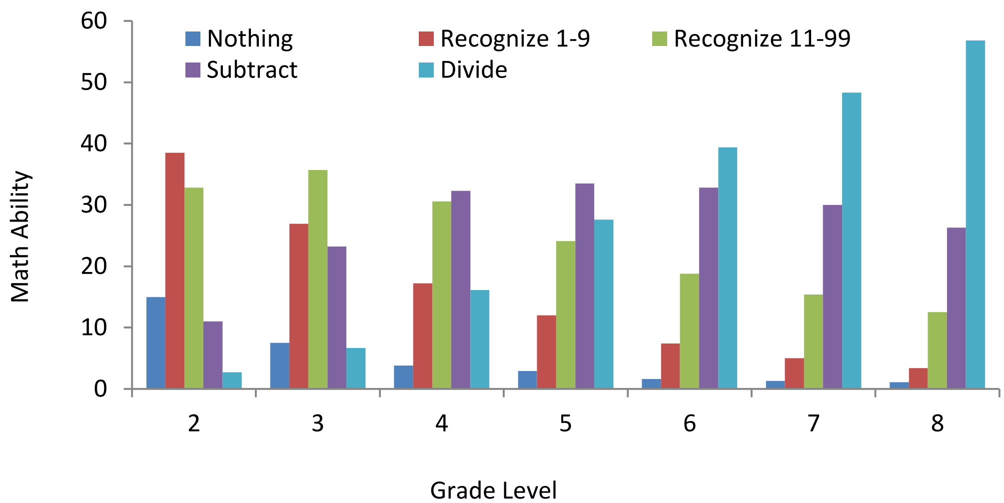

Figure 11: Math Ability of Children in grades 2 to 8 (All schools 2011)
Source: ASER 2011

A similar picture emerges in mathematics. On examining the graph in Figure 11 for grade 4 students again, we observe that 3.8 percent of the children cannot recognize numbers 1-9, 17.2 percent can recognize numbers up to 9 but not more, 30.6 percent can recognize numbers 1 to 99, but cannot subtract, 32.3 percent can subtract but cannot divide, and only 16.1 percent can divide. Since its inception, ASER data have consistently exposed the fact that children are not performing at grade level. In fact, in most instances, they are between two and three years behind their current grade level. As will be discussed later in the chapter, children in rural Chhattisgarh, the research setting for the study, also display very similar patterns.

The situation in reading and mathematics raises the question: why aren't children learning? As has been evident in the past, the sensitivity of the question evokes a blame game of sorts. Ramachandran, Bhattacharjea, and Sheshagiri (2008) point out that while some blame the government, others deplore systemic corruption or the politicisation of school curriculum. Of course, there are others who place the blame squarely on teachers. But the authors argue that while that seems to be the emergent trend, the fact of the matter is that teachers are simply "a powerless pawn in an intricate game of electoral politics" (p. 5), and faulting them entirely for the lack of quality is unfair.

The blame game, according to Ramachandran, Bhattacharjea, and Sheshagiri (2008), has resulted in three broad sets of arguments. In the first, the onus is on teachers. This argument is based on the premise that despite recent increases in teacher salaries and improved teacher training, the quality of education remains abysmally low because teachers show a lack of commitment. This argument gains traction when viewed in light of research and policy documents and media reports that expose alarming rates of teacher absenteeism[10] in addition to their inability to demonstrate basic content knowledge.

The second argument is the one provided by teachers in which they blame the political establishment for the shortfalls observed in schools. They lament the constant work pressure, and unsatisfactory working conditions as reasons for the lack of quality. Further, they deplore situations where "they have to negotiate a corrupt system where programmes involving mid-day

[10] Chaudhury, Hammer, Kremer, Muralidharan, & Rogers (2005) concluded that teacher-absenteeism in India is 25%. At any random time, 25% of teachers are absent from schools. Some of the reasons for such high rates of absenteeism have been a gross lack of accountability and absence of proper economic incentives for teachers.

meals, construction and repair of buildings, teaching-learning material (TLM) and, most importantly, teacher-training, are converted into rent-seeking opportunities" (Ramachandran, Bhattacharjea, and Sheshagiri, 2008, p. 6).

Beyond these polarizing viewpoints, is the stance taken by non-governmental organizations (NGOs), whose argument focuses on fundamentals such as what defines a "teacher" and "teaching" and how are these concepts reflected in today's education system. Having engaged with teachers, NGOs recognize there exists a massive disconnect between what policy documents purport teachers and teaching to be and what actually happens on the field. Following prolonged engagement with teachers, NGOs have come to realize that the education system is grossly prescriptive, often viewing teachers as "lowly recipients" (Ramachandran, Bhattacharjea, and Sheshagiri, 2008, p. 6) who are simply expected to implement content that was designed elsewhere and not created by their own active engagement. But for the quality of learning to change and for reforms to succeed, NGOs argue, teachers need to be central to the process.

There is also a structural explanation about the shortcomings evidenced in learning levels of primary students. Perhaps we have not seen improvements in students' attainment levels because we are not serious about the change. The lack of improvements is due partly to the fact that into the very structure is continued marginalization, which makes success elusive.

These are divergent viewpoints with very little overlap. The difficulty in a lack of consensus on the diagnosis is that, solutions have been difficult to come by. And the impact on attainment has been clearly challenging. However, at the core of all this argument has been the question—what defines quality education? Batra (2009) in defining quality encapsulates fundamental aspects that education must comprise:

> Quality education is centered on a quality curriculum, improving the teaching-learning environment in the classroom to bring every child into the fold of education, appropriate and adequate preparation of and incentives for teachers, a positive and an inclusive milieu for children (including proper nutrition), a psychologically safe, conducive and pedagogically sound environment along with family and social support. The missing link that connects all these elements is the school teacher (pp. 7 - 8)

From the above definition, one can infer that quality includes facets of curriculum, school and classroom environment, teacher, and teaching. However, one point of contention is the burden of responsibility on the school teacher, in being the "missing link" that connects these critical elements. While it is generally accepted that teachers have a vital role to play in delivering quality education to children, it is equally imperative that in order for them to function better as educators, the system must be favorable and supportive. Then, it becomes a matter of partially shifting the responsibility to efforts such as teacher training and development, and content creation and development.

In July 2004, the Executive Committee of India's National Council of Educational Research and Training (NCERT), a government body responsible for assisting the Central and State government on issues of school education, decided to review and revise the National Curriculum Framework (NCF) as it existed during that time. Feedback and ideas were sought from scholars, educators, NGOs, NCERT officials, parents and various other stakeholders. The result was a revised NCF published in 2005, one that benevolently endorsed concepts such as learning without burden and child-centered education. Acknowledging the challenge that education had come to be viewed as burdensome and stressful, especially by parents and students, the NCF sought to change this by proposing that curriculum development be guided by five basic principles: 1) connecting knowledge to life outside the school, 2) ensuring that learning shifts away from rote methods, 3) enriching the curriculum so that it goes beyond textbooks, 4) making examinations more flexible and integrating them with classroom life, and 5) nurturing an overriding identity informed by caring concerns within the democratic polity of the country (NCERT, 2005).

Importantly, the NCF 2005 also recognized that for any of these changes to ultimately occur, certain systemic reforms were necessary. While Chapter 5 of the NCF was dedicated to a wide range of these systemic overhauls, those relevant for the purposes of this study were calls for a more effective and participatory academic planning by school principals and teachers, revamping and strengthening teacher education programs that would enable teachers to engage in active learning and child-centered education practices, reinforcing in-service education programs, greater communication and collaboration among teachers to create novel learning experiences, and getting teachers involved in content creation. Further, recommendations also emphasized reducing stress among students by making examinations less steeped in content-based testing and more on problem-solving and understanding.

In principle, critics argue, while these are all desired outcomes, efforts on the ground are complicated because reality is not ideal. Highlighting the need to contextualize education and discourage children from memorizing learning material, Batra (2009) argues, requires that teachers play a more active role in the design of curriculum content, and have the necessary content expertise to make learning a more meaningful exercise for children. However, for learning to be active and meaningful, teaching efforts must be sustained by an effective support system, which include the availability of learning resources, ability to identify appropriate content, and the opportunity to integrate learning resources outside the classroom. These points raise concerns about infrastructure and teacher readiness.

Para-teachers: The new response to teacher shortage in rural India

School systems in India come within the purview of state governments. While the Central Government confines itself to broader policy formulations, such as establishing overall educational quality standards and resource allocation through centrally-mandated schemes, the states are essentially responsible for matters involving teacher recruitment.

In recent years, states have resorted to recruiting para teachers as a response to teacher shortages in schools across the country. Para teachers are teachers appointed on a contractual basis, who work full-time in regular schools and are offered a monthly remuneration that is much less than what a regular full-time teacher would be paid. Kingdon and Sipahimalani-Rao (2009) estimated para teacher make less than 25 percent of regular teachers' pay. The origin of para teachers in India can be traced to the *Shiksha Karmi Project* in the state of Rajasthan, which was started with support from the Swedish International Development Agency (SIDA) in the 1980s. The premise for the project was that the state education department was finding it increasingly difficult to appoint qualified teachers in remote Rajasthan. City-based teachers were unwilling to relocate to remote areas due to difficult working conditions and an innate inability to relate to the local culture. The *Shiksha Karmi Project* sought to overcome this challenge by recruiting local youth "though academically under-qualified, and professionally untrained, as teachers" (Pandey, 2006, p. 322). Today, in most states of India, para teachers are almost always local residents, who belong to the same village where they teach and speak the same language as their students. This carries the advantage that para teachers have "insider' status, something that regular teachers often might not enjoy, especially those who come from outside the village they teach in.

But contrary to the earlier objectives that led to the para teacher phenomenon, today, these contract teachers have come to replace regular full-time teachers in many parts of India.

Not surprising, therefore, that the issue of para teachers has emerged as an extremely divisive policy matter, evoking very strong responses across both sides of the aisle. The center has given the issue its stamp of approval on the grounds that it enhances teacher accountability and promotes fiscal responsibility. Its argument is that in making the local community involved in the recruitment of para-teachers, will infuse accountability into the process, and matters of teacher absenteeism will be addressed and resolved. Second, the recruitment of para-teachers will allow states to address the issue of teacher shortage in an affordable manner. As Govinda and Josephine (2004) posit:

> The economic argument for para teachers is that provision of teachers as per requirement is possible within the financial resources available with the states. The non-economic argument is that a locally selected youth, accountable to the local community, undertakes the duties of teaching children with much greater interest. The accountability framework is well defined and by making the local authority as the appointing authority, the para teacher's performance assessment is the basis for his/her continuance (p. 12).

However, replacing regular full-time teachers with para teachers is an unfortunate development and almost counterproductive to its initial validation. To begin with, the concept of para teachers was first introduced to assist single-teacher schools to cope with increases in student enrolment and to ensure that children in remote areas were not robbed of an education due to a lack of teaching staff. Additionally, as noted above, it was also a source of local employment for educated rural youth. Most importantly, there was no evidence to suggest that they should be appointed in place of regular teachers (Govinda & Josephine, 2004). That perception has all but changed today. As more and more schools resort to this scheme, regular teachers are increasingly being replaced by para teachers.

The outcry against para teachers is essentially an argument about quality. Detractors disapprove of this system because in their opinion it lowers the standards of educational quality by lowering professional training requirements and educational qualifications of such teachers. Critics argue that the education imparted within the classroom suffers because the majority of para teachers are both under-qualified and under-trained. To be a para teacher, a candidate must only have a high-school diploma (equal to 12 years of schooling.) Interestingly, when compared to regular teachers, the educational requirement is not drastically different between the two groups. The point of contention starts at the level of the pre-service professional training requirement. While regular teachers are required to have completed a two-year diploma or certification in teacher training prior to appointment, para teachers do not undergo any equivalent pre-service requirement. Instead, after appointment, they attend an induction training, conducted either by the Block Resource Center (BRC) or Cluster Resource Center (CRC) or the District Institute of Education and Training (DITE). The duration of the induction varies from state to state, and is anywhere between 20 – 40 days. Critics contest both the duration and quality of the induction training program, especially with regard to whether it adequately prepares teachers for the complexities of classroom teaching. Further, although on paper, the renewal of tenure is performance-based, 95 percent of para teachers in India are offered an extension (Govinda & Josephine, 2004). This has called to question claims that local involvement in para teacher recruitment will infuse accountability into the process.

Impact on quality

Govinda and Josephine (2004) caution that to understand the impact of para teachers on quality, one needs to factor in school and classroom conditions and transactions. The diversity in school environment manifests in the kinds of schools para teachers work in remote single teacher schools and/ or regular schools. With the advent of policies such as multi-grade classrooms, the pupil-teacher ratio (PTR) in both these kinds of schools has attained extremely lopsided proportions. In some cases, one teacher is responsible for a class of more than 50 students at any given point in time. The quality of the education imparted is further impacted by the lack of additional resources at the teachers' disposal. Although schools receive an annual grant, it is often so negligible that teachers are unable to buy additional resources for the classroom. In effect, one witnesses classroom interactions that are heavy on traditional, teacher-centric, text-book-focused practices. Further, the lack of professional development opportunities also places them at a disadvantage to cater to the varied complications that arise in a classroom full of primary school goers. Past research on para teachers has concluded that the induction training is insufficient and saturated with traditional pedagogy. Pandey (2006) reiterates that training programs for para teachers are often focused less on quality and more driven by an emphasis on supply.

Contrasting the description of the current situation of education in rural India with Batra's earlier definition of quality education, several concerns arise. The five facets, as emphasized in her definition: curriculum, the school and classroom environments, teacher, and teaching are severely deficient because of the conditions prevalent in rural schools. For instance, teachers do not possess necessary skill sets to invest in curriculum development, or even engage in learner-centric teaching due to the lack of additional resources that would make constructivism a living reality in the schools. Further, when the government uses the fiscal responsibility argument to support the employment of untrained teachers, the ripple effects on the quality of classroom interactions leave very little to the imagination. By being constantly exposed to a substandard educational environment, the impact on attainment is but obvious. It is against this context that efforts such as CAL must be understood.

Computer-Aided Learning Program

The Bangalore-based NGO, Azim Premji Foundation was founded in 2001. It functions with a vision to "significantly contribute to achieve quality universal education that facilitates a just, equitable and humane society[11]." In prioritizing national development as the overall objective, the Foundation's efforts have been focused on facilitating the creation of a society as was envisaged by the founding fathers of the Indian Constitution. Within development, the Foundation has placed tremendous emphasis on education as "a critical lever that directly impacts the economic, social and cultural development of the nation and attainment of its Constitutional directives.[12]"

The bulk of its efforts have been in primary education, with a focus on developing "proofs of concept" that have the potential to bring about systemic changes in government-run schools across the country. This focus is a direct response to the access versus attainment conundrum that has become a permanent fixture in India's primary education sector. The Foundation's efforts are also a testament to the belief that for any systemic change to occur, capacity building must happen at the teacher and education administrator-level. Toward that goal, the Foundation works very closely with teachers and administrators in developing a vision for their respective educational institutions, and building the appropriate tools and environment to meet it.

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[11] http://www.azimpremjifoundation.org/

[12] http://www.azimpremjifoundation.org/

It identified five factors: curriculum, public examination, teacher preparation and support, management of the education system, and technology, as critical to influencing a teacher and administrator's vision, capability, and motivation. Within curriculum, the focus is usually on identifying pertinent content and ensuring there exists an effective way to relay the content in a constructive manner to students. Likewise, teachers and administrators must recognize that the objective of public examinations is not for students to regurgitate content verbatim from curriculum material. Instead, the emphasis must be on finding innovative ways to test whether students comprehend the context and implications of what is taught in class.

Further, the Foundation acknowledges that teacher support and management are two factors critical in guaranteeing that individuals who choose teaching as a profession are adequately driven to remain in the profession and also motivated to perform their best. Further, there is a need create a conducive school environment that safeguards and retains these motivation levels. Finally, the Foundation acknowledges that there is a role for ICTs to make education a meaningful and fun experience, both from the perspective of the learner as well as the educator.

However, while recognizing the significance of each of these factors, individually, in its efforts, the Foundation has followed a combined and collective approach, primarily because such an approach is integral to guaranteeing systemic changes that the education sector so critically needs. Committed to working toward these systemic changes, the Foundation does the following[13]:

- Experiment to enhance its understanding of the critical five factors discussed above
- Design and implement large scale interventions (for example, whole district) to demonstrate how systemic change can be brought about

[13] http://www.azimpremjifoundation.org/

- Advocate to enable change at the macro level
- Build partnerships with other organizations to accelerate the progress towards its vision
- Continuously build capability of the Foundation and its members

The Foundation's experiments on the ground are reflective of its focus on the four key areas identified as critical to influencing teacher motivation, capability, and vision. These are — examination led reforms, teacher preparation and support, education management, and the use of technology as an enhancer and enabler. The Computer Aided Learning Program (CAL) was established to explore ways in which educational technologies could be introduced in classrooms to improve the learning experience of students. The program was launched in government-run classrooms, with functional ICT infrastructure, most of which remained either underutilized or unutilized.

CAL was first launched in the south Indian state of Karnataka, in response to feedback from rural parents who had expressed an interest in their children acquiring spoken English and computer skills. It essentially started as a three-way partnership between the school, local community, and APF. While the school head principal was a willing and enthusiastic partner in exploring the role of technology in the classrooms, the community provided basic infrastructural support. APF, on the other hand, provided the computer, furniture, and salaries of people who would help in the training.

As the program took-off, the Foundation realized that the majority of educational content that existed during the time were meant for western countries and were more often than not teacher-centric. In order to counter the challenge, the Foundation became involved in content creation. It engaged in a democratic process, inviting school teachers to become part of the content creation. A decision was made to create a package of 100 CDs, which would contain curriculum-based content in local languages, which supplemented classroom curriculum and offered children a fun and interesting way to comprehend concepts.

Research Setting: Chhattisgarh

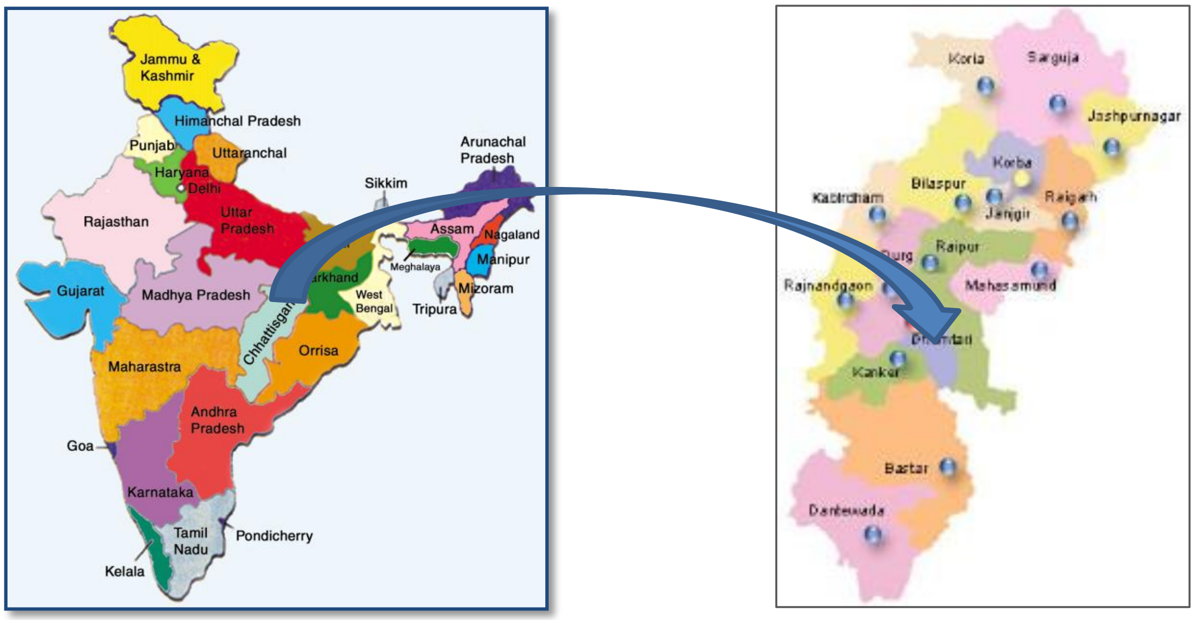

Figure 12: Map of India and District-wise break-up of Chhattisgarh

Chhattisgarh (see Figure 12) came into existence on November, 1, 2000. The decision to carve out Chhattisgarh from the Indian state of Madhya Pradesh was Chhattisgarh from the Indian state of Madhya Pradesh was prolonged and an outcome of several factors. Most notably, the state’s tribal population was consistently of the opinion that their interests were being largely overlooked by the government. This, in spite of the fact that the area has one of the largest mineral deposits of the country, including substantial deposits of limestone, iron-ore, copper-ore, rock phosphate, manganese-ore, bauxite, coal, asbestos and mica exist in the state. Equally important, the state is well known for its forest cover, as is evidenced by the fact that approximately 12 percent of India's forests are in Chhattisgarh.

In addition to the dissatisfaction expressed by Chhattisgarh's tribal population, the political establishment had also gradually come to accept that Chhattisgarh had a socio-cultural identity of its own, and one that was remarkably distinct from Madhya Pradesh, which warranted a bifurcation. After the official partition in 2000, Chhattisgarh became India's 26th state

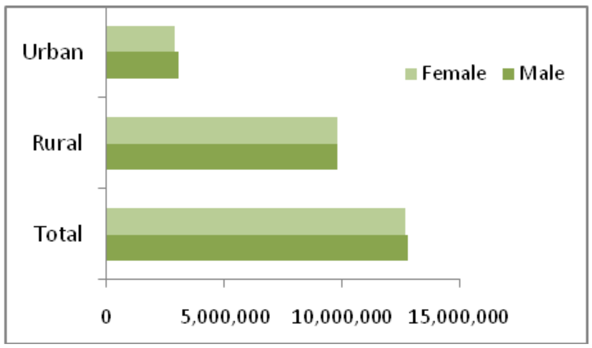

Figure 13: Sex Ratio by State and Location
Source: 2011 Census

comprising 16 districts. Currently, Chhattisgarh is the 17th most populous state in India, and approximately 76.76 percent of its population lives in rural areas. In spite of being predominantly rural, Chhattisgarh has one of the best female sex ratios of any state in the country. In 2011, there were 991 females for every 1000 males in the state. As is evident in Figure 13, the commendable sex ratio for the state is strongly driven by a positive sex ratio in rural areas, where females slightly outnumber males. This is in stark contrast to several other Indian states, where the sex ratio has been a policy concern for years.

Chhattisgarh has also made significant improvements in literacy since its establishment. As evident in Figure 14, in 1991, as part of Madhya Pradesh, the literacy rate for the region was only 42.91 percent. This improved to 65.18 percent in the decade that followed, and has gone up even further to 71.04 percent according to data available for 2011.

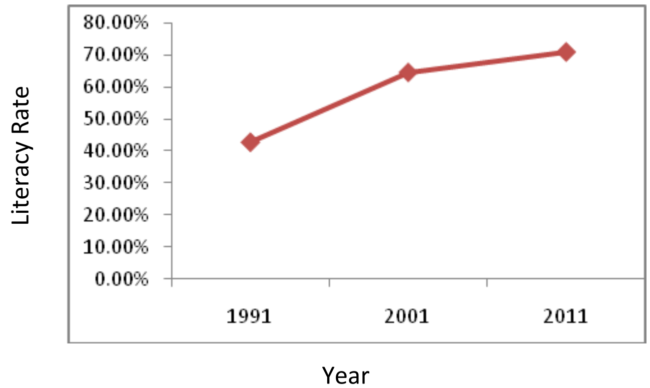

Figure 14: Literacy Rate in Chhattisgarh (1991 - 2011)
Source: Census Bureau of India

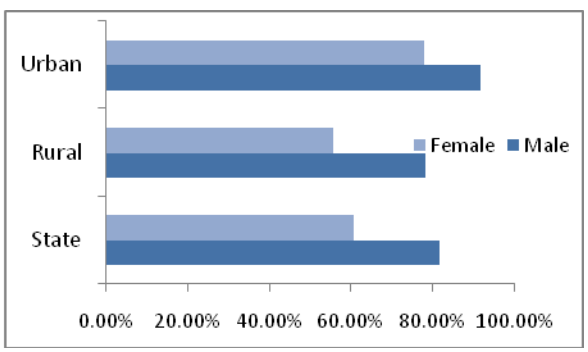

Figure 15: Literacy Rate by Sex and Location in 2011
Source: Census Bureau of India

While these improvements are commendable, disparities in male and female literacy remains a constant concern. Figure 15 shows male literacy rate, according to the 2011 census, was 81.45 percent compared to 60.59 percent for females. While gender disparities in education persist in both rural and urban areas, it is starker in rural areas. Urban disparity is 22.8 percentage points, compared to 13.98 percentage points in urban areas. Although official documents express a commitment toward improving education, health and livelihood indicators, progress has been slow, especially in the rural areas. However, in order to improve educational access and quality, the state has made primary education compulsory for children until the age of 14. Schools also provide free mid-day meals to motivate parents to send their children to school.

<u>Primary enrolment versus attainment in Chhattisgarh</u>

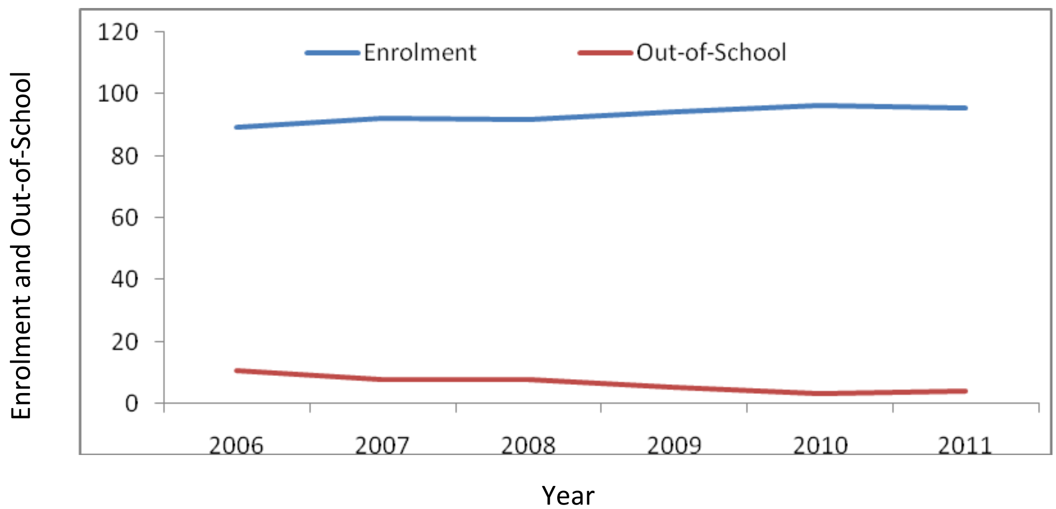

Figure 16: Enrolment versus Out-of-School between 2006 and 2011 (Grades 1-8)
Source: ASER 2011

This chapter began with the enrolment versus attainment conundrum facing majority of rural India. Data on Chhattisgarh presents a very similar picture. ASER 2011 data on the state reveals a very similar pattern—increases in enrolment with simultaneous declines in out-of-school rates. As is evident in Figure 16, between 2006 and 2011, the increases in student enrolment and declines in the number of out-of-school children in grades 1-8 were relatively the same. While enrolment increased by 6.43 percentage points, out-of-school numbers declined by 6.44 percentage points during this time period.

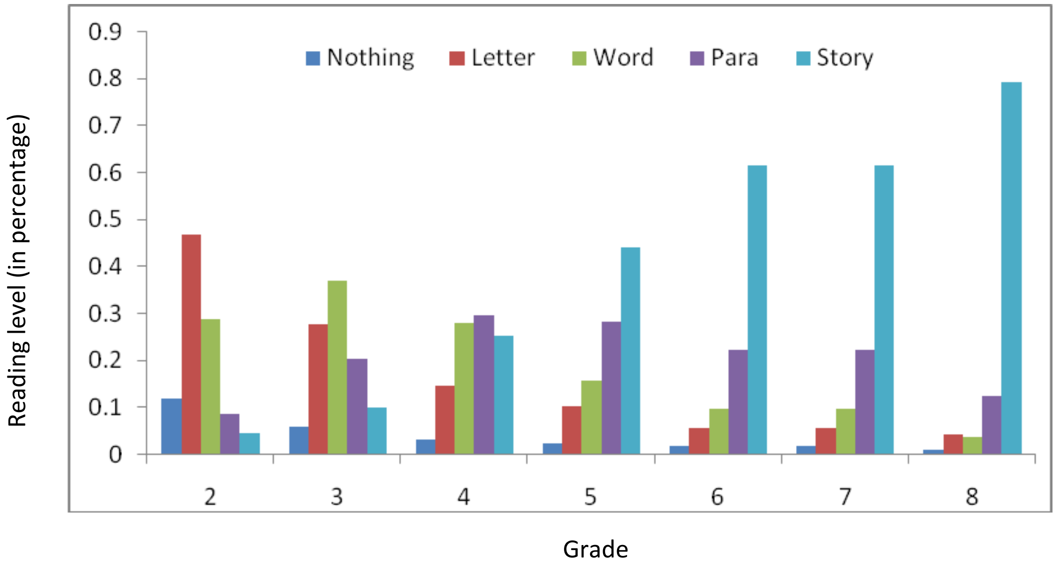

Figure 17: Reading Level Results for Enrolled Children - Chhattisgarh (Grades 2 -8)
Source: ASER 2011

Unfortunately, however, the attainment story is the same as in the rest of the country. Data available for reading and mathematics show that a substantial percentage of students are not performing at grade level. ASER 2011 data on Chhattisgarh proves this point. Children between the ages of 5 and 14 were administered a reading test in a language of their choice. The highest level tested was equivalent to a grade 2-level text. Five different categories were created to determine the highest level at which a student could read comfortably. “Story” referred to a student’s ability to read a long paragraph; “para” meant that a child could read a short paragraph; “word” referred to a child’s ability to read 4 out of 5 words correctly; “letter” was a child’s ability to read 4 out of 5 letters correctly; and “nothing” meant the student could read fewer than 4 out of 5 letters correctly.

Figure 17 depicts data from the reading assessments for students in grades 2 to 8 for 2011. If we focus on the performance of grade 4 students, we observe that only 27.92 percent of the students could read 4 out of 5 words correctly and no more, approximately 29.46 percent of the students could read a short paragraph, but no more, and 25.21 percent of students could read a long paragraph. These numbers are relatively unsatisfactory when one bears in mind that the assessment was done on grade 2-level text.

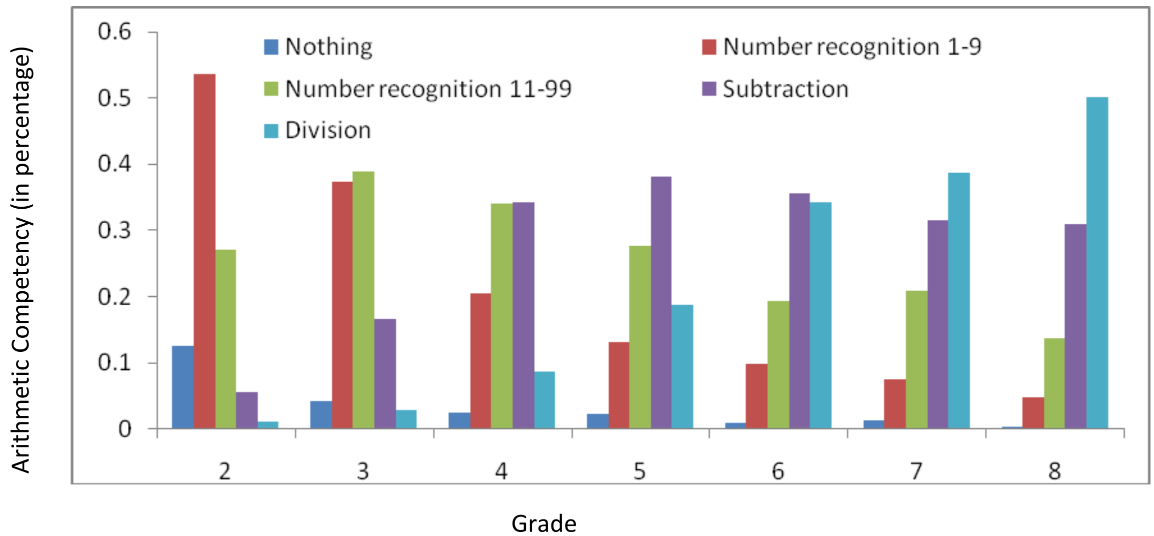

Figure 18: Arithmetic Level Results for Enrolled Children - Chhattisgarh (Grades 2-8)
Source: ASER 2011

Likewise, mathematic competency has also been a cause for worry for policymakers and educators in Chhattisgarh. The ASER study administered a basic arithmetic test to all children in the age group 5-16 years. The highest level tested was a 3-digit by 1-digit division and each student was marked at the highest level he/she could perform comfortably. Yet again, five categories were created: “division” referring to a student’s ability to solve a 3-digit by 1-digit division problem; “subtraction” referring to a student’s ability to solve a 2-digit by 2-digit problem with carryover; “number recognition 11-99” measuring a child’s ability to identify 4 out of 5 numbers between 11 and 99; “number recognition 1-9” referring to a child’s ability to identify 4 out of 5 numbers between 1 and 9; and finally “nothing”, which meant that a child could identify fewer than 4 out of 5 single-digit numbers correctly.

Student achievement in the division, subtraction, and number recognition categories was found to be grossly lacking. In all of these categories, less than 35 percent of students could attain the competency established for each task. Looking at grade 4 students (See Figure 18), one observes that only 20.49 percent of students could recognize 4 out of 5 numbers correctly between 1 and 9. Surprisingly, however, the ability to recognize 4 out of 5 numbers correctly between 11 and 99 increases slightly to 34.09 percent. Of the greatest concern is that only 8.66 percent of the students tested could solve a 3-digit by 1-digit division problem. Such achievement levels do call for some very strong and swift corrective action.

The question that emerges from these numbers is: what is going on in the Chhattisgarh rural school system that is prompting such deficiencies? Do the reasons that explain dire achievement levels in the rest of rural India applicable to Chhattisgarh as well?

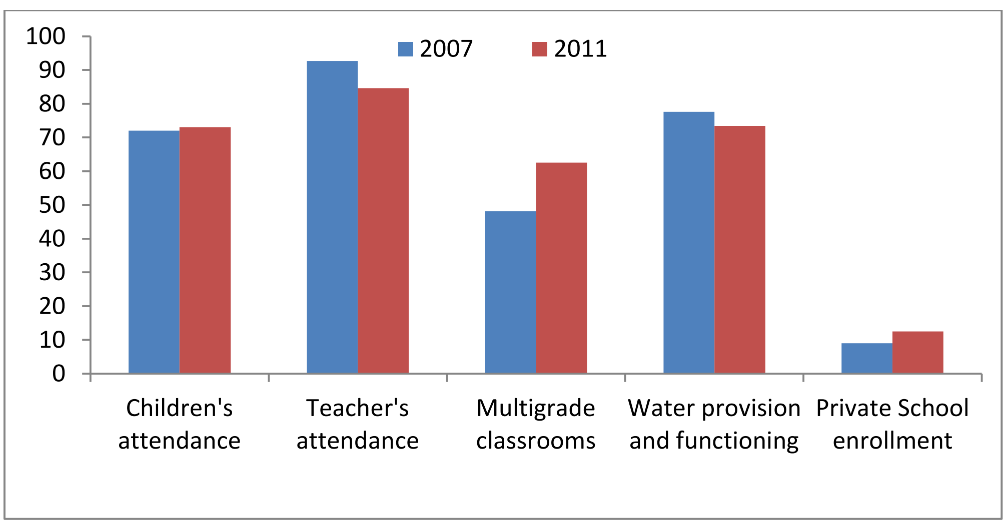

Figure 19: Contrast of School Indicators in Chhattisgarh between 2007 and 2011
Source: ASER 2011

As evident in Figure 19, of perhaps the greatest concern in Chhattisgarh is the increases in multigrade classrooms, in conjunction with declines in teacher attendance and school infrastructure, and how that might have implications on student attainment. Recent reports have also suggested that the state government has been on an overdrive in recruiting more and more para teachers to fill in the vacancies left open due to a lack of full-time teachers. Data available for early 2012, estimates that approximately 41 percent of teachers in Chhattisgarh's primary schools are employed on a contractual basis (Verma, 2012). As mentioned earlier, concerns surrounding para teachers in Chhattisgarh echo what we've observed in the rest of India—they are increasingly being sanctioned as replacements of regular teachers. This is especially problematic when one considers the lowering of academic requirements for such positions and the lack of professional development programs for teacher preparedness.

CAL in Chhattisgarh

In 2008, the Foundation and the state government of Chhattisgarh jointly collaborated on a three-year CAL research study. The decision to explore CAL as a research study primarily stemmed from the fact that although parents, teachers, and students were unanimous in perceiving the computer as a source of learning, when ascertaining the impact of technology on outcomes, the verdict was clearly ambiguous and often wrought with complications. The results from other project sites had yielded the following conclusions[14]:

- Children see CDs but there is no integration of technology to the lesson.
- The one day training given to teachers by APF did not equip them to handle computers as a pedagogical tool
- There was no data on impact of using technology on teaching itself
- Schools were not using the computers because of problem associated with power, payment of bills etc.,
- Schools were not using the computers because of hard ware problems
- The number of computers in schools were inadequate
- The student to computer ratio was highly lopsided. There were many children at one terminal at the same time.

[14] CAL Concept Note in Chhattisgarh

- The pupil-teacher ratio (PTR) was also imbalanced, to the extent that teachers found it extremely cumbersome to send students to the computer laboratory for CD viewing and did not know how to engage children who were not seeing CDs at that point in time
- More than technology itself, the way of using the technology was important

The decision to explore the role of technology in education was borne out of a need to address systemic concerns regarding low attainment, high drop-out rates, and teacher quality in rural areas. The Computer-Aided Learning Program (CAL) was introduced to examine technology effectiveness in making learning fun for all students. The program upheld the qualities of equality and equity in ensuring that knowledge reached all and that everybody had an equal opportunity to access it. In order to do so, the Foundation created syllabus-based bi/trilingual multimedia contents for the schools that were participating in the intervention.

Certain critical factors were identified as central and vital to the success of the program. Program personnel realized early on that a program exploring the role of technology as a pedagogical input as opposed to a stand-alone would have very different outcomes. In order to guarantee regular and effective use of technology, it was important to make these tools an integral part of the curriculum. The perception, based on earlier efforts, was that teaching technical skills as separate from curriculum would result in an underutilization of these tools as well as a tendency among teachers to forget the skills. Most importantly, however, if the focus were entirely on imparting technical skills to teaching personnel, the use of technology for curriculum needs of students would be relegated to secondary status. Thus, consciously, the program emphasized the use of technology for pedagogical needs, first to demonstrate to teachers how these tools could be used to supplement teaching, and second, to make learning fun and playful for the students.

But, the Foundation was also of the opinion that for state governments to implement large scale technology-based interventions, it was essential to identify best practices about technology use in education, which in turn would allow for informed decisions going forward.

As mentioned in chapter 3, between 2008 and 2011, Kurud block in Chhattisgarh was the setting for a three-year CAL study. The study had two components—first, a computer-based component that would supplement teachers' efforts in the classroom while also allowing students to engage in active learning processes; and second, a pedagogy component that empowered teachers to invest in learner-centric processes in the classroom.

In all, 60 schools were selected as research participants. These schools were randomly divided into three groups of 20 schools each. In the first group of experimental schools (called E1), teachers were offered both technology and pedagogical development. In the second group of experimental schools (called E2), teachers were only offered teacher development. The remaining 20 schools or C served as control, devoid of either input. For the purposes of this study, the data collection was confined to teachers in E1 and E2 schools.

Eventually, the program aimed to study the impact of the intervention by establishing a different set of outcome indicators for students, teachers, and classroom processes. For students, the desired outcomes would entail increased affective outcomes, like improved attendance, and better attainment as evidenced by an increase in reading and writing abilities, learning achievement levels, and improved critical thinking. For teachers, the program established that favorable outcomes would include reduced absenteeism, punctuality, an improved sense of self-efficacy, and ability to engage in reflective practices. Most importantly, however, the study also aimed to establish whether the program had favorably impacted classroom processes, by facilitating the creation of constructivist learning environments as opposed to existing traditional environments. Gauging this transformation would involve paying attention to whether the classroom environment fostered learner-centric practices, such as offering students a contextualized education, and offering them the opportunity to become active creators of knowledge as opposed to passive recipients of content. Ultimately, the study would offer the Chhattisgarh Government hard data on the impact of technology for teaching and learning, enabling it to make informed decisions on the efficacy of technology deployment in education.

The understanding with the state government of Chhattisgarh for the implementation of CAL proceeded in different stages. At its very nascent stage, the Foundation drafted and shared a concept note with government officials. This note clearly laid down the roles and responsibilities of the Foundation and the Government. This was especially done to infuse accountability into the process. While the Government was made responsible for the provision of functional and adequate hardware and infrastructure, the Foundation focused on providing pedagogical content and technical training to the teachers. After the MOU was signed between the two parties, the Foundation established a field team, who were ultimately assigned the task of providing academic support to the teachers at the schools the program would be implemented in.

Prior to the actual commencement of the program, a baseline on teacher attitude toward teaching, background in computer usage, classroom processes, and students' reading abilities and learning levels was conducted. Encapsulating the function of the baseline study, APF field staff, Anuj, says:

> The baseline was about understanding teacher attitudes. What is 'teaching' according to these teachers? What is its purpose? What do they perceive their role to be? In the baseline, we asked teachers about their views. And these very same questions were again asked during the endline study to gauge if attitudes had changed.

Overall, the baseline captured three aspects—two from the learner's perspective, which comprised a competency achievement test (CAT) and a reading ability test (RAT), and one from the teacher's perspective, which largely captured their attitudes toward teaching in general. In order to gauge the academic competency of students, CAT targeted their ability in environmental science and math, while RAT was singularly focused on language. Students were not tested on their writing skills.

The results from the RAT section were particularly illuminating. Children were given short passages to read and were assessed on their ability to read fluently, and comprehend succinctly. Three common errors were exposed while students participated in this task – a tendency to not read fluently, a propensity to emphasize letters and then stitch them together to form words, and finally, an ability to read fluently and yet make no sense of text.

Teacher responses to the baseline survey, on the other hand, underscored the prevalence of traditional teaching practices across the selected schools. For instance, teachers, through their responses, implied that a good student was necessarily a quiet student, and therefore by the same logic, a good classroom was a quiet classroom where information flow was mostly one-way. The survey responses also exposed a degree of obliviousness to the reality that all children were capable of learning, albeit, with differing pace. Teacher responses indicated that only smart children were capable of learning, while weaker ones lagged behind because they did not work hard or simply put, were incapable.

In order to incorporate the findings into the program modules, APF staff created a dossier on each teacher response. On an average there were three teacher respondents per school and only those teachers who would be part of the eventual intervention were asked to participate in the baseline.

The analysis that resulted from the baseline survey served to conceptualize and formulate training materials and program focus. Two objectives were formalized: one, to develop and empower teachers so as to enable them to enhance student learning and create learner-centric classroom processes; and two, develop and empower teachers so as to enable them to enhance learning of students and create learner-centric classroom processes through the use of technology. Thus, while CAL attempted to examine the role of technology in education, it was also focused on shifting teachers' pedagogical practices from a more traditional mindset to one that incorporated constructivist principals. A teacher development package, along with technology skills was drafted. Field personnel started conducting workshops and training sessions for both E1 and E2 teachers. While the focus was predominantly on pedagogy for E2 teachers, E1 teachers were also offered technical training to supplement classroom curriculum.

While formulating the concept note for CAL in Chhattisgarh, the team identified clearly defined goals for the duration of the intervention. In Year I, it was envisaged that the focus of the program would be on providing support to teachers and assisting them in developing reading and writing abilities of the students. To do so, APF field staff would provide both on-site and off-site support to teachers to develop their ability to systematically analyze students' reading, finding broad error patterns, grouping students on the basis of their error patterns and designing and providing need-based (error-targeted) learning materials. Based on this experience, the objective was to develop a broader perspective on what reading and writing entailed and how they were to be taught in class.

The focus of the program would also be to enable teachers to develop basic technical skills like Word, Paint, PowerPoint, Excel, and Web search. APF personnel decided to conduct the technical training in a phased-wise manner. In order to ensure a clear integration between classroom curriculum and technology, the program would support and encourage teachers to explore the use of technology to develop classroom content, while also guiding them in the use of already existing CDs to supplement the curriculum.

In Year II, the program plan of action was to support teachers in developing a perspective on teaching subject-specific curriculum, like math, and EVS. Yet again, the focus would continue on encouraging them to use technology to teach certain pre-identified topics and use technology for assessments.

CAL Implementation

Following the baseline study, the first interaction CAL personnel had with teachers in the program was to introduce to participants the intervention, its components, objectives, and goals. This one-day induction program was conducted in October of 2008, when CAL officials invited a mixed group of teachers from both E1 and E2 schools to introduce to them the objectives of the three-year study. During this time, the officials fielded questions like “what is CAL about?” “why are teachers participating in it?” and “what is expected from the intervention?” from school headmasters and teachers. The introductory session proved useful in getting teachers to be informed and ponder over program objectives, expectations, and the plan of action for the next 3 years.

During the very next month, the training sessions began with the first of many focused on language pedagogy. During the training, teachers were told of the results from the reading ability test (RAT) conducted as part of the baseline study. As mentioned earlier, as part of RAT, CAL officials identified reading passages that measured grade 3, 4, and 5 level competencies. Questions were also developed from these passages to be administered to children from the respective grades. Children were asked to read out these passages and later tested for reading competency and comprehension. The results from RAT helped identify common mistakes made by students while reading text aloud.

The training was focused on informing teachers of the different kinds of mistakes made by students, how these could be identified, and possible ways to rectify them. This two-day training was conducted for each participant in the program and was attended by both E1 and E2 teachers. The training commenced with APF staff sharing the baseline findings with the participants to infuse context into the process. CAL member Divya puts it:

> The results revealed three competency levels – first of those students who read fluently, but could not make sense of the text. This was obvious when they were unable to answer questions from the passage that they had just read. The second category comprised those students who would break up each alphabet and then stitch them together to form words. Their reading pace was also slow – something that should have taken them 3 minutes to complete, in actuality, took close to 30 minutes. However, there was also this third category of students, albeit very small, who could make sense of the reflective questions and answer them. Having arrived at these three reading levels, we proceeded to categorize the readers. This would help us identify problems associated with each level and suggest solutions.

Ultimately, the training was designed in a manner that would assist the teachers in identifying the three categories of readers—first, was the student a good reader; second, was he/ she making a mistake while reading; and third, was the student making too many errors while reading. Thus, at the training session, the teachers comprehended what constitutes an error and what were its manifestations.

Eventually, the result from this exercise enabled CAL to develop the "teacher development interaction and training" framework. The framework, while incorporating the findings from the baseline exercise, also integrated the basic principles of language training, with a focus on how language must be taught in the classroom. Anuj describes the process:

> What we did is: we first familiarized the teachers with the kinds of mistakes commonly made by students in class. To do so, we distributed students' answer sheets from the baseline RAT study to their teachers. The RAT study had a specific format. Let us suppose there is a word and a child has only partially succeeded in reading out the word. We asked the teachers to look at the student's RAT sheet and identify the kinds of mistakes made by him/ her. Once, we guided teachers in identifying the mistakes, we introduced the different approaches they could resort to, in order to rectify these mistakes as well as teach content. We emphasized against using alphabets to start teaching. Instead, we encouraged them to start with a story. And while telling the story, we encouraged them to contextualize it with the student's background and environment.
> Additionally, we also introduced them to concepts such as differentiation in the classroom. Our baseline results overwhelmingly supported the finding that teachers perceived classrooms as homogenous entities. There was this overarching belief that all children were the same. If one was not performing well it was due to his/ her inability to learn. We tried to alter that perception by guiding teachers to identify the need of the student. The RAT results were clearly indicative of the fact that while there existed this one category of students who could read very fast, there was also another group of students who read very slowly. So how were they to deal with this latter group? How could their teaching be modified to address both these categories of students?

Having familiarized the teachers to such concepts as contextualization of education, differentiated teaching practices, and constructive learning processes, CAL officials introduced several activities that would enable teachers to improve a students' comprehension ability in language education. Between July and August, 2009, the language training shifted focus to equipping teachers with the requisite tools to rectify these errors spotted in students. Yet again, this was done as part of a three-day language-training program for both E1 and E2 teachers. CAL deliberately avoided focusing on technology at this point in time because their first thought was to convey to teachers the principles of language education.

In order to remedy the errors, teachers were offered several ideas about encouraging group activities among students. These activities bound together students who were committing the same kinds of mistakes and personalizing the content in a manner that would improve comprehension among such a group of students. Divya explained the ideology behind such an activity-based learning scenario: "Suppose, there are five students in your class who are committing the same kinds of mistakes, then how must the teacher approach the issue? Likewise, if you have a different group of students who are making a slightly different kind of error, how must you tackle those?"

In designing activities that met the individual requirements of students, the broader purpose of differentiated learning would be achieved. Between the two trainings – spotting errors and resolving them, CAL officials offered onsite support to the teachers. Divya goes on:

> Whenever teachers faced a roadblock, unable to rectify a problem, they would call us, or we would discuss it during our school visits. At times, challenges also arose on account of teacher's inability to spot errors. For instance, you might argue that a child is reading well because he/ she has memorized the passage. To overcome the challenge, we gave teachers short passages for their students to read from. This would help the teachers identify mistakes.

Language pedagogy formed the core of the CAL Program in Year I. Between July-August, 2009 and February 2010, APF staff continued to offer on-site support to teachers in all the participating schools. During the on-site support, teachers were offered insights into how to create student groups in the class, the kinds of activities they could plan to engage students within these groups, and also ways in which students could be encouraged to use Room-to-Read books to improve their reading ability. This continued until January, 2010.

When Year II commenced, the program shifted focus to mathematics pedagogy. During this time, the training was modified to suit the requirements of E1 and E2 teachers. A 10-day residential training was conducted in May, 2010.

In the May training session, CAL officials followed a specific format to convey both pedagogical aspects of math learning as well as nuances that would enable teachers to integrate technology with the curriculum. To do so, teachers were first acclimatized to mathematical concepts and principles, and then introduced to its various applications and eventually, encouraged to reflect on the process. Ultimately, for E1 teachers, the goal was to innovate with ways in which technology could be brought into the mix. All this and more were part of a 10-day residential training program in May. The decision to conduct a residential training program was a conscious one. APF staff Vishal explained:

> What usually tends to happen is that, once a teacher is at a computer, he/ she tends to forget the time. Now, if we have established training hours from 9-5 or 10-6, teachers had a tendency to rush things. A residential training program gets rid of this need to hurry things along, because there are no specific after hours. As trainers, we are also in a better position to offer teachers extra time.

Simultaneously, a similar training program, albeit focused entirely on pedagogical concepts was also conducted for E2 teachers.

Although the May training session was open to approximately 40 teachers, only 29 attended. The remaining teachers were unable to attend because they had to report for mandatory census duty. To compensate for this, CAL officials organized a second training program in October, 2010 reaching out to the teachers who were unable to attend the May training session. Yet again, separate sessions were held for E1 and E2 teachers. The same format was followed during the October session. In the interim and in between training sessions, CAL officials offered constant on-site support to both E1 and E2 teachers.

The difference between E1 and E2 schools was that they did not have access to technology and therefore, the focus was primarily on the pedagogical aspect. Instead of computers, the trainings focused on encouraging teachers to use objects, or play acting, as mediums to explain concepts to children. Likewise, instead of lesson planning, E2 teachers were trained and encouraged to design learning plans. In creating the learning plan, APF field staff worked with teachers and encouraged them to think about ways in which a particular topic could be addressed, how it could be taught, and what kind of activities could be planned around the lesson. Teachers were encouraged to write their ideas.

Table 5: CAL Highlights

- Conducted five Orientations
- Conducted three state-level review meetings in addition to regular meetings with education officials
- Conducted seven teacher development interactions, which included an orientation to the program; informing teachers about the results from the RAT and CAT; training in math pedagogy; integrating technology with math pedagogy; and an extensive training on technology integration
- Integrated technology with MGML in math
- Conducted CD–curriculum mapping workshop, in which 66 CDs pertaining to math and environmental science were mapped
- Constant on-site support to teachers in all 20 E1 and 20 E2 schools

Once teachers formulated ideas, APF field staff sat with them to discuss what additional components could be introduced. Thus, the creation of a learning plan was also a joint effort between teachers and CAL. Effectively, while in E1 schools, children sat around a computer and engaged in collaborative learning, in E2 schools, class activities were designed sans computers such that children could engage in collaborative learning within the classroom. Highlights of the CAL program are presented above in Table 5.

CAL: Implementation Challenges

CAL's implementation was replete with several challenges that emerged very soon after the MoU was signed with the State Government. These challenges resulted in gaps between training programs, shifting focus of the training modules, and even re-creating content matter that would attune to the foci established by the State machinery.

Perhaps, of the biggest consequence was the State Government's February, 2010 decision to bring grades 1to 4 within the purview of the multi-grade multi-level learning (MGML) program. This was a holdup for CAL because the decision to work with grades 3, 4, and 5 teachers was borne out of an earlier State Government decision to introduce MGML in grades 1 and 2 only. Based on that decision, APF officials chose to work with grades 3, 4, and 5, and focus on creating grade-specific content for those classes and equip teachers with the necessary pedagogical tools to augment the quality of classroom interactions. Unfortunately, when the government decided to include grades 3 and 4 within the MGML fold, the focus had to be revised and content re-created. This challenge was especially acute for E1 schools. According to APF officials, the issue that emerged, was schools that were using books until now, how would they migrate to using tools like CDs? Divya explains:

> Prior to MGML, we had our own way of innovating around technology. We used the textbooks at our disposal and used them as the basis against which we created CDs that would integrate technology with the curriculum. However, after MGML was introduced, we had to rework everything in accordance with the concept arrangement in the ladder[15]. The technology cards that we had made earlier, we had to re-explore ways of integrating technology with the new MGML ladder system. We worked on it for 4-5 months. We created new technology cards, which were introduced as components in the ladder system. So we lost close to 3-4 months in that. Also, when MGML was introduced, the teachers were unclear

The ladder system in MGML measures competencies and sub-competencies among students. As children clear one level, they progress onto the other.

> and unprepared for this kind of pedagogy. Teachers were neither prepared nor pedagogically trained to work with the MGML concept. As a result, we ended up spending a lot of time trying to enhance teachers' understanding of MGML. MGML uptake among teachers was anything but smooth. As a result, not every school implemented the system. Some did, other did not and we had to make sure that we catered to both groups of schools. It just became very complicated.

To familiarize teachers to MGML and how technology could be used to complement the system, CAL organized a two-day workshop for E1 teachers, offering them a CD-curriculum mapping workshop. This training was conducted in two schools, where the number of computers was the maximum. APF staff introduced APF CDs to these teachers and taught them various ways to comprehend the purpose of each content, as well as, identify the competency to which the content related to. Having done that, the teachers were encouraged to cross reference textbook content with what was available in the CDs. Anuj explained:

> Now we did this because, suppose I am teaching students in grade 5, and I do not know that I am going to teach division to the students, then how can I integrate technology with the curriculum. As a teacher, I am first required to understand what is available in the textbook, as well as what is available on the CDs. Only then will I have a clear idea of how to use the computer to my best advantage.

The purpose of this exercise was to cultivate a tradition among teachers to start lesson planning before teaching concepts to children in class. In trying to source material through different avenues, CAL officials argued that teachers would offer students access to a diverse and rich learning experience, and clearly one that was not exclusively a product of only the textbooks prescribed for the respective classes.

Another issue that emerged was related to the time lapses between training programs. As mentioned earlier, while the first training occurred in November, 2008, the follow-up was not conducted until July/August of 2009. To explain the reasons for this, APF staff Maya said:

> This is because around January 2009, several of the teachers in the program got transferred here and there. Now once that happened, we got busy trying to

> understand and collecting data on how many teachers left the program, how many newly joined it, and identifying the gaps in training. We lost approximately 2 months doing this. While this took away most of our time, our ability to offer on-site support also suffered. We tried to assist the teachers to the best of our ability, helping them identify mistakes.

This was a setback for CAL because prior to signing the MoU, APF officials had laid down a few conditions indispensable for the purposes of the study. One among them was for the State to ensure that teachers who participated in the program would not be transferred to other schools which were not participating in the study. This, they argued, would help establish the true impact of the program on teachers. Most importantly, in ensuring that participants had prolonged access to the program, arguing toward any causality would also gain credence.

Other factors identified as vital to the success of the program were the availability of fully functional infrastructure and hardware. As part of the MoU, the onus of ensuring that lay on the state government. The Foundation, on the other hand, took responsibility for making available digital learning material of adequate quality and quantity, while also facilitating a continuous dialogue with teachers on ways to explore technology use for education. In the end, the program aimed to develop a demonstrable model of technology usage in schools that would focus on both capacity-building among teachers as well as supporting them to use technology to meet the ends of learning. Overall, the model also endeavored to demonstrate ways to empower teachers so as to enable them to enhance student learning create learner-centric classroom processes with and without the use of technology.

Some concerns were also raised about the delay in implementing the technical component of CAL for E1 teachers. According to CAL officials, problems arose because the infrastructure did not arrive at the schools within a stipulated timeframe. Anuj explained:

> The MoU started in February 2008. Everything should have reached schools latest by April. But infrastructure was a huge issue. It was in January, 2010 when we got the entire infrastructure (for E1 schools), including tables and everything. Because see, in 2009 when we did our language training, we were supposed to use different tools like audacity and photostory (ICT-based education tools), which required headphones and microphones to record. That itself we got in January, 2010. So that whole year (2009) we could not use technology because the schools did not receive the headphones and other peripheries required to introduce the technology component. We used some CDs in those schools that were equipped with speakers. In those cases, somehow we managed. For the furniture, you won't believe, we were supposed to give the dimensions – length and all. In one school, I know, the furniture has not arrived till date. They do not have the furniture because the person who was supposed to give the furniture kept it for himself/ or he took the money and never gave what he was supposed to.

Infrastructural concerns, coupled with the State's inability to provide E1 schools with the essential peripherals meant that APF staff could focus on the technical aspects for only a fraction of the timeline that was earlier established.

Compounding the lack of time were official holidays, summer vacations, census duties, and teacher strikes. Thus, although the MoU between the Foundation and state government was for three years, APF field staff contends that they did not get that time to fully accomplish what they set out to do. Divya explains:

> In a year, we lose two months to summer vacation—May and June. Festival season is a holiday. We lost approximately four months to teacher strikes. Infrastructure came in late, which was an additional loss of time. Every time there was an extended break due to these problems, teachers would entirely forget what was taught to them. We would have to revise concepts to bring them up to speed when we reconvened. We tried to work around these challenges. But it is tough.

The CAL training officially ended in January 2011. By February, field staff became involved in administering endline surveys to teachers. The final conclusion on demonstrated effectiveness was shared with education officials.

During the three years that CAL was underway, the field staff was involved in both monitoring and support. Going forward, their emphasis has shifted to providing assistance to

Block Resource Centers (BRCs) and Cluster Resource Centers (CRCs), who are effectively responsible for these school clusters.

Table 6: CAL Timeline

Month	Activity
February, 2008	MoU between state government of Chhattisgarh and Azim Premji Foundation
October, 2008	Induction program conducted. Teachers from both E1 and E2 schools invited to the induction. The purpose was to introduce CAL to headmasters and teachers
November, 2008	Two-day language training. Teachers were informed of the findings from the baseline.
	On-site support
January, 2009	Several teachers get transferred
	May-June, 2009: Summer vacation
July-August, 2009	Second training session in language. This training focused on equipping teachers with tools to rectify errors spotted in the baseline
	August, 2009 – January, 2010: On-site support
October, 2009	Computer installation in schools
February, 2010	State government decides to introduce MGML
February, 2010	CD-Curriculum mapping training for E1 schools
	April-May, 2010: Teacher strikes
May, 2010	10-day residential training in math pedagogy for E1 and E2 schools. E1 teachers were offered additional training in ways to integrate technology in math pedagogy. However, all teachers could not attend the training because a substantial number had to report for census duty
	May-June, 2010: Summer vacation
June, 2010	Head phones and audio multiplexer received in schools
October, 2010	Second batch of training in math pedagogy and technology integration for teachers who missed the May, 2010 training.
	November - December, 2010: Teacher strikes
July 2010 – December 2010	On-site support
January - February, 2011	APF officials get involved in collecting endline data
February, 25, 2011	Last date of MoU

Summary

The 3-year CAL research study was unique in that it addressed the central theme in the ICTs for education space—the notion of technology integration. Table 6 summarizes the timeline for the program. While aspects such as the impact of technology on learning and teaching were clearly critical to the study, it took a step back to address the issue of what could be done with the available technologies to improve the quality of the learning environment. In doing so, it also laid emphasis on putting processes in place that would make teachers challenge their pedagogical perception, which was expectedly more inclined toward traditional modes of teaching and learning. The study introduced teachers to aspects of constructivism and within it familiarized them to student-centered teaching practices.

Over three years, CAL conducted seven teacher development interactions, which included orienting teachers to the objectives of the intervention, familiarizing them to constructivist practices in reading, writing, language, math pedagogy, and training them in the use of technology to enhance the quality of the learning environment. Seven CAL field officials were also constantly involved in offering regular onsite support to both E1 and E2 teachers. In fact, between August 2009 and December 2010, each staff member made approximately 150 school visits to provide on-site support to teachers. In all, these officials trained approximately 220 teachers from E1 and E2 schools between 2008 and 2011.

However, as will be discussed in Chapter 5, technology integration is a complicated process and severely dependent on the interplay of numerous factors. In spite of the necessary processes in place, the majority of E1 teachers had stopped using technology by the time CAL officially ended in 2011. In the subsequent chapter, I examine what factors affected E1 teachers' ability to successfully integrate technology with the classroom curriculum.

Chapter 5: Factors Affecting Technology Integration in E1 Schools

In this chapter, I present findings on research question one. Part I describes the manner in which the CAL Program integrated technology with the classroom curriculum. Part II presents findings on whether teachers use the technology-based educational tools; and if they do, what are the different ways in which teachers experiment with the tools to enhance the learning experiences of their students. The findings in Part II shed light on Part III, which discusses the factors that were instrumental in how teachers' used technology.

Part 1: Technology Integration in the Computer-Assisted Learning Program

Technology integration in CAL had four critical facets: providing multimedia educational CDs, training teachers in technology usage, monitoring assistance, and providing training to teachers in ways to integrate technology with the classroom curriculum. As a start, creating educational CDs formed the core of the program. Content for the CDs was created after brainstorming with government elementary school teachers, subject matter experts, community members, children's storybook writers, e-learning content creators, and children. These stakeholders participated in a national workshop, where among other issues, they deliberated on the profile of the "end user" and what would constitute for effective content dissemination. The participants arrived at the consensus that content diffusion would be most effective if it had a strong interactive component. The logic being that if a child interacted with the computer, his/ her learning experience would be more engaging than if he/ she were simply to watch a video.

With this rationale in mind, the Foundation created competency-based educational CDs. The CDs were typically organized in a manner that first, it involved activities that gauged whether students had the necessary pre-requisites to comprehend the primary content matter. Subsequently, the main content was introduced through the use of games, music, songs, and animations and had a learning and assessment component. Assessment was done through time-bound games or score challenges. The feedback was instant with children either being congratulated for a right answer or encouraged to try again for a wrong one.

These CDs were translated into regional languages to cater to the needs of students in the different states that CAL had been implemented. As a strategy, the content for the CDs was generated in a manner such that children were self-reliant while using them. Overall, the content was curriculum oriented, child-centered, self-paced, interactive, and multimedia based[16]. This was not to suggest that the role of the teacher was redundant in CAL. On the contrary, the program placed the teacher at the core of the intervention, equipping them with tools to innovate with technology and create e-learning material that would complement their teachings in class. Apart from the curriculum-based CDs created by the Foundation, children were also encouraged to work on already available programs like "Tux Paint", "Tux Math", "Audacity", and "GCompris", etc to further their educational experience.

The CDs possessed several key attributes. They provided students with a learning experience that was self-paced and non-threatening. The content encouraged self-paced learning, enabling children to progress at their own pace. Comprehension of content was made easier and simpler through the use of games and stories. Most importantly, the CDs allowed for differentiated learning because children accessed that content, which corresponded with their classroom progress. Most importantly, unlike classroom scenarios where wrong answers are

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[16] APF documents

often greeted by admonitions, children felt relatively safe within the confines of the computer laboratory.

Observation of the CDs also revealed that content was designed in a manner such that feedback was instantaneous. When students gave a wrong answer, characters appeared on-screen, urging them to try again. Students were not allowed to progress until they provided a correct answer. This was in stark contrast to what was observed in the classrooms, where teachers proceeded with the content matter irrespective of whether everyone in class had understood what was being taught.

In its manner of implementation, the CAL model encouraged group-learning. Partly, the group learning was assisted by the fact that the student-computer ratio in most schools was 5:1. Thus, forced by circumstance, children were expected to work in groups. As also observed during the data collection, children divided the work amongst themselves while wading through content matter. For instance, when a problem appeared on screen, one child read it out, a couple discussed it, one announced the answer and finally, one clicked on the option that the group collectively thought was correct. This practice established a democratic participatory form of educational experience for these children, who were all equally invested in the learning process.

Additionally, interactivity was key. In CDs, such as “Photostory”, children clicked on the images on the screen to move a story forward. Likewise, online mathematical games allowed children to engage with the content. This ensured children remained motivated and involved in the learning process. What was also observable is that rather than design content that reflected grade-specific curriculum, the Foundation created CDs that were competency-based. From a constructivist perspective, such a system allowed for differentiated learning. It functioned on the premise that children learn differently and at varying paces. Thus, children accessed only that content, which tested them on their current competency.

These self-paced, child-centric, interactive CDs were made available in E1 schools. The focus of the intervention was primarily to help children reinforce curricular content taught in class. However, a secondary benefit of the exercise was that children imbued necessary technical skills, essential to maneuver the CDs.

Program Features

The computer component of the curriculum was incorporated into the regular timetable of the school. In some schools, children were also encouraged to use the resources during any free time available—for instance, lunch break or in between class. The purpose of technology integration was first, to simplify curriculum in a manner that could be easily understood, and second, impart technical skills to children and make them self-reliant in the use of computers. Explaining the manner of their operation further, Anuj offers:

> Suppose the teacher has taught the concept of addition to children. Now, she might use objects or any other medium to convey the concept to children. But when it comes to application, how can the computer be of assistance? How can the computer enhance a student's ability to apply the concepts learnt in the classroom? While we were keen that children use the computer to apply the concepts learnt in class, we also wanted to ensure that we imbue basic technical skills in them. So we introduced activities that would enable children to both understand addition and also the technicalities associated with the computer. So during a lesson in addition in the computer lab, children would be instructed to open a Word file, insert images and then add the number of images to give the correct answer. Thus, while they were doing a simple addition in the computer lab too (similar to what they were doing in the classroom), however, the difference here is that they simultaneously learnt how to insert images, they also learnt how to color the images, and if they were asked 3 + 3, they knew how to insert three pictures each and write the correct answer at the bottom.

Earlier CAL efforts were focused on creating content based on the textbooks children were assigned. However, that strategy was overhauled when the state government decided to commence with the implementation of MGML in grades 1-4. Suddenly, the content created on the basis of textbooks was redundant and a new approach had to be initiated in order to integrate technology with the MGML curriculum.

When MGML was introduced in E1 and E2 schools, it abolished the grade levels that CAL worked with in the creation of technology-based educational resources. Instead, a nongraded system was introduced wherein grades 1 through to 4 were combined and children were offered a series of learning matter, which were competency based. Thus, based on a child's competency level, he/ she had the discretion to navigate the curriculum at their own speed.

In rethinking ways to introduce a technical component to the students' educational experience, the CAL program introduced technology cards, which complemented the different competencies as part of the MGML system. The MGML cards came from the government. Some of these cards helped children revise what had been taught before. However, in some cases, these cards had been lost and not replaced by the government despite repeated reminders and requests. Instead, APF officials replaced these lost cards by introducing technology-related material in those gaps. In addition, part of the MGML cards was also converted into tech cards. Thus, instead of working on the MGML card in class, students were encouraged to go to the computer laboratory and work on the technology cards. Once a child reached a certain competency milestone and picked up a technology card, he/she could go to the computer laboratory to accomplish the tasks listed on the card. Anuj explains the entire process of tech card creation and implementation:

> We proceeded as follows. First, we tried to understand the MGML process. We tried to grasp what the concept contains. It was observed that there were three simultaneous concepts in any one milestone. The process tied two or three concepts together. Initially, our understanding was that one milestone would contain only one concept. And the next milestone would pertain to the next

> concept. In reality, however, this was not the case. So we spoke to state-level authorities, enquiring why this was so. They gave us some reasons. On the basis of those reasons, and without wanting to make too many changes, we used the same order and sequence established by MGML to introduce an additional tech card. This card would link the card prior and the one proceeding. This was our idea. So, teachers were informed beforehand that when a child reaches a certain tech card, then he/ she (teacher) must keep in mind what card the child was on prior. The teacher would have to relate the cards to the children (because this card was a new addition and had not been given by the government). And they were also told that once the child completes the card, having completed all of the activities mentioned in the card, then the student may proceed to the next card. But, it was the teacher's duty to connect the sequences, because only then would the cards created by us have any value. Following this method, we introduced a new tech card at each milestone. That card used to be both concept related and activity related and also a link between the card prior and the one proceeding.

General instructions on computer usage for these students would first be written on the blackboard. In these instructions, children were first asked to recollect the lesson taught in classroom. Subsequently, the tech card would instruct students to solve problems based on the lesson learnt. Thus, for instance, if children were taught a lesson on addition, then having repeated it in the computer laboratory, they would be asked to compute 4 + 3. Simultaneously, however, they would also be taught that in order to do so they would first have to insert images, then add them and then derive the right answer and write it at the bottom of the images.

In order to simplify the process more, the technology cards contained additional instructions. For instance, the cards contained images and icons that guided children on ways to retrieve images, insert them on a word document, and paint them. To make the experience more democratic, the tech card also assigned individual tasks for each student. If there were three students at each of the computers, then each of them would be designated individual tasks. For instance, one would insert one image, the second would insert another image, and the third would insert the third image. Likewise, one would color the images, one would compute the answer and the third one would write the answer. This way, every child had the opportunity to play with the mouse and work at the computer. These features were especially enforced so that no one student would monopolize the computer, while others get sidelined.

Training features

Since MGML was also card-based, there was a certain degree of apprehension among APF officials and teachers regarding the utility of the technology cards. But program officials took suitable steps to ensure that teachers understood the distinction between the two systems and especially grasped the process of the technology cards. Divya explained:

> When we conducted the residential training for math, we worked with teachers and explained to them the process of these cards. We then introduced the cards in E1 schools. The teachers were first made aware of what exists in the cards, why have they been introduced at that particular point in the lesson, what is the teacher's role, what is the student's role, and if there are multiple students, what is each student's role. These are just some issues that were meticulously communicated to the teachers.

Additionally, in order to ascertain that technology became a systematic component in the educational experience of children, APF field staff, in conjunction with the teachers, were also involved in designing a timetable that clearly charted out when computers could be used during the course of the school week. Anuj explains further:

> We used two different approaches – one for grades 3 and 4 and another for grade 5. This was because grade 5 did not come under the purview of MGML. Thus, for students of grade 5 alone, we made it mandatory that they be allowed a minimum of two periods of computer usage. Conversely, grades 3 and 4 were following the MGML system. We reasoned that the sequence in which children reached certain competency cards, that they follow the same sequence into the computer laboratory.

The field staff also dealt with the issue of student computer ratio in a manner that would make time spent in the laboratory most rewarding. Some degree of homogeneity was desired in the students who sat together as a group at a computer terminal. It was essential that these students displayed relatively similar intelligence and competency. Vishal offered:

> We could never gauge for certain how many children would reach any particular milestone simultaneously. We were not sure if there would be one student or more on the same card. So what we did is, if there were multiple children on the assessment card, which was usually at the end of each milestone, then we suggested that all of them proceed to the computer laboratory together. And suppose they were not on the assessment card yet, we recommended that they still be allowed to progress together. So that when they finally arrived on the technology card, they would be able to work together at the computer. As a general rule, we endeavored to have at least groups of three, who were on the same card, at each computer terminal. We reckoned that would be the most efficient and effective arrangement.

As mentioned earlier, MGML classes were an amalgamation of students in grades 1 through to 4. But, CAL was confined to students in grades 3 through to 5. A challenge that soon emerged was that in certain cases, teachers were faced with the circumstance that students in grades 3 and 4 displayed the intellect of students in grades 1 and 2. To counter this concern, teachers were given a resource book that clearly outlined for them the strategies that would help them cope with the situation. This resource book comprised activities and lesson plans specific to the requirements of such students.

But, the above approach did not work well in schools where MGML ran into implementation issues, primarily on account of infrastructural concerns, space constraints, and lack of resources. To counter this challenge, CAL offered a different approach to these teachers—they were given resources that mapped the Foundation CDs with the grade-wise curriculum. Vishal adds further:

> However, for these schools too, we gave them a timetable, with clear instructions on where and when computers must be introduced as part of the lesson plan. So, if grade 3 students were learning a new mathematical concept today, we suggested that two math periods be allotted—first, learn the concept in class, and second, use the CDs in the computer lab to reinforce the concept.

However, CAL officials were apprehensive that the diversity in the resources would lead to confusion and even a waning of teacher interest in some cases. To prevent such an occurrence, field officials, among themselves, divided the schools into small groups on the basis of geographic proximity and were responsible for constant and regular monitoring. Continuous follow-ups entailed talking to teachers on the phone or in-person to gauge the progress of students. Anuj explained:

> During these conversations we focused on student progress. For example, we discussed that if these three children are on this card right now, then what is probability of reaching the next stage and how much time would that take? Teachers, in turn, informed us of their next course of action and a dialogue would ensue. This was constant and mutually beneficial because we were abreast with student progress and teacher efforts, while teachers had the opportunity to discuss roadblocks and solutions.

The intervention also steered teachers toward creativity by offering them the acumen to plan a lesson and put the technological resources to appropriate use. Anuj goes on:

> For instance, if a teacher is teaching division, we told them that the topic is mentioned in such and such chapter of the book, and within the topic what all must be conveyed to the students. But see, in order to be effective, it is essential that if I am the teacher then I make adequate preparations before class. I should know exactly what I am supposed to teach, what is TLM, and how can I integrate technology with this topic. If the teacher makes such preparations beforehand, then this process will not appear burdensome to them. Instead, if the teacher is of the opinion that no my way is the correct way, I will continue to teach the way I teach, and since we have already been given the timetable, I have only to ask the students to go sit in the lab during the designated time, then this exercise has no meaning at all.

This is another aspect where CAL's contribution was of paramount importance. They inculcated in teachers a culture of lesson planning, and the different ways in which classroom sessions could be made interactive and engaging. Most importantly, lesson planning was not confined to technology use alone. The focus in this case was strictly pedagogical and teachers were encouraged to ponder over lessons prior to class and develop activities that would lead to more constructive outcomes. Technology was plugged in wherever it was thought that the CDs would enhance the learning experience of the students. As mentioned earlier, each staff member was responsible for a small cluster of schools. To instill in teachers the significance of lesson planning, each staff member worked in tandem with the teachers of those schools they had jurisdiction over. Field notes from these experiences reveal three emphases: first, gauging teacher understanding of what a lesson is trying to convey; second, how might that be conveyed to students; and third, where might technology simplify and amplify the process. Figure 20 is just one among several examples of how APF staff worked with teachers to develop a learning plan. In this case, the learning plan pertains to the mathematical topic of place value[17].

[17] After MGML was introduced in Kurud, the textbook-based content created as part of CAL became redundant in many schools. Only those schools that consciously decided against implementing MGML continued to use this previously created content. After MGML, CAL focused primarily on Mathematics. As a result, most of the examples offered under program features are math-based.

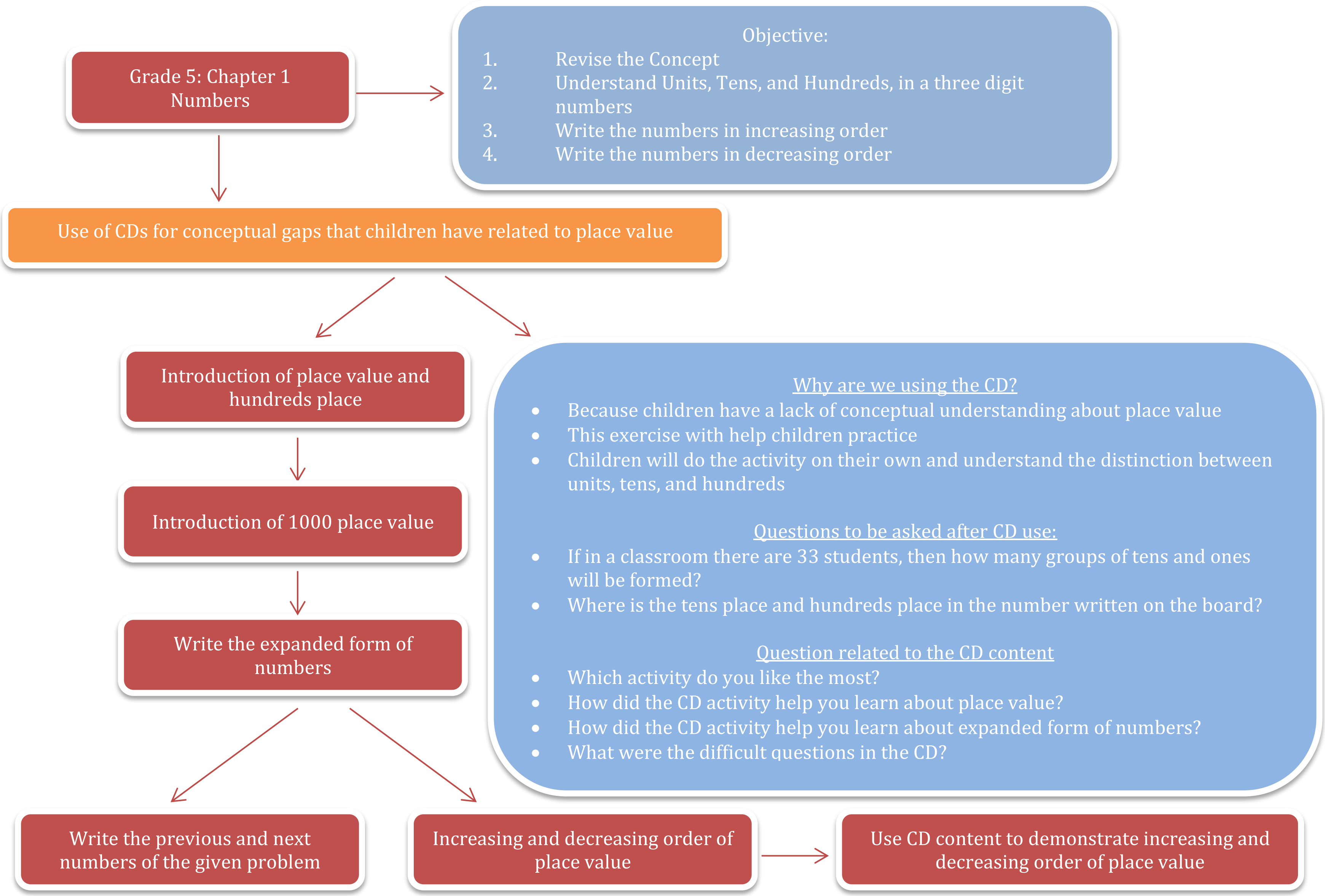


Figure 20: Development of Learning Plan (CAL field notes)

In the field notes shared by APF staff, one observes a methodical approach to lesson planning. As part of the CAL intervention, field staff and teachers worked together to design an approach to teaching the concept of "place value" to students. Discussions with teachers usually began with arriving at a common consensus on what the objective of the chapter on "place value" is and how might that be conveyed to students. Transferring the knowledge thereafter was made possible through in-class discussions, activities and CD content. Field staff, in conjunction with the teachers, clearly mapped out avenues where CD content would supplement classroom lectures. The learning plan also helped identify common challenges children faced while comprehending the concept. For instance, teachers shared that children displayed a lack of understanding on place value of ones, tens and hundred. As a result, their ability to add and subtract was substantially hindered. This was evident in the following example provided by the teachers:

Often times, children had difficulty writing down an addition and subtraction problem, especially when it was given orally. A question asking students to add 21, 721, and 21 was written as follows:

Hundreds	Tens	Units
	2	1
7	2	1
2	1	

Two reasons emerged for this fallacy: first, children were grossly unclear about place value; and second, since they often wrote from left to right, they used the same reasoning to write down mathematical problems. Additionally, a second challenge that emerged from the lack of clarity on place value was that a mathematical problem such as (25308) – (76397) was automatically modified as (76397) – (25308) by students. From student observations it became obvious that an inability to solve ‘carry-over’ problems was the reason children altered such questions.

To assist teachers in simplifying the concept in a manner that would improve comprehension among students, each APF staff conducted regular meetings with teachers in those schools they were responsible for. These meetings were held predominantly to inculcate in teachers the significance of lesson planning. Lesson planning involved deliberations on a whole range of questions—what is the objective of the lesson; what did the teacher want students to learn from this topic; what must students be able to do when they do the activities in the textbook; and are there any pre-requisites that children must complete before arriving at “place value.”

Likewise, teachers were encouraged to identify avenues where CDs would augment the learning environment. To that end, CAL officials encouraged teachers to ponder over questions like: why did they want to use a particular activity from a CD at a particular place; what follow-up questions might they ask students when they view the CD, etc.

One critical aspect about CAL was that it was premised on the fact that teachers needed be at the center of the innovation. Technology was not touted as a substitute, instead it was considered only supplemental to the efforts of the teachers. This was clearly evident in the manner in which the CDs were designed. The majority of the content was used to reinforce concepts already taught in the classroom.

Part 2: How were E1 teachers integrating technology with the curriculum?

Data collection for this study began in June, 2011, during which time the 2011-2012 academic calendar had commenced. However, the CAL intervention had officially ended in March, 2011, with the 2010-2011 being its last year. Observations made during the field visit revealed disappointingly negligible use of technology in the majority of E1 schools. Teachers in my sample reacted to technology in one of three ways—avoidance, integration, and technical specialization. The majority of the teachers displayed apathy, a few engaged in some degree of integration, and a rare handful used technology to create something new and proactively endorse its use amongst their students.

During my field visits, the majority of computers in E1 schools were lying idle. Equipment lay there, unused and gathering dust. In many instances I observed that headphone wires and power chords had been chipped away by rodents, rendering them unusable. Computers had stopped functioning, and according to some teachers, had not been used for more than 4 months. In some other instances, computer laboratories had not been opened since the beginning of the 2011-2012 academic year. On being asked why, teachers responded that students had not yet arrived at that stage in the curriculum where the computer components could be introduced. This reasoning lacked credibility because the computer modules extensively covered prerequisites to current curriculum and could be used to reinforce concepts learned in prior grades. As will be discussed later in the chapter, infrastructural bottlenecks and the recently introduced MGML policy amounted as the biggest reasons for the lack of computer use in E1 schools. Given that the use of technology at the time of my visit was clearly minimal, in order to gauge how teachers used the tools for their instructional purposes, I modified my survey to invite responses about computer use in the previous academic year.

Types of technology programs run in schools

Survey responses revealed that CAL training encompassed two components: a technical component wherein teachers were imparted necessary technical skills involving basic computer usage and software prowess; and an educational component comprising resources that augmented the learning environment. But, these two components were not exclusive of one another, because the Foundation argued that such a strategy would fail to equip teachers with the skills to integrate technology with the curriculum. As a result, both occurred simultaneously. While the former enabled teachers to acquire necessary technical skills, the latter opened ways for them to use this newly acquired skill to enhance the learning experience of students in their class.

Teachers were trained on a wide variety of technical and software use. Table 7 presents the names of software programs and C.Ds that teachers used and encouraged their students' to use. What is essential to note here is that Table 7 is simply an aggregate of the survey responses. It does not reflect each and every teacher's use of technology in school.

Table 7 : Types of Programs run in Schools

Name of Program and C.D	Brief Description
Microsoft Word	Prepare class lists, create posters, type the national anthem, maintain progress report of students, write questions for mid-term and end-of-term examinations, create birthday posters, type out midday meal menu for the day
Microsoft Excel	Maintain the midday meal list and expenses, and record class attendance
Microsoft PowerPoint	Create slides to explain educational concepts to children
Photostory C.D	Teachers encouraged children to use this software which would allow children to click on the images on the screen to move a story forward
C.Ds	Used C.D.s created by the Foundation to explore avenues where technology could simplify and help reinforce classroom concepts to students
Baraha Hindi Typing	A Hindi language software that teachers used for their typing requirements
Drawing	Create images using Paint
GCompris	Yet again, teachers encouraged students to use GCompris, an educational software comprising more than 100 different activities. The activities allowed children to refine their ability to work at the computer, using the mouse and keyboard, while playing logic and reasoning games.
Tux Paint	Children used Tux Paint as a computer-based drawing activity. The software combines animation and sound effects to guide

	children as they paint on a blank canvas and be creative.
Tux Math	This program helped children reinforce mathematical concepts taught in class. It offered mathematical games based on addition, subtraction, multiplication, and division of positive and negative numbers. Children used the keyboard to enter the correct answer. Through the use of sound effects and animation, the software provides instant feedback.
Audacity	Teachers used Audacity to record sound with special effects.

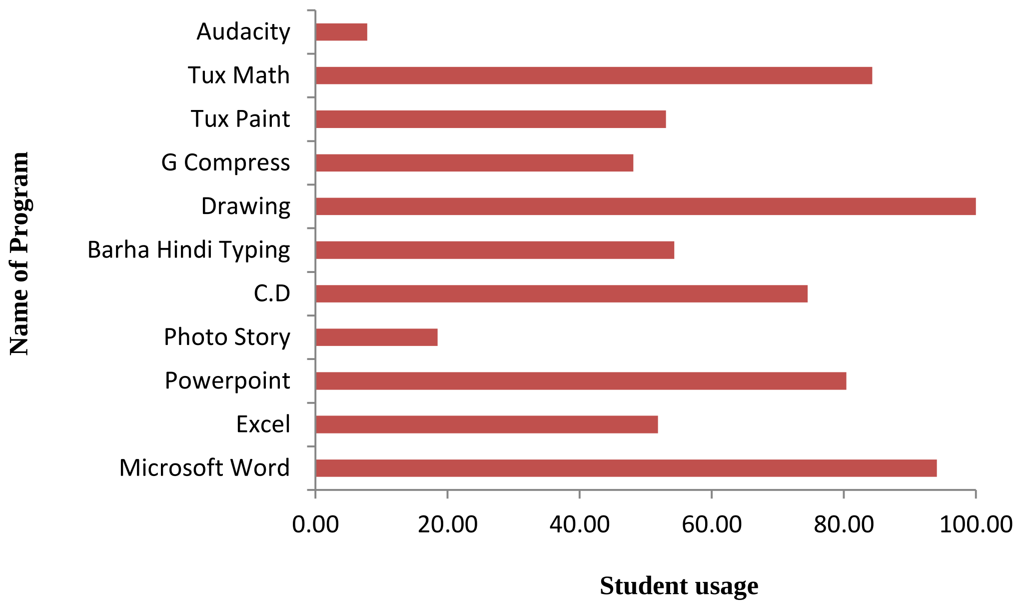


Figure 21: Technology Use in Schools

Figure 21 delves deeper into technology use among students in E1 schools. As is evident, the most commonly used programs were "Drawing", "Tux Math", "Word", "PowerPoint", "C.Ds", and "Baraha Typing". Of the 51 E1 teachers surveyed in the study, drawing was by far the most used program among their students in schools with 100 percent of respondents reporting its use, followed by "Microsoft Word" (94 percent), and "Tux Math" (84 percent).

According to teachers, "Drawing" was clearly the most popular program among students because it gave them the opportunity to create something new, play with colors and express their imagination. One of the school principals, Akash, explained the popularity:

> Children were most excited about painting and drawing. Friends would get together, sit at a terminal and discuss animatedly about a picture they wanted to draw. Or, they would retrieve a saved image and discuss how to paint it. My students would engage in group activity but only about making a nice picture. On many occasions, this would keep them busy for half an hour or 45 minutes.

Children's fascination for paint was further aided by the easy-to-use and engaging interfaces provided by programs like "Tux Paint". As students gave shape to their imagination on a blank canvas, the in-built interface of the paint programs gave them animated hints on how to move forward.

The use of "Microsoft Word" and "Tux Math", as the second and third most widely used program was on account of them being closely tied to the curriculum. As mentioned earlier, children used computers to reinforce classroom concepts, while simultaneously acquiring technical skills. When working on a tech card, children were encouraged to maneuver the "Word" program on their own. For instance, to solve a math question, the tech card required them to open a "Word" document on their own, retrieve already saved images in the computer, position them on the document and then add them up for the correct answer. They also used "Word" to practice Hindi typing using the "*Baraha"* font software. According to teachers, typing their name on a document would get them very excited and thrilled.

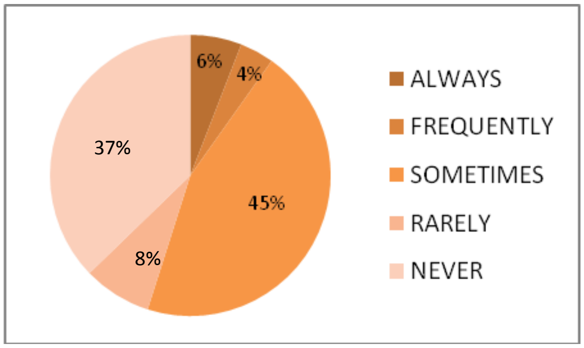
Like "Tux Paint", "Tux Math" also stirred students' curiosity and enthusiasm regarding math. Teachers reasoned the game interface of the program was partly responsible for the favorable results. The program allowed children to improve their grasp of addition, subtraction, multiplication, and division, while also familiarizing them to the keyboard. When accessing a "Tux Math" module, children would have to enter the correct answer using the keyboard. Children, as a result, became familiar with the number keys.

Given these responses, it was essential to understand how teachers perceived technology integration in order to gauge how invested they were in the process. To do so, as depicted in Table 8, my survey contained 12 items that captured the different use cases of technology. These statements reflected the three uses of technology—for instructional purposes, non-instructional purposes, and as a learning tool. These 12 items were on a five-point Likert scale, ranging from 1 (Always) to 5 (Never).

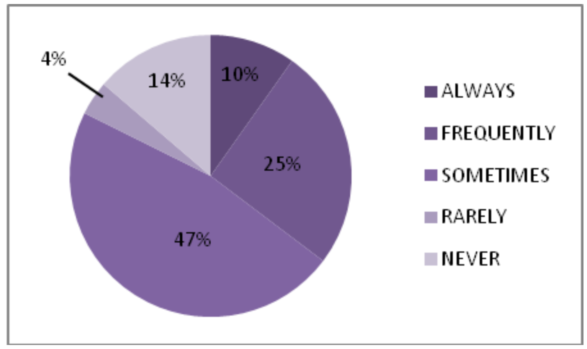
Table 8: Teacher responses on Technology Use

Type of Use	Survey Item	Mean (N=51)
Non-instructional Use	I use the computer to create the syllabus	3.67
	I use the computer to record attendance	4.11
	I use the computer to conduct classroom assessments	2.86
	I use the computer to make timetable	3.04
Instructional Use	I use the computer to clarify students' doubts	2.31
	I use the computer to run simulations and games that explain concepts	2.18
	I use the computer to build problem-solving and reasoning skills among students	1.94
	I use the computer to create lesson plans	3.35
Learning tool	I use the computer to encourage group activity among students	1.98
	I use the computer to encourage students to interact with each other	2.47
	I use the computer to make students play educational games	1.96
	I encourage students to use the computer during class time	1.71

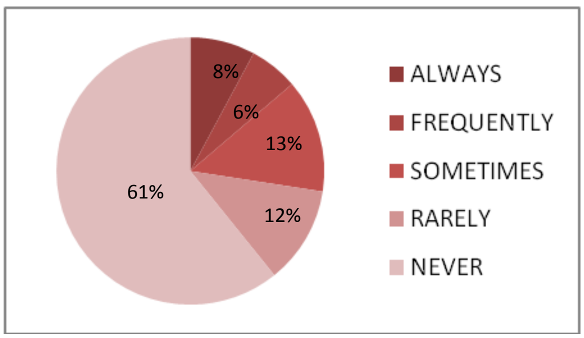
<u>Non-Instructional Use of technology</u>



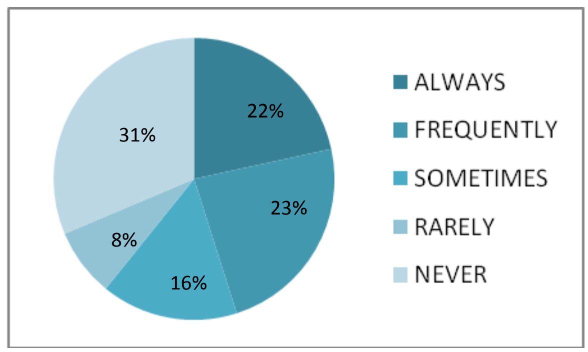
I use the computer to create syllabus



I use the computer to conduct classroom assessments



I use the computer to record attendance

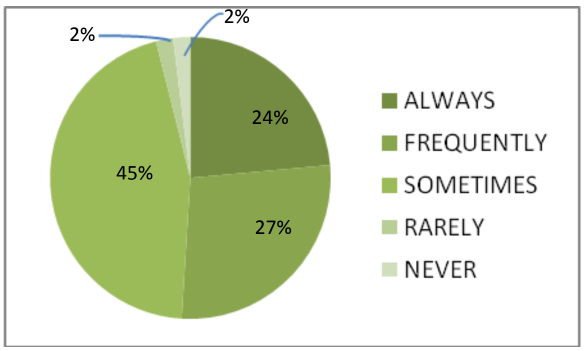


I use the computer to create the timetable

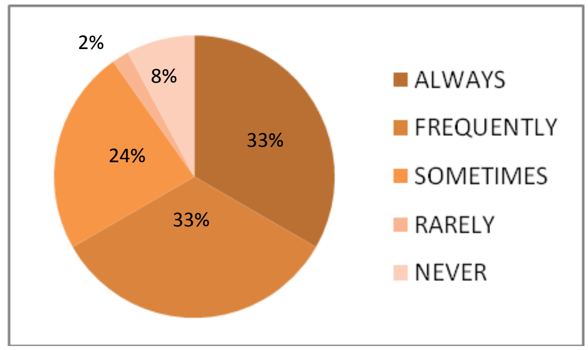
Figure 22: Non-instructional use of technology

As evident in Figure 22, teacher responses were typically “sometimes” for the majority of the items measuring non-instructional use, except on the item measuring computer use to record classroom attendance. Interviews with teachers revealed that while they are officially required to maintain extensive records on assessments and attendance, which are shared with government officials, these are essentially offline activities. It also emerged that teachers do not have the discretion to plan the syllabus. However, 3 teachers from among the sample of 51 took the initiative to redesign the syllabus. As will be discussed in Part 3 of this chapter, one of the reasons this was the case is that these teachers enjoyed tremendous support from their respective principals and were constantly encouraged to innovate with their teaching strategies.

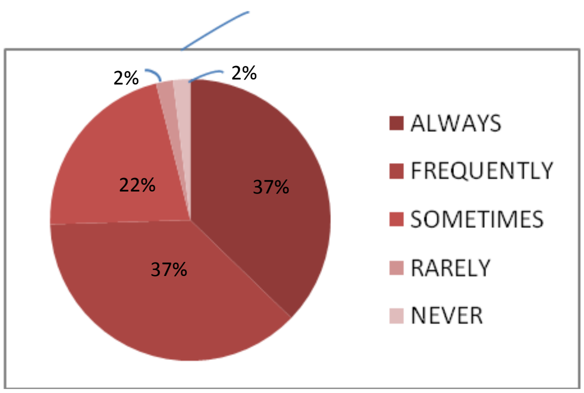
Instructional Use of technology



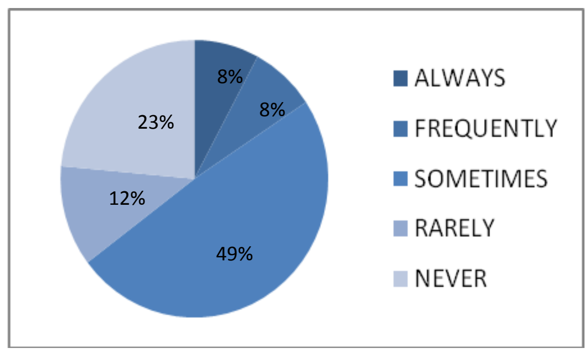
I use the computer to clarify student doubts



I use the computer to run conceptual games



I use computer to build problem solving and reasoning skills among students



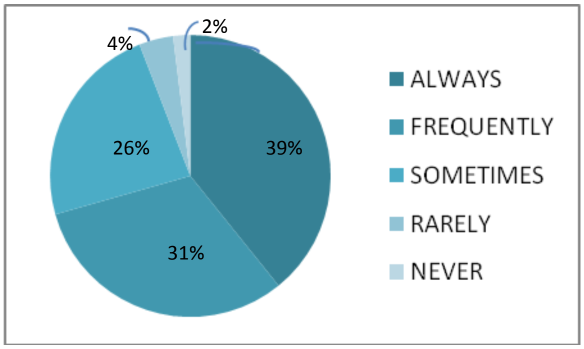
I use the computer to create lesson plans

Figure 23: Instructional Use of Technology

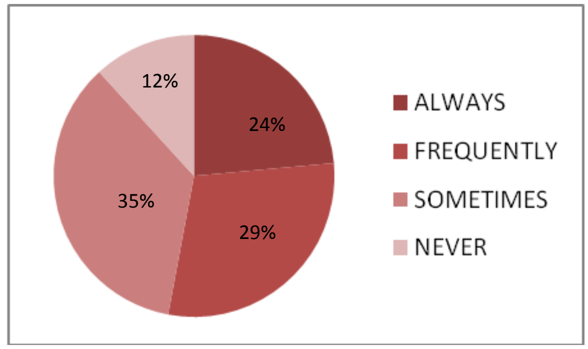
As portrayed in Figure 23, teacher responses on items measuring instructional uses of technology suggest that they "always" or "frequently" used computers to play educational games and content that helped build students' problem-solving ability and reasoning skills. However, technology wasn't used extensively to create lesson plans or clarify student doubts. What must be noted here is with CAL, teachers were for the first time introduced to the concept of lesson planning. During the earlier stages in the CAL study, lesson planning was a concerted effort between teachers and APF field officials. During this training phase, teachers were exposed to the various ways the technology modules could be integrated with the classroom curriculum to enhance the quality of the learning environment. Importantly, APF field officials educated teachers in the different ways in which technology could become part of a student's learning experience. However, this required considerable time and effort on the part of teachers and a substantial understanding of what each CD module contained and where those could be plugged in. As will be discussed later, time was a significant impediment in teachers' ability to abundantly explore how technology could be aptly utilized.

Likewise, approximately 45 percent of teachers stated they only "sometimes" used computers to clarify student's doubts. Interview data collected during the field study revealed that computers were used mainly to help students reinforce concepts taught in class. Reinforcement occurred through the use of educational games. For instance, following an in-class lesson on addition, students were encouraged to proceed to the computer laboratory to play games that tested their ability to solve addition problems. Similarly, students were encouraged to explore the curriculum-based CDs created by the Foundation. However, clarification of doubts in the computer laboratory was only done "sometimes". Given the class size in some E1 schools, students were divided into two groups to accommodate a suitable number in the computer labs. While one half remained in the classroom, the second half proceeded to the computer laboratory to work on the modules. As a result, often times, the teacher's role was reduced to ensuring that students in both settings did the assigned work in an organized manner. Further, in the absence of the entire class, teachers could not personally use technology to clarify doubts for the class in its entirety.

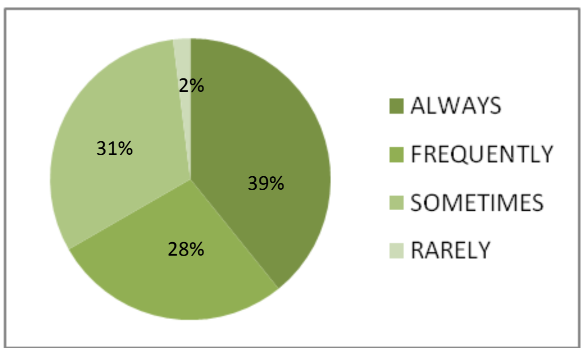
Technology as learning tool



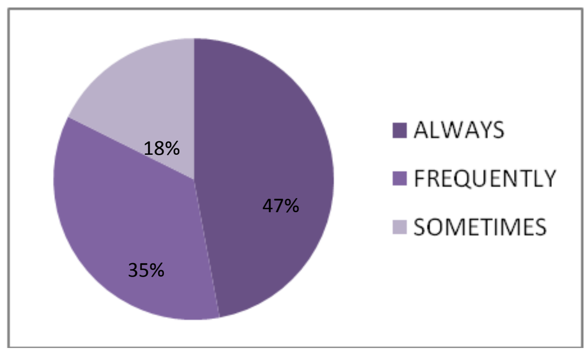
I use the computer to encourage group activity among my students



I use the computer to encourage students to interact with one another



I use the computer to encourage students to play educational games



I encourage students to use computers during classtime

Figure 24: Technology use as a learning tool

Figure 24 depicts teacher responses on how often they used technology as a learning tool. Almost uniformly, the teachers expressed that they either "always" or "frequently" used technology as a learning tool, as evidenced by how often they used computers to encourage group activity among students, allow students to play games, or encourage students to use the computer during class time.

In addition to what these survey items captured, from the interview data, it also emerged that teachers used programs like "Word" and "Excel" to perform administrative duties. Some of these activities were recording midday meal data, writing down monthly expenses, and maintaining class lists. Yet again, these were mandatory and required by government officials. Teacher responses suggested that often their use of technology was confined to playing the curricular-based CDs on the computer or having children run other CD modules that tested their knowledge of curricular content. Rarely did they use technology to create something new. Three teachers, however, deserve particular mention here. They were perhaps the only ones from among the sample of 51 who used their training to create new content that helped clarify student doubts and/ or assess their progress. The following illustrates their efforts.

Seema’s use of PowerPoint to explain the Solar Eclipse to her students

Figure 25: Seema's PowerPoint presentation of the Solar Eclipse

Seema’s students were very curious about the phenomenon of solar eclipse, having experienced it recently in their village. They asked Seema to explain exactly how an eclipse occurred. Seema selected three students in class and assigned them to play the role of the Earth, Sun, and Moon. She asked them to stand in a straight line such that the Moon was between the Earth and the Sun. Using this role play, she explained to her students how an eclipse occurred. However, on encouraging feedback from students, she realized that were still unclear. On asking why, the predominant reason that emerged was that students found it difficult to relate to humans as the Earth, Moon, and Sun. It then struck Seema to use her newly acquired “PowerPoint” skills to demonstrate the eclipse to her students. Figure 25 presents a screenshot of Seema’s presentation on solar eclipse. To make the lesson interesting for her students, she used animation that enabled her students to see the Earth and Moon’s trajectory vis-à-vis the Sun, and how as they make a straight line, the Moon blocks the Earth’s view of the Sun causing the eclipse and a temporary darkening of the sky. According to Seema, not only did her students gain clarity over a new concept, they were also thrilled at the computer graphics on display.

Dibakar’s use of Word to explain fractions and Hindi vowels

Dibakar realized that children understood mathematical concepts much better if there was visual representation of what was being taught. He found this line of reasoning particularly pertinent while teaching

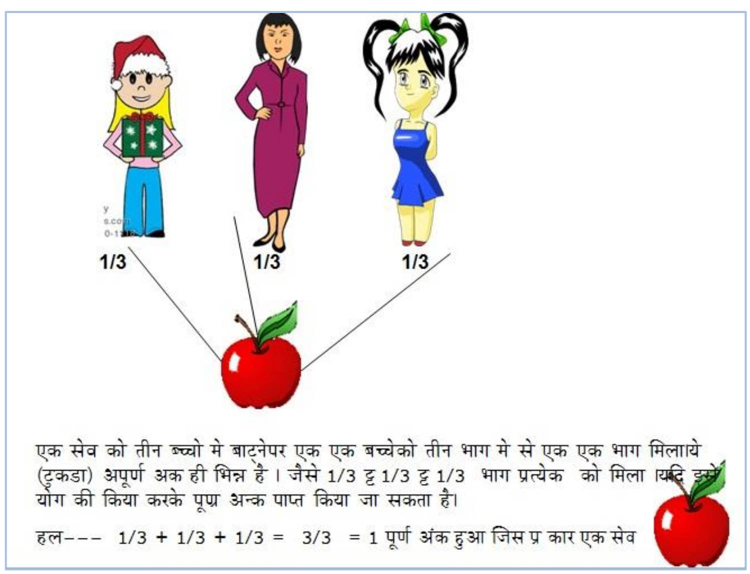


Figure 26: Dibakar's use of images and text to teach fractions

students a lesson on division. As depicted in Figure 26, he inserted text and images to teach children how an apple would be divided among three people. Dibakar opined that images helped student understand the concept of division far more easily than focusing on a blackboard would have merited.

Figure 27: Mala using Excel to test student knowledge of mathematical shapes

<u>Mala's use of Excel for math assessment</u>

Unlike Seema and Dibakar, who created concept-oriented resources, Mala used her skills to design assessment modules for her students to work on. Figure 27 portrays her use of excel to create an assessment module on mathematical shapes. She asks students to correctly guess the number of sides for each of the shapes. Each correct answer is congratulated with an instant "good", while for every incorrect answer the student is prompted to try again. She created a similar module testing children's knowledge of national flags. According to Mala, the visual effects, along with the instant feedback were an immediate hit among her students.

While Seema, Dibakar, and Mala, unanimously extolled the benefits of technology in transferring conceptual knowledge of curricular content to students, they said that school conditions were often inhibitive to unimpeded access. Seema encapsulates these challenges:

> I was happy to create the PowerPoint slides. But when I took my students to the computer laboratory, I could install the slides in only one computer. All my students had to stand huddled around that one terminal to understand what was going on. The other alternative was for me to install the slides in each computer. But there is hardly adequate time to move from one computer to another explaining the same concepts to students. Ideally, if all the students could watch me play the slides at one go, it would be most effective.

From the survey responses and interview data it became evident that while teachers used technology for instructional purposes, their efforts were limited to running already existing content matter. Children used the computer to strengthen their understanding of content matter. Creativity was limited and only confined to activities such as painting or drawing by using the appropriate computer program. E1 teachers integrated technology by incorporating CD content with existing curriculum. They planned their lesson delivery in a manner such that the curriculum-based CDs could enhance and simplify conceptual understanding among students. Following in-class lectures, children were encouraged to play educational games that tested their knowledge of the concepts newly learnt.

Unfortunately, however, the majority of E1 teachers stopped using technology by the time the program officially ended in March 2011. At the time of the data collection, between June and September, 2011, the majority of E1 schools were not using computers. Of the 19 schools that allowed me access, I saw children in only three schools using computers. Reasons for the lack of use were plenty. However, power outages and malfunctioning equipment were primarily to blame. While equipment lay unattended, some schools used the computer laboratory as regular classroom because the rains had flooded the other rooms. In some others, the laboratory remained unopened since the beginning of the 2011-2012 academic year.

While the current state of technology usage was extremely disappointing, what also became obvious is that perhaps teachers used technology during the three years CAL was in existence because they were accountable to the field staff. APF field officials, through regular on-site support, guaranteed teachers utilized the tools at their disposal. But, by the time the project ended in March 2011, and the on-site support stopped, computer usage in most schools had all but ended.

Part 3: What factors motivated or demotivated teachers to innovate with technology?

Part 3, essentially investigates the first research question on what motivated E1 teachers to integrate technology with the curriculum. To do so, I identified 8 case studies. For the case studies, I used a snowballing strategy to identify key informants, who would provide the most information-rich cases. To highlight the differences between the cases, I selected teachers on the basis of three criteria: 1) how did the teachers use technology; 2) did they continue to use technology during the field study; 3) were their noticeable differences in the school environment that would explain the differences observed in 1 and 2. The school environment was singled out as a factor at the selection stage because issues like policy and infrastructural readiness appeared to affect schools.

<u>Participant information</u>

This section elaborates on the interview participants for this study. It is important to note here that none of the interview respondents below were formally credentialed.

Nisha

Nisha is a 22-year-old, first time teacher. She joined her current school right after high school. When I visited her school, Nisha's students were not using computers. In her own words, CAL had been relegated to second-class status, because there was tremendous pressure on her and her colleagues to implement MGML. She expressed frustration at being unable to continue CAL because children had shown tremendous enthusiasm in computers. She was frank and sounded cynical about MGML, arguing that although the system was competency-based, students in her class were learning less than they were in the textbook-based system. She expressed displeasure at being forced to implement a system that she was unclear about. The pressure to focus on MGML also meant that her pleas to government officials about malfunctioning computers fell on deaf ears. With the official closure of CAL, Nisha was unsure whom to approach to get the technical issues sorted. Her problem was also compounded by the fact that her school was without a permanent principal at the helm. The block had instated someone temporarily. However, he, Nisha complained, was unwilling to listen to their day-to-day challenges, while dissuading them from focusing on CAL. He wanted the teachers to focus all their attention on MGML because that is what the block office expected him to ensure.

Based on her involvement in CAL in the previous year, there was no evidence to suggest that she had innovated with the tools that were made available. Her involvement with CAL was at a very basic level, where she used the components to help children reinforce concepts. She would send her students to the computer laboratory following classroom lectures and encourage them to work on practice modules that would strengthen their theoretical and applied knowledge of what had just been taught to them.

Seema

Twenty-seven-year old Seema, has been one of CAL's star performers from its very beginning. Her efforts are that much more praiseworthy when viewed in the light of her complete lack of prior experience with computers. By her own admission, she was so technologically ignorant that she didn't even know how to switch a computer on or off. Although initially intimidated by the prospect of having to learn to maneuver the computer, Seema decided to persevere when she saw tremendous interest among her students. They vociferously expressed to her their desire to work with technology and she reasoned that their access to computers would greatly depend on how much she was willing to be invested in the process. She was one of a very small group of teachers, who used her newly acquired training skills to create lessons for her students. As mentioned above, she used PowerPoint to explain the concept of solar eclipse to her students.

Seema's efforts at technology integration were greatly aided by an extremely supportive school staff. Her school was also being pressured to implement MGML. When she realized her students were not learning under MGML, she took up the issue with her principal, imploring him to restore the earlier textbook system of education. While he refused to dismiss MGML entirely from his school, he allowed his teachers to follow a dual system — MGML for one half of the school day and textbooks for the remainder. He also encouraged Seema to spend time in the computer laboratory to experiment with the existing tools and refine her technical skills.

Akash

Sixty-year-old Akash is the principal of his school and the senior-most participant in my sample. His school was in an extremely rundown, dilapidated condition. The walls had cracks in them and the classrooms were very small. My visit to his school also coincided with an exceptionally rainy day. The rains had flooded most of the classrooms and his office. As a result, he was forced to use the computer laboratory as a regular classroom.

Akash took a very strict stance against MGML. His own experiences as a teacher demonstrated to him the ineffectiveness of MGML in his school. He complained his students' quality was slipping and it was becoming increasingly difficult to manage the classrooms under the new system. Based on his own experience and feedback from other teachers, he decided to revert to the earlier textbook-based system.

Akash expressed tremendous interest in computers but admitted that administrative responsibilities and teaching obligations had inhibited his ability to fully explore the CAL tools. His school had only three teachers, including Akash, who was expected to take regular class in addition to all the other responsibilities that came with his designation. Although time constraints prevented him from experimenting with computers, he encouraged ingenuity among his teachers.

Unfortunately, however, in spite of the encouraging environment, technology use was limited in Akash's school because of numerous infrastructural constraints. The laboratory had malfunctioning equipment. It had been months since the computers stopped working and repeated complaints to the block office produced no action. Electricity was a particularly challenging issue in this village. During the summer months, power outages were so incessant that the school would be without electricity for hours at end. As a result, the school was unable to optimally use the CAL tools.

Fani

Like Akash, 50-year-old Fani is also the principal of his school. However, unlike Akash, Fani's school does not bear a decrepit existence. The school walls looks strong and the classrooms appear unaffected by the rains. Fani sits at the entrance of the elementary school building. Above his desk, painted on the wall is a list of 72 tasks the education department has deemed critically important. Ideas such as lesson planning, weighing children, mid-day meals, are just some of them.

Expressing displeasure at MGML, Fani also decided against its implementation in his school because children, according to him, were unable to acquire foundational understanding of key concepts. Instead, he went back to the textbook system and initiated a system in his school, wherein the same teacher would teach the same cohort of students from grades 1 to 5. In spite of following the textbook system, computer use in Fani's school was disappointing. By his own admission, after every big break (summer vacation, for instance) he had a tendency to forget everything that was taught at the training. In fact, he admitted that he had even forgotten how to switch the computers on.

In the previous academic year, while CAL officials were still actively conducting follow-ups and on-site support for teachers, he would send the children to the computer after every math lesson. However, that system had not been resumed in the current academic year. The computer laboratory was left open when I visited, but children were not using them. Partly, malfunctioning equipment was to blame for the problem.

Giri

Giri's school is one of the smallest in the sample. The entire school has only 32 children, taught to by three teachers, including Giri who is the principal. MGML is being implemented in this school because there aren't enough students to warrant one teacher per grade. Teachers also find the classrooms manageable unlike other schools where the pupil-teacher-ratio (PTR) has become more lopsided since the introduction of MGML.

When I visited the school, it had no electricity for a few months. Giri said that electricity had been a persistent challenge in the previous academic year. During the rare times that the school had power, the voltage fluctuations affected the equipment. As a result, the computer laboratory was non-operational for approximately seven months, and had been converted into storage space. The computer screens had been covered with cloth and the UPS were gathering dust. Giri was almost indifferent to the situation. According to him, he had tried to approach block officials to rectify the problem. But after prolonged inaction, he decided it was not worth his time and energy.

Ramesh

Forty-three-year-old school principal, Ramesh, was the only participant in my sample who was defiantly dismissive of CAL. He viewed the entire program as added work for himself and had very definite views on what teachers needed to commit to in terms of responsibility. From among the three systems in place — MGML, textbook-centric and CAL, he stated that teachers must be required to follow only one system of education. Clearly he didn't view CAL as supplemental to classroom curriculum, rather an add-on responsibility. Surprisingly, according to Ramesh, his students also felt burdened at being forced to use the computer. This was a startling testimony, especially in light of the fact that none of the remaining 7 teachers in my sample felt their students took exception to being asked to work at computers. On the contrary, every teacher emphatically stated to being witness to positive affective outcomes among their students in the presence of computers. Students demonstrated a heightened sense of curiosity, were prone to be less absent from school, and were generally enthusiastic while working on the CAL modules. Ostensibly, that was not the case in Ramesh's school. As a result, he didn't express regret at being unable to run the computer laboratory or even voice any interest in making an effort in the future.

When I visited the school, the computer laboratory had not been used since the start of the current academic year. While some of the computers had broken down, others were simply sitting idle. According to Ramesh, children had not reached that stage in the curriculum where the CAL modules could be introduced. He also complained that the gap between the previous and current academic year meant that teachers, including him, had forgotten how to use computers. Apart from a lack of time, he put the onus for the lack of technology use on APF staff, arguing that he, on countless occasions, had asked the trainers to provide them with a detailed brochure with all the functions and commands mapped out. Without it, he argued, teachers would continue to forget and be forced to relearn computer usage after every long break.

Vimal

Vimal's school was one of three schools where computers were still being used during the time of my field visit. Although this school faced the same infrastructural challenges as most other E1 schools, computers were still functioning because Vimal and his colleagues have had some prior training in computer usage, which assisted them every time the equipment broke down. According to him, the most common problems were virus attacks or RAM shortages, which he was confident of rectifying. However, for every sophisticated problem, he needed to rely on technical expertise. With the official closure of CAL, that had become a problem because the block office had not returned his school's request to get their malfunctioning equipment fixed. Most of the computers that lay idle in the laboratory had hardware issues and needed to be taken apart.

As teachers filled out the survey, I watched a group of children working at the computer on Tux math and paint. On enquiring what was being made, the girl responded a house. At the other computer, four girls worked on Tux Math. They solved addition and subtraction problems together as they appeared on screen. Tux Math software is like a game, where questions keep trickling down the screen, and by the time they hit the bottom, the student must guess the answer. The students consulted with another and worked through the module. For each correct answer, the program congratulated them, which made them visibly excited.

The computers were equipped with one mouse and multiple headphones. Four students sat at each of the functional computers and were allowed 20 minutes each with the mouse. Whereas the majority of schools reasoned the delay with the introduction of CAL content was because children had not reached corresponding curricular content, Vimal's students worked on the modules in spite of that because they, according to him, had attained the required milestone in the previous academic year to be able to work on modules that tested prior competence.

Children's enthusiasm for computers was clearly palpable. Their attention was glued to the screen regardless of whether they were in charge of the mouse. According to Vimal, his students would initially ask questions about how to operate the computer. But very soon they had become self-sufficient and fully capable of steering themselves through the various programs.

Rajaram

Twenty-seven-year-old Rajaram was noncommittal about his opinion on either CAL or MGML. Clearly, he did not want to have an opinion out of fear of antagonizing both government officials and APF staff. However, for obvious reasons, his efforts were more geared toward ensuring he was not found slacking in the implementation of MGML.

I asked him to show me the computer laboratory, which had remained locked since the new academic calendar began. Rajaram took a huge bunch of keys to the computer laboratory and fumbled with it for a long time. He had clearly forgotten the right key. Seeing him trying to open the door, a crowd of students gathered around us, thinking the laboratory would finally be opened. While Rajaram rummaged through the massive bunch, two grade 5 boys offered to help. They opened the lock in no time.

The laboratory was equipped with 10 computers, of which three had stopped functioning. Several headphones lay tossed around because the wires had been damaged by rats. Interestingly, the school authorities stacked away the functional ones for fear of more damage. CAL posters from the previous year still adorned the walls. These posters gave students clear instructions on how to switch on the computer, open the correct program, and steps to operate the correct modules.

Rajaram admitted computers had done wonders to his students' general attentiveness to studies. In fact, such was the level of interest, that there were occasions in the previous academic year when children would get into fights trying to get to a computer terminal. He had never witnessed anything similar in the classroom, he said. Unfortunately, however, in spite of the impact of CAL on students' affective outcomes, the school had not proactively pursued last year's strategy. Teachers, Rajaram argued, had more pressure to guarantee MGML took off smoothly and effectively, which left them with very little time to devote to CAL.

Two observations were made from the analysis of the survey and interview data. First, technology usage was almost non-existent by the time CAL ended as an intervention; and second, there were visible differences between a small minority of E1 teachers and the majority of their peers in the kind of technology integration they engaged in. What emerged, therefore, was essentially a "why" question, which made it imperative to understand the factors affecting both outcomes.

Motivation not to use technology

At the outset, a survey of the literature had served to identify factors that affect technology integration. Once the data analysis was complete, eight factors explained the reasons for the differences observed between the case studies. Using Zhao et al. (2002) and Groff and Mouza (2008) typology, these factors are classified under four categories: policy, innovator, innovation, and school context. In the subsequent sections, I discuss how these factors individually and collectively impacted successful integration of technology within the classroom.

<u>Policy: MGML</u>

One of the most formidable hurdles to successful technology integration in E1 schools was the sudden introduction of MGML in grades 1 to 4. Testimonies from the various interview participants and CAL field officials suggest several challenges arose following the implementation of MGML. These had lasting implications on teacher ability to integrate technology in the classroom.

Initially, CAL efforts were focused on creating CDs based on grade-specific textbooks and training teachers in ways to integrate the content with classroom lessons. However, with the introduction of MGML, teachers were forced to acclimatize themselves with a very different form of teaching and then getting retrained in ways technology could complement the new system. This proved especially challenging for the majority of teachers who found the new system extremely complicated and themselves grossly undertrained. The interview data point toward three main challenges arising out of the introduction of MGML and its subsequent impact on teacher ability to integrate technology with the curriculum. First, teachers felt they were being pressured to adopt an extremely complicated method of teaching and learning. This sentiment did not bode well for teacher ability and enthusiasm to implement the new system. Second, since teachers felt the MGML system was complex, they ended up spending considerable time trying to understand it. This left them with very little time to explore ways to integrate technology with the MGML system. Although APF field staff organized training sessions to familiarize them to the new system and ways in which technology would be beneficial, teachers unanimously felt that time constraints prevented them from wholeheartedly investing in the process. Third, some teachers felt that the pessimism resulting from being forced to adopt a new system negatively impacted their eagerness to experiment with technology.

In order to understand how MGML affected teachers' ability to integrate technology, it is imperative to comprehend what the system entailed. Multi-grade schooling, in many parts of the developing world, is frequently proposed as a solution to problems associated with educational access. Often, schools challenged by geographic isolation, low student enrolment, and very high teacher absenteeism cannot justify the need for one teacher per grade level. In such schools, teachers are forced to have a responsibility for two or more curricular grades simultaneously.

In Chhattisgarh, the MGML system combines grades 1 to 4. Teachers are required to engage in activity-based learning practices, wherein children are taught using cards and logos. Classroom interactions are enhanced by dividing the children into six thematic groups. These groups are: teacher-supported, partially teacher-supported, peer-supported, partially peer-supported, self-learning, and evaluation groups. In dividing the class thus, MGML, at its very core, acknowledges that classrooms are not homogeneous entities. By engaging in activity-based learning practices, the aim is for teachers to engage in constructivist teaching practices, by encouraging collaboration, interaction among students, while also engaging in differentiation learning strategies.

The infrastructure requirement for MGML is as follows: a series of graded cards and pictorial graphics called learning ladders, which measure competencies and sub-competencies among students. As students complete one level, called milestone, they progress onto the next; instead of books, the system relies on cards that cover academic concepts. These cards are then divided into the different subjects taught in class. Additionally, each card pertains to the various competencies that children must cover to progress through the academic year; trays, to hold these cards, and finally, racks, to hold the trays.

As was evident during the data collection, the system ran into challenges at multiple levels. Most importantly, by combining four grade levels, class sizes increased in many instances. In the absence of very clear guidelines, schools resorted to one of four ways to implement MGML. In the first scenario, the entire pool of students from grades 1 to 4 was divided into four groups. Of the four teachers, each became responsible for one subject: English, Math, Environmental Science, or Language. Children moved from one classroom to another as the day progressed. In effect, therefore, these teachers were teaching approximately 160 students in the course of one working day. This proved extremely taxing and exhausting. In the second instance, the students were yet again divided into four groups. However, in this case, the implementation was slightly altered and each teacher taught all four subjects. In the third case, schools followed the MGML system in the morning and went back to following the grade-wise curriculum in the afternoon. This was essentially done to keep both government officials and teachers happy. Finally, in the fourth scenario, schools abolished the MGML system altogether because they found it too complicated to implement.

The sudden increase in the number of pupils in scenarios 1 and 2 proved tremendously problematic for teachers. To effectively manage all six groups, and ensure that students get the individualized attention MGML proposes to achieve, Divya explains, “At a bare minimum, you need at least two teachers in the classroom. This is so that the six groups are reasonably taken care of. But this is a near impossibility in E1 and E2 schools because they are severely understaffed.”

Another issue that emerged is, periodically, the block office conducted in-service training for teachers every two months. Teachers attended these training sessions in batches so that not all teachers from a given school were absent from school simultaneously. But, this also meant that the teachers who remained in school had an added responsibility of filling in for their colleagues who were away at training. Most importantly, however, all eight interview respondents found the trainings lacking in structure and content. Nisha says:

> Every time I attended these training sessions, I would go there prepared with many questions and doubts. At the end of the day, however, I would have neither found answers to those questions, nor clarified any doubt. On the contrary, I would just come back dejected. Several times, I shared the challenges I faced on a day-to-day basis in class at these training sessions. Instead of offering a solution, the master trainer would tell me that I was old enough and intelligent enough to handle the situation and that I must use my presence of mind. He

> would also ask those present at the training to offer me suggestions. What suggestion can they offer when practically everyone present is facing the same kinds of challenges?

Fani echoed Nisha's anger and said that, out of frustration, he had on countless occasions requested the master trainers to visit his school and demonstrate to his teachers how to handle an MGML classroom. The master trainers had politely changed the topic on each of those occasions. Thus it was left to the teachers to experiment to the best of their ability how to provide their students an education that was meaningful and effective. As a result, some principals made the decision to either stop following the MGML system altogether or spend only 50 percent of the school day on it. Ultimately, the differences observed in technology usage between schools depended to a very large extent on how school principals shielded their teachers from MGML. When his teachers complained, Akash decided that he wouldn't follow MGML in his school. He reasons:

> Students were not learning anything. I understand that it is supposed to be self-paced, interactive, activity-based. The system allows children to learn from one another. But when students themselves are unclear about basic concepts, then what are they going to teach their peers or what will they learn from them? The classroom became chaotic. We are supposed to form six groups. Look at the size of the classrooms and decide for yourself if we can make six separate groups. One group would spill onto another. Children would want to go sit in the same group as their friends, in spite of their competency level. Two out of the six groups were supposed to be supported by the teacher – one fully and the other partially. But in reality, that was never the case. Children from every group would come to the teacher for every doubt. It just became too complicated for my teachers and me to handle. When we, as teachers, are unclear about MGML, how can you expect our students to understand the process? Further, we collectively realized that children were falling back on concepts. Based on these observations, I decided to stop MGML. Whenever someone from the Block Office would come enquiring how MGML was being implemented, I would simply say we were doing great. They didn't probe further, and that was the end of it.

Seema's principal took a different approach to MGML, but one that was receptive to the concerns shared by his teachers. He established a system wherein teachers would use the earlier grade-wise curriculum in the morning and follow MGML in the afternoon. He called it "killing two birds with one stone." While teachers were happy for being allowed to continue the earlier system, which in their opinion was more effective, government officials were happy that the school was following the new policy. In being given the freedom to engage in practices teachers were comfortable with, these schools ensured that technology remained a perennial focus for teachers and children.

Nisha, on the other hand, felt she had no choice but to follow the new system of education because her school had gone through several changes at the administrative level and was for an extended period without a principal at the helm. The block office had instated someone in the interim until a permanent solution could be found. However, teachers found him unreceptive and indifferent to their concerns. Thus, unlike Seema, Nisha and her colleagues did not have a "go-to" person with their grievances. Instead, the pressure to acclimatize to the new system was on them. In the absence of much-needed freedom to teach the way they wanted to, teachers were dejected and unhappy. This left them with very little enthusiasm to relearn ways in which computers would enhance lesson delivery under MGML. Computer integration, as a result, suffered in such schools.

Overall, however, irrespective of the school the interviewees came from, there was resentment on the introduction of MGML. Fani sums up teacher antipathy:

> The issue here is nobody (referring to government officials) cares about results. After all, when you introduce something new, shouldn't you be concerned about how students are reacting to it? Has the reaction been positive or negative? Nobody cares. Instead you scale it up to include more and more schools. Just keep introducing something, keep forcing new things on us. It's been some time since since MGML was started. Who has ever come to monitor how it's being implemented? It's not like officials don't visit our school. They come, have something to eat, chat a little and leave. There is pressure on us that we give in writing that the policy is being implemented smoothly. But reality is, it's

> (MGML) just not working in our school. This time, I gave it in writing that it's not working and that we are not following the MGML system. They are free to take whatever action they like. And then there was a meeting in the collectorate's office where they threatened that if we don't implement MGML in our school, they would take legal action against us. What legal action can they take against us?

One evidences defiance in Fani and Nisha's testimonies. Because of the negativity surrounding MGML implementation, they both agreed they resisted the urge to put in extra effort to learn how technology might supplement classroom curriculum within the new system. They contended that the confusion with the new system left them with very little time to explore ways in which computers might be helpful. While children continued to use the computer laboratory from time to time, they did so fleetingly and often in an impromptu manner. Time spent in the computer laboratory was very rarely tied to the curriculum.

From the above testimonies two reactions to MGML are obvious: first, in which teachers decided to revert to the earlier curriculum because MGML implementation had collapsed in their school; and second wherein teachers grudgingly continued to follow MGML because they didn't have a choice. Both decisions had very serious implications on the use of computers in school. Ultimately, however, the role of the principal emerged as crucial in the course a school took. This factor will be elaborated upon in the later sections under the "motivations to use technology."

For schools which continued on the MGML track, there were some additional infrastructural concerns that impeded technology use. As mentioned earlier, an MGML classroom relied on the use of cards and logos for lesson delivery. Children were instructed to work with curricular content that was competency appropriate, as evidenced by the milestones accomplished by them. Since its implementation in E1 and E2 schools, several of these cards and logos had either been damaged or gone missing. Teachers argued that the loss of cards was expected because children were using them. Despite repeated requests from teachers to replace the cards, Block officials were simply apathetic. In Giri's school, some cards had been missing for more than a year. Explains Giri:

> Time and again, we asked Block officials to replace the damaged and lost cards. They never paid heed. What ended up happening is, in the absence of cards, children could not progress onto the next level. So even if there were modules in the computer system pertaining to the relevant milestone, children could not work on them because they did not have concept clarity. The cards explained concepts and then the computer modules would allow children to complete assessments that would test them how well they understood. My teachers would have to identify these gaps and come up with ways to link the different cards. Now there are so many children at so many different milestones. How many concept cards can I or my teachers be expected to make? Then I might as well leave everything else and do this only.

Clearly, there was overall resentment in reaction to the state's decision to implement MGML. Teachers found the concept too confusing and its infrastructural requirements too limiting. In addition, the training sessions did not help placate teacher concerns. The combination of these reactions meant that teachers felt disgruntled and resentful. This in turn, negatively impacted their enthusiasm and eagerness to integrate technology with the curriculum. Given that the government was equally invested in CAL, clear guidelines as to how technology could enhance the MGML system and subsequent classroom delivery of teachers would have been useful. While this did not happen, the time constraints it placed on teachers jeopardized teacher ability to integrate technology with the curriculum.

<u>Administrative responsibilities</u>

From conversations with E1 teachers, it also emerged that the lack of time was further exacerbated by the innumerable administrative responsibilities assigned to them. Time deficiency coupled with the lack of freedom to teach as they deemed fit had frustrated the teachers. Most teachers complained that apart from teaching, they were required to fill out time sheets, maintain up-to-date attendance registers, mid-day meal lists, MGML status, and participate in census duty. As a result, quite understandably, the amount of time teachers allocated to teaching and classroom-related activities depended on how much time they had at their disposal after having fulfilled most of these mandatory obligations. On further questioning it became clear that teachers were frustrated at the redundancy of some of this work. In MGML's context, Vimal shares:

> MGML is very heavy in its administrative requirement. Teachers are expected to maintain a log on each student. But I must enter the same information in three different formats. These books are supposed to help me keep track of my students' progress. This work takes away 50 percent of my class time. I also have to maintain a "daily diary", clearly outlining what I taught, each day. Although, the government wants us to spend time filling this information, so far no one has ever asked for these logs or even checked what is going on in school.

Teacher frustrations were also high on account of having to run impromptu errands for the school. CAL field officials described situations wherein sometimes even if teachers were present in class, their time was spent fulfilling administrative obligations. "Often times, these were time-bound obligations," said Divya. Given the nature of these tasks and the need to fulfill them within the stipulated time frame, teachers would have to forego that day's teaching. In such circumstances, teachers resorted to one of two options: they either gave students some work to keep them occupied while they were away, or had a colleague substitute for them. However, despite either option, such work kept teachers away from class and placed unprecedented demands on their time. As a result, it became increasingly difficult for teachers to commit time to technology integration. Pressure on teachers to follow top down policies wasn't confined to MGML alone. That teachers are starved for time does not come as a surprise when one considers the number of programs they are required to implement on a daily basis. Vimal summarizes, "We must implement MGML, we must also complete all of the textbooks that have been given to us, we must run the radio program (spoken English program), must run the Room-to-Read libraries, make sure children borrow books and return them in a timely manner, have to make children draw, and write… the list is endless."

Clearly, there is no dearth of programs in these primary schools. While teachers do not disagree on the intent of these programs, their frustrations pertain to the manner of the implementation. The short-sightedness of these policies has left teachers with little time while unfortunately, results remain elusive. Akash points out that guidance is severely lacking on ways to space out the numerous programs on any given day to enhance their effectiveness. The English interactive radio instruction (IRI) series, for instance, has been developed to improve children's grasp of English, and consists of multiple levels for students in grades 1 to 5. He argues:

> There are two problems: the program is broadcast at a set time every day. But by the time children finish their previous class and come to the hall to listen and settle down, 10 minutes of the instruction are already over. Second, the program is interactive and children are supposed to repeat what is said. But they don't understand that most of these children have no background in English. The time between sentences is so small that by the time children comprehend what is being said, the instructor has moved on to the next sentence. It becomes a futile exercise this way.

Such feedback, Akash argues, is not solicited and, if offered, not appreciated. Thus, despite the challenges, teachers must persist in implementing these programs. In such a scenario, the biggest casualty becomes teachers' time and additional efforts like CAL suffer.

The School Context

The relationship between inadequate infrastructure and technology integration is both commonsensical and well-researched in the literature. In CAL's context, technical and physical infrastructures were two aspects that were of paramount importance in a teacher's ability to innovate with technology.

Physical Infrastructure

CAL's technical infrastructural woes date back to its inception. As mentioned in Chapter 4, although the MoU between the Foundation and state government of Chhattisgarh was signed in early 2008, the hardware deployment was a long drawn affair. E1 schools faced challenges on several fronts. First, in many schools, computers and the requisite peripheries, like furniture, battery-back-up, and earphones did not arrive until 2010. This already delayed teacher ability to use technology. Giri's school is a case in point. He explains:

> Installation of the computers took even longer in our school because the furniture, on which the hardware would be mounted, never arrived. The person who was supposed to deliver the furniture to us, kept the money for himself and never gave us the tables and chairs required to place the hardware. We waited a long time, but to no avail. Eventually, we made cement slabs on the walls, on which we kept the computers. The problem is, when you keep the computer on a static object like a cement table, children cannot move around it. So they have to sit in one line. If there are four children to a computer, for those sitting on the outer edges, it becomes very difficult to see what is going on. Their experience isn't very engaging unless they are the ones sitting at the center, right in front of the screen and maneuvering the mouse. We were completely ready only in 2010.

Thus using technology to enhance the learning experience of the students was both delayed and impossible. With CAL officially ending in early 2011, teachers received very little time to apply all that was taught in the training sessions. Additional challenges also arose on account of delays in the deployment of other peripheries like earphones, essential for the use of programs like audacity.

However, once the computers arrived, additional problems like frequent power shutdowns inhibited teacher ability to use technology. During the summer months, this problem was especially acute. These circumstances were especially unfortunate for teachers like Akash who, according to APF field staff, was earnest in his desire to use technology. He says, “Electricity is a huge problem. There are days when the power comes for 5 minutes and is gone for an hour. There have been times when I’ve taken my students to the computer laboratory, only for us to leave because the power went off right when we were getting started. This is a persistent problem.”

Power outages in Indian villages aren’t an unusual phenomenon. The problem increases exponentially during the summer and rainy months. Envisaging this challenge, the Foundation had requested the State Government to supply batter back-ups lasting at least three hours to each of these E1 schools. Ultimately, however, the batteries that were supplied to the schools lasted between 5-15 minutes. Mala added that the time was only enough to save what the students were working on and shutting the system down. Such frequent disruptions were extremely discouraging, she added and hindered the use of technology. By and large, this was a recurring problem in all E1 schools.

Another daunting challenge emerged during the rainy seasons that had implications on how often and how much computers could be used. In Akash’s school for instance, the rains had flooded some classrooms which were situated in a low-lying area. He says:

> Since children sit on the floor, rain water had rendered these classes unusable. To ensure that classes were not disrupted, we moved the students to the computer laboratory. During this time, we also covered the systems because I was worried

> the seepage through the walls would affect the computers. I can say we hardly used the computers during these months.

The combination of these factors proved disastrous for teachers and their ability to integrate technology with the curriculum. In other schools, a rodent problem proved fatal for the computers. In Rajaram's school, for instance, rats had chipped away at computer and headphone wires rendering them useless. His school also had a severe dust problem, which constantly led to technical glitches. Eventually, technical issues resulting from these problems meant that often times a substantial number of computers stopped working. Rajaram says:

> This led to two problems: our school received ten computers, of which three stopped working due to these problems. The number of students to a computer increased substantially, because we were working with fewer functional computers. Additionally, there was also a time conflict between me and my colleagues because my class' time in the computer laboratory started spilling onto some other teachers'. It became a little chaotic.

Technical trouble-shooting

Through the interview data it was obvious that technical problems were a common occurrence in all E1 schools. During the school visits, almost all E1 schools reported some or all computers malfunctioning. In some schools, faulty computers lay idle for three or more months, having broken down in the previous academic year. As noted earlier, malfunctioning equipment skewed the computer-student ratio and student experiences were sub-par at best. Against this, a teacher's ability to use technology depended to a large extent on the kinds of organizational arrangements in place. This would include the presence of a responsive technical team that could counter the challenges arising out of technical glitches in a timely manner.

Yet again, this aspect proved problematic. According to the MoU, the government was to take responsibility for malfunctioning equipment, ensuring faulty equipment was either repaired or replaced in a judicious manner. However, when problems arose in the field, very little help was forthcoming from the government. Maya says:

> The government did not deliver on this part of the MoU. As a result, faulty computers lay idle and teachers were unable to use them. We thought this would change, but it didn't. Now we couldn't wait indefinitely for things to improve, so we (the Foundation) signed an annual maintenance contract (AMC) with Wipro (the Foundation's parent company and technical giant) for Rs. 1.5 Lakhs. It was not our job to begin with; it was the government's job. Thankfully, we had a team that could take over this task of repairing faulty equipment. Otherwise, the project would have been in jeopardy. The government had appointed someone to do technical repairs. We met them on countless occasions. But really, nothing concrete came off these meetings.

Gradually, APF field personnel became involved with technical issues. Every time a technical concern emerged, teachers turned to APF staff instead of government officials to resolve the problem. However, this arrangement could not be sustained indefinitely. As mentioned earlier, during the time of the data collection, the majority of the schools were not using the computers. This was due, in part, to the fact that most schools did not have functional computers. However, since CAL had ended, schools were unclear whom to approach for technical problems. While some teachers thought APF field staff would solve these issues, others approached government officials. Yet again, teachers complained of government apathy. As a result, while some resorted to private technicians to solve such matters, others simply ignored the problem. Thus, many computer laboratories remained unused because faulty computers remained unrepaired. Fani relied on private technicians to repair the computers that had stopped working. He summarizes the dilemma:

> We have stopped asking for help from government officials. We do not receive any support from them in this regard. Last year, district officials held a meeting. In that meeting they mentioned that a technician would be assigned to deal with technical problems in E1 schools. We were given his number. Every time our computer broke down, we tried calling him up. He never responded. The point is, there is way too much complacency at the government level. The general impression is that if you have a problem, deal with it. Their (CAL) program has

> ended. Right now, in our school, three computers are not working. Now in the months of May and June, we allowed students from fourth and fifth grade to use the lab for a couple of hours every day. I don't know what they did, but three computers and two microphones stopped working. So I called a private technician and had the computers repaired for Rs 600 and microphones for Rs 300.

Fani's ability to spend money for the technical repairs was an exception and not the rule. For instance, resource crunches prevented other schools, like Akash's, Nisha's, and Giri's to get their computers repaired. As a result, neither children nor teachers in these schools could use these tools optimally. Thus technical and human infrastructure proved vital in a teacher's ability to use technology.

The challenge in E1 schools was further exacerbated because schools did not have the requisite support structure and instead had to depend on outside sources for technical issues. Within schools, there was a severe shortage of organizational arrangements to counter technical issues arising out of CAL. Teachers did not possess the necessary skills to resolve counter the issues arising out of technical challenges. Had they been well-equipped with the knowledge to solve the issues, some of the delays that one observed may have been avoided. This was impossible because the majority of E1 teachers had never worked with computers before.

Innovation (CAL)

As noted by Zhao et al. (2002), the success of any ICT-based project depends on the nature of the innovation itself. In this case, while CAL appeared to have made a substantial dent in a few schools, in most others it had barely managed to scrape the surface. While clearly, factors like context, technology, policy, and teacher-related aspects explained some of the variations observed between schools, CAL's very nature was also the reason why some schools did better than others. In defining the role of "innovation" in technology integration, Zhao et al. (2002) refer to two dimensions: distance and dependence. Within distance, they explore three aspects: how far was the innovation from the school culture, how far was the innovation from existing school practices, and how far was it from available technological resources. Dependence, on the other hand, refers to the extent to which teachers have to depend on outside resources for the innovation to take off. In CAL's case, both distance and dependence influenced teacher ability to integrate technology with the curriculum.

Distance

In the section on "context" I have already explored how infrastructural issues affected technology integration. This section looks at whether a synergy existed between CAL and school culture and practices, a condition necessary for successful technology integration. Later on, I elaborate on the "dependence" aspect and how that may have affected efforts of continuous and sustained technology integration.

At the outset, it is important to mention that the three-year CAL program was proposed as a research study, mainly to understand the efficacy of technology and whether there was evidence to suggest that the benefits resulting from it justified scaling it up to other primary schools. Teacher involvement in CAL occurred only at the implementation stage, not at the design phase. It is also important to be mindful of the fact that although all teachers had heard of computers and expressed a desire to acquire technical skills, their knowledge of technology was exactly as old as the project. The majority of teachers had never worked with computers before, and therefore, this was an extremely novel experience for most of them.

Clearly, the novelty meant that the distance between the project and teachers' existing pedagogical practices was substantial. This aspect was detrimental to the success of technology integration efforts in most E1 schools, and perhaps explains why many schools had stopped using the computers once the project officially ended in 2011. If the innovation had been a derivative of something that teachers had been accustomed to previously, then technology integration would have flourished in most E1 schools and efforts would have continued. Unfortunately, however, CAL was an entirely different and new experience for teachers, which required acquiring new skills altogether. In addition, the program encouraged teachers to confront themes like traditional and constructivist teaching, which were again very new to them. In hindsight, APF field staff recognized that the lack of computer use in E1 schools was not a matter of surprise. Vishal reasons:

> There are many factors at play. Keep in mind that the majority of teachers in E1 schools are para teachers—young and have no formal background in teaching. When you have an 18-year-old become a teacher, he/ she will obviously replicate the experiences they were used to as students. This means, they will engage in extremely traditional forms of education, where the information flow within the class is one-way and hierarchical. As students, they never engaged in interactive, activity-based, fun learning. In their mind, what they experienced as students is what teaching is all about. For us to suddenly come into their lives and expect them to instantly embrace concepts like constructivist, technology-based learning is foolish. Such things take time because we are talking about changing mindsets. In my opinion, three years is a very short period of time for that change to occur.

Because CAL introduced a new tool and a new concept to these teachers, it appears that sustained and prolonged involvement is just two of many essential conditions to ensure success of the project. However, as mentioned earlier, prolonged engagement was suspect due to the delays in infrastructural deployment, impromptu holidays, and teacher strikes. APF staff soon realized that any gap in the training proved disastrous. Maya says, “It’s almost as if they pressed a reset button. After every long break, they would forget everything.”

This was not unusual. Trainings would most often happen at a centralized location, which was generally a big school with the most number of computers. However, after every training session, teachers did not have the opportunity to go back and practice because the computers had not arrived in their school. Without personal computers at home, and no prior knowledge, it was natural that teachers forgot what was taught.

Here is also where the lack of time was an added challenge. Following the introduction of MGML, teachers were not only forced to fathom a new system of education altogether, they also had to relearn how technology could be used to enhance the quality of that system. This meant having a very good grasp of MGML content and CAL modules that were meant to complement the new system. Teachers needed to be well versed with every student's progress and at what stage they were to be sent to the computer laboratory to complete assessments in the computer instead of in the classroom. All in all, it is safe to deduce that the interplay of the various factors proved detrimental to the sustained use of computers in school.

Dependence

By now, it is obvious that E1 teachers were severely reliant on government officials and APF field staff to use computers in their schools. From an infrastructural readiness perspective, teachers had to depend on government officials to have computers and furniture delivered to them. Additionally, whenever computers broke down, they had to bank on government officials again. During this stage, some school principals complained repairs would take days on end. Akash shares, "There were times when repairs would take three months. We would call the necessary resource person, but he wouldn't respond. Such times were tough because the number of students to a computer would increase."

However, the dependence was not limited to infrastructure alone. The nature of the innovation was such that E1 teachers had become dependent learners. Although it was necessary, some field staff concurs that it may have even led to complacency in certain cases. To the staff, the objective behind the training sessions and on-site support was to create agency among teachers and eventually guide them to a point of self-sufficiency. However, after 3 years, there was very little evidence to suggest that teachers had become self-reliant in their ability to use technology or even attempted to use their training to complement the curriculum.

One might also argue that had teachers been involved in the design phase of the intervention, they may have been more invested in ensuring it was used optimally. For instance, teachers were expected to stay abreast of each student's progress so that they knew exactly at what stage they should send children to the computer laboratory to work on the MGML or textbook modules, as the case might be. But there were times when teachers were unaware of student progress, and APF staff responsible for the school, would have to bring them up-to-date. Anuj explains:

> Each of us was responsible for a cluster of schools. We kept track of student progress, in the sense; we knew what card each of the students was at. We gauged that if these three children are on this card right now, then what is probability of them reaching the next stage, how much time will it take them. And then we would remind teachers, by calling them up or during the field visits, that these three children are currently on this milestone, so now what was next for them? We used to constantly remind them of their student's progress and the subsequent course of action for the students.

Clearly, this strategy worked until the time CAL was officially functional in E1 schools. Also, some CAL officials contend such planning may have worked in favor of technology integration because teachers felt they were responsible and accountable to the field officials. However, once the project ended, that sense dissipated and teachers did not prioritize computer usage any longer because other considerations became primary. However, the dependency was not confined to ensuring teachers were aware of student progress alone. Anuj adds further:

> The materials given to the teachers were very detailed. For instance, if a teacher was teaching division, we told them that this topic is mentioned in this chapter of your book. We also told them what within the topic should be conveyed to the students, and how. But see, in order to be effective, it is essential that if I am the teacher then I make adequate preparations before class. I should know exactly

> what I am supposed to teach, and how must I integrate technology with this topic. If the teacher makes such preparations beforehand, then this process will not appear burdensome to them. Instead, if the teacher is of the opinion that no my way is the correct way, I will continue to teach the way I teach, and since we have already been given the timetable, I have only to ask the students to go sit in the lab during the designated time, then this exercise has no meaning at all. Then technology integration will never happen.

Given the novelty of the intervention, some might argue that such level of dependence on APF staff was necessary. However, in some cases it worked out to the detriment of the project. In fact, APF staff contends there came a time when some teachers expected to be reminded or prompted of student progress on a routine basis. It was no surprise that technology integration suffered in these schools.

<u>Innovator (teacher)</u>

The teacher is undoubtedly a vital factor in the success of any technology integration effort. Some research even goes as far as placing the entire onus of success or failure on teachers. As is evident by now, such inferences are unfair because teachers are but one of several factors that control the eventuality of any technology-based effort. In exploring the relationship between E1 teachers and the success of CAL in their schools, two factors emerged prominent: technical proficiency of teachers and their attitudes toward technology.

Technical proficiency

The relationship between technical proficiency and teacher ability to integrate technology is fairly commonsensical. The more proficient a teacher is in using technology, the chances of successful technology integration are greater. By the same logic, one of the reasons E1 teachers, in general, were unable to optimally use the tools to their advantage was due to their lack of proficiency in technology usage. The lack of proficiency also explains some teachers' tendency to forget how programs were run, and hesitance to continue using these tools after CAL ended. However, the lack of proficiency was relatively common to most E1 teachers, spurred on by the absence of personal computers at home and malfunctioning equipment in school.

Attitudes toward technology

While proficiency was clearly critical in how much and how often E1 teachers used technology, attitudes explained why differences existed between teachers who innovated and continued to use technology and others, who did not. Illustrating this aspect are two strikingly conflicting teacher testimonies by Seema and Ramesh. As mentioned earlier, Seema was one of CAL's star performers. She belonged to a select group of teachers who not only used technology as a reiterative tool—encouraging her students to use the curriculum-based CDs to reinforce classroom concepts, she also used her training to create new content for her students. Ramesh, on the other hand, viewed CAL as an added responsibility and was unwilling to spend time exploring the efficacy of technology beyond its use as a tool children could use to strengthen classroom concepts. To field staff, this attitude was contrary to what CAL endeavored to be—primarily a tool to complement classroom curriculum. To them, CAL was never meant to be viewed as an added responsibility. On the contrary, the aim was to put into effect a system wherein technology simply blended in with the learning environment.

Interestingly, although both Seema and Ramesh approached the concept of technology-based learning with some trepidation, their eventual manner of implementation was in stark contrast to one another. Seema shares:

> When I first started, I had never touched a computer before in my life. I did not even know how to switch it on and off. Frankly, I was quite intimidated by it. If you ask me, is it easy to use, I will say it's as easy as you make it out to be. I found it hard in the beginning. But when I saw the reaction among my students, I knew I had to make an extra effort. They were really very interested. That urged

> me on. The sirs and madams (referring to APF field staff) were also very encouraging and kind. When you see them put in so much effort, the least you can do is respond accordingly. I consciously made an effort to rid myself of the fear. Eventually, I quite began to like it. And then very slowly, I started to think of ways in which I could use technology to explain concepts to my students. The solar eclipse was a perfect opportunity to test my ability.

To Seema, the potential of technology had manifested in very favorable affective outcomes among her students. They demonstrated increased enthusiasm, attentiveness in class, and reduced absenteeism. She indicates:

> In class, they hardly used to pay attention. They are present in class, but their mind is elsewhere. But then, you can take to the computer lab, and they are a whole new person altogether. They literally fight for the mouse. Their attention level and span changes drastically. When I saw such changes, I knew the day needed to be planned in such a way so that children got to use the computer on a daily basis.

To perpetuate these promising tendencies among her students, Seema ensured that computers became a permanent fixture. Of course, the obstacles she faced were the same as they were in other E1 schools: infrastructural concerns, intermittent power supply, and erratic policy propositions. In spite of the challenges, she persevered because first, she believed in the potential of technology and second, her school principal supported and backed her decisions.

Like Seema, Ramesh was also unfamiliar with computers until his school participated in CAL. However, in spite of the training, he didn't feel his anxiety toward technology dissipating. He even claimed he'd learned absolutely nothing from CAL program, accepting that he remained clueless about the programs that he was required to run on the computers. He says:

> I did not use the computer too much. I don't really know how to use it. We used to attend the trainings and they would teach us what to do. But only if you continue using computers will you retain what is taught. I honestly don't even know how to switch on the computer, forget running programs. The training was fine. At the training sessions, I understood what they told us. But when you come back to your own school, then somehow all they taught does not seem that straightforward.

Ramesh's apathy toward technology was not the sole outcome of personal anxiety alone. He put some of the onus on his students too, arguing that children felt inundated with too many changes, all at the same time. He goes on to say:

> I told them (CAL officials) at the training to follow one system— do computer-based and forget MGML or follow MGML and forget computers. Because when you offer us two paths, which one do we keep and which one do we discard? Because in my school - we have textbook-based learning, MGML, and then computers also. Do this, do that...it confuses us. Besides, even if you give one hour of your day to computers, it is too less. It will take you 10 minutes to even start the system. And then again, whatever you teach, you have to have an MGML card, then take the students to the lab and make them do MGML cards there. Children also wonder how much should they study? They even question, what to leave, what to keep.

Ramesh's testament indicating that children demonstrated a lack of interest in computers because they felt deluged contradicted the testimonies of all other teachers combined. Not one teacher claimed that computers disinterested their students. On the contrary, they extolled the benefits of computer-based education, especially with regard to its impact on students' enthusiasm levels. As Seema offered, most teachers felt children were far more attentive in the computer laboratory compared to the classroom. However, if Ramesh's students displayed a lack of interest, then he was perhaps justified in minimizing time at the computer laboratory and instead following, what he called, one system of education.

Technology integration requires teachers to confront their own set of pedagogical values. If technology does not align well with a teacher's pedagogical beliefs, successful technology integration will be elusive. Likewise, in spite of the inhibitions, unless teachers display a positive attitude toward technology, technology integration will be difficult to accomplish. From the above quotes it is fairly evident that despite her apprehensions surrounding technology, Seema made a conscious effort to overcome her fears because she felt her students would benefit with a blend of technology. She took full advantage of the training sessions and the existence of a project like CAL, to strengthen her skill set and explore avenues for technology integration. Ramesh refrained from a similar approach because he did not believe that it warranted such efforts. Understandably, however, teacher attitudes determine to what extent children gain access to technology. While in Seema's case, technology had become a part of her students' learning experience, Ramesh's students remained aloof.

Motivation to use technology

From the above testimonies it is clear that teachers viewed policies, such as MGML, as prescriptive and unfavorable to successful technological integration in the classroom. The argument was mainly one of time. In viewing these policies as coercive, teachers expressed dissatisfaction and a sense of lethargy, which in turn inhibited them from investing in other effort. But one observes clear differences between teachers with regard to what they did with technology and whether they persisted with its continued usage. In comparing the teachers, the one aspect that emerged as crucial in enabling some teachers to persevere in their efforts was the support they enjoyed from their school principal. This factor explained the observable difference between Seema and Mala on the one hand, and Nisha on the other.

As explained earlier, Seema's principal, took a novel approach to MGML implementation in his school. While he did not want to antagonize state officials, he was also clear that his teachers' views were sacrosanct. In trying to please both sides, he convinced his teachers to follow the MGML system of education for the first half of the school day and return to the pre-MGML system for the latter half. This was in response to teacher concerns that classrooms were becoming unmanageable and children were not learning. In creating a responsive and receptive environment, school teachers like Seema felt they had the autonomy to teach the way they deemed appropriate. Since technology fit into that mindset, she was able to put her training to good use and create new content for her students. Seema explains:

> The lesson on solar eclipse was not part of the syllabus. Children were just curious because we'd just experienced an eclipse in our village. When my classroom explanation did not work, I asked Sir (Dibakar) if it was okay for me to spend some time working on a presentation for my students. He was more than happy to allow me to spend time creating the slides. He is very encouraging and that makes me want to keep trying harder.

Seema's testimony emphasizes the importance of an amiable teacher-principal relationship in encouraging teachers to be innovative in the classroom. Dibakar ensured that teachers were accorded the opportunity and the liberty to teach the way they deemed appropriate and effective. Additionally, according to Seema, the principal was equally convinced of the efficacy and usefulness of technology in enhancing the quality of the learning environment. Not only were teachers convinced of the efficacy of technology in their teaching, there was sufficient buy-in from Dibakar, which pushed along the process of technology integration.

Akash's reaction to MGML was slightly different from Dibakar's, in that he decided against its implementation in his school, because his teachers, like Mala, found the system ineffective and chaotic. Instead, he supported his teachers' decision to revert back to the earlier system for which CAL had created digital content based on the textbooks. Like Dibakar, Akash also demonstrated receptivity and openness, which spurred on teachers like Mala to create new technological content. In doing so, they enabled students to take advantage of the existing technology.

Contrast this with Nisha's case, whose school was without a permanent principal at the helm. In its place was a Block appointee, who quite obviously extolled the virtues of MGML, in complete disregard to how teachers felt or the challenges they faced. Nisha argues that this resulted in all round resentment, and placed tremendous demands on their time, sparing very little for exploring ways for successful and continued technology integration.

Seema and Nisha's ability to innovate illustrates the contrasting management styles their principals engaged in. Although both teachers were not involved in the formation of broader education goals, Seema felt her consensus on school decisions mattered and her feedback sought. She was vociferous in her reservations about MGML and how that impacted student quality. Dibakar, Seema's principal, was open to these concerns and even willing to make the necessary adjustments suggested by his teachers. By mediating the pressures the block officials placed on schools, Dibakar offered Seema the opportunity, time, and motivation to explore technology for her pedagogical goals. For Nisha, a similar support system was missing. She had to communicate her concerns to a temporary appointee who towed the official line and was disinclined to teachers' feedback. When faced with a situation where her opinions were clearly not solicited, Nisha's impulse, in her opinion, was to minimize the effort she invested in the process.

Summary Statement

The combination of quantitative and qualitative data from E1 schools in Chhattisgarh revealed several important findings. Most importantly, it reiterated the complexities involved in technology integration, especially in a rural context. From the above analysis, it is clear that E1 teachers' ability to integrate technology depended on four factors: the existing policy climate, teacher ability (innovator), school context, and CAL (innovation).

The implementation of CAL in E1 schools was particularly challenged by the lack of infrastructure readiness. It took the government a significant amount of time to deploy computers and other peripherals to the E1 schools. Although computers should have arrived in the schools prior to the start of the program, they ultimately arrived in all the schools only around 2010. As a result, many schools did not unpack the hardware well into 2010, by when considerable time had been lost. In addition, as I observed during the school visits, in some schools, the furniture never arrived. As a result, these schools spent their own money to construct cemented slabs that doubled as tables on which the computers could be mounted.

An additional problem that emerged from the infrastructure deployment was the lack of power back-up in schools. As is known, many parts of India are severely challenged by incessant power outages. To counter this problem, the Foundation had insisted on battery-back-up for the school computers that would last at least a few hours. In the end, however, the schools were given batteries that lasted between 5 to 10 minutes. The combination of these infrastructural issues only meant that teachers and students suffered on account of the lack of ready access to the resources that were meant to enhance the learning environment.

Apart from infrastructural deficiencies, and contrary to what the Foundation had requested, the state government's decision to roll out the MGML program during the same time that CAL was being implemented jeopardized teacher ability to integrate technology with the curriculum. The decision to implement MGML had unfavorable consequences on teachers' time and motivation to explore technology use in the classroom.

Factors associated with teachers and the program itself also contributed to the lack of technology use in schools. The lack of technical proficiency among E1 teachers, combined with the novelty of CAL proved unfavorable to the smooth uptake of technology among teachers. In the absence of requisite support from block officials, teachers had to rely on APF staff for their day-to-day technical needs. This proved problematic once the project ended and a fallback support structure was missing.

The combination of these factors was detrimental to the implementation of CAL. However, a clear distinction was evident among a small group of E1 teachers and a larger majority of their peers in the extent to which they innovated with technology and their ability to persevere while faced with the same impediments that affected all E1 schools. This was primarily due to the support they received from their school principals, who were attentive and receptive to their views and concerns, while offering them a school environment that fostered and even encouraged innovation among teachers.

Chapter 6 – Technology and Constructivism

In this chapter, I present findings on research question two: were there statistically significant differences between E1 and E2 teachers in the extent to which they engaged in constructivist teaching practices? In Part I, I discuss notions of constructivism and traditionalism and the implications of either ideology on education in general. Part II presents the findings from the quantitative analysis of the survey data. As shown in the analysis, there does not appear to be statistically significant differences between E1 and E2 teachers. Part III, therefore, explores the question: is technology necessary to change the pedagogical orientation of teachers?

Part 1: Traditionalism versus Constructivism

In recent decades, education has undergone a paradigm shift. The perception now is that the ubiquitous drill and practice form of learning that goes on in most classrooms does not make learners critical thinkers or even prepare them for the complexities of life. Researchers argue that student performance is often deficient because learners are constantly exposed to learning environments that cultivate an oversimplified and superficial understanding of important issues. What has emerged is that creative responses are necessary to combat the dilemmas that plague education worldwide.

Constructivist teaching or learner-centered pedagogy has gained tremendous attention against this enormous need to reform the way students learn. Constructivism represents an approach to education in which the learner is at the center of the learning process. Unlike traditional classrooms, where the focus is almost entirely on didactic, teacher-directed and teacher-centered instruction, learner-centered pedagogy allows for knowledge creation and transfer, and optimization of the learning processes by enabling the learner to reflect, understand and apply knowledge.

McCombs and Whisler (1997) define constructivism as:

> The perspective that couples a focus on individual learners (their heredity, experiences, perspectives, backgrounds, talents, interests, capacities, and needs) with a focus on learning (the best available knowledge about learning and how it occurs and about teaching practices that are most effective in promoting the highest levels of motivation, learning, and achievement for all learners.) (p. 9)

McCombs and Whisler's definition of learner-centered education highlights the difference between traditional forms of learning and constructivism. Traditional educators have forever involved themselves with transmitting their interpretation of knowledge, frequently the standard viewpoint, to students. Likewise, they have adhered to standard procedures like standardized tests to gauge the extent and degree of knowledge acquired among learners. Constructivists, on the other hand, enable learners to create their own knowledge representation. Reeves (1998) argues that how students create knowledge depends to a great extent on "what they already know, their previous experiences, how they have organized those experiences into knowledge structures such as schema and mental models, and the beliefs they use to interpret the objects and events they encounter in the world" (p. 19).

Whether students are offered a traditional or constructive learning experience, depends to a great extent on the learning environment they are exposed to. Learning environments play a pivotal role in ensuring that the true purpose of education is achieved. Nevertheless, what constitutes a powerful learning environment has been a source of prolonged debates for many years. Designing an effective learning environment involves multiple decisions. Collins (1996) advises educators to look at every decision from a cost-benefit tradeoff perspective, while still functioning within the broader objective of making learning an authentic experience for children:

> What are the potential uses for the knowledge? How can a learning environment be created that reflects those possible uses? Too much of what we teach in school is taught because it has always been taught.... Much of what is learned in school is never used, because it is often the wrong knowledge for the modern world, and even when it is the right knowledge, people do not know how to apply it (Collins, 1996, p. 347).

By way of example, he argues, is the goal of education to encourage memorization among students or allow them the opportunity to think critically? There are trade-offs involved in each of these decisions. The only constant, Collins reiterates is to be guided by principals that would make the learning experience authentic for the students.

The richness of learning environments is further augmented by situating or contextualizing the content being learned (Barab, Hay, & Duffy, 2000). This would involve problem-solving, sense-making, understanding, transfer of the learning, and creativity. Encouraging classroom interactions and communication between peers also adds to the effectiveness of the learning environment (Mercer, 1996). Communication between peers contributes to knowledge creation and understanding. A learning environment that encourages collaboration between peers inherently facilitates the joint construction of knowledge by teachers and learners. Additionally, a learning environment must be cognizant of differences in intellect that exist within a classroom (Kerry & Kerry, 1997). Differentiation strategies, involving grouping by ability or providing different levels of support to students is an effective solution to the issue of mixed abilities in classrooms. Customized teaching methods tend to improve and enhance the effectiveness of an educational setting.

In summary, Smeets (2005) recapitulates factors that determine the effectiveness of a learning environment as one which is:

- Open-ended with adequate opportunity to interact and co-operate
- Not one-way knowledge transfer with teacher drilling lessons

- Mindful of the fact that classes comprise mixed ability
- Integrates rich text and tasks with theory
- Allows for independent learning

Powerful learning environments are valuable platforms for constructivist learning—allowing for knowledge creation and transfer, and optimization of the learning processes by allowing the learner to reflect, understand and apply knowledge. This warrants the question, what is the role of the teacher in facilitating a student's ability to create or construct their own meaning of knowledge?

Prawat (1992) summarizes the argument succinctly: How a teacher teaches is largely dependent on their individual views of teaching and learning. For the longest period of time, views on teaching have generally supported a "transmission approach to teaching and an absorptionist approach to learning" (p. 356), while at the same time relegating students to the role of passive recipients. However, for that to change, teachers must be adequately stimulated to thinking about teaching and learning differently. Researchers argue that teachers are truly empowered when they are equipped with the tools to challenge tradition and traditionally held views of teaching and learning.

Part 2: Impact of CAL on Teaching Practices of E1 and E2 teachers

The purpose of this chapter is to gauge the impact of technology on the teaching practices of E1 and E2 teachers. As mentioned earlier, CAL broadly emerged out of the need to address persistent educational challenges like high-drop-out rates, low achievement, and low affective outcomes among students in rural India. The basis for the program was that in order to improve student outcomes, pedagogical practices, and techniques needed to be changed. Thus, the intervention comprised two components: first, a computer-based element that would supplement a teacher's efforts in the classroom while also allowing students to engage in active learning processes; second, a pedagogy component that empowered teachers to invest in learner-centric processes in the classroom.

Research question 2 examines the teaching practices of teachers in grades 3, 4, and 5 in E1 and E2 schools. In selecting only these two groups of schools, the purpose was to gauge the value of technology in enabling teachers to engage in more learner-centric learning processes. The research question was so identified because one of two outcomes was envisaged: first, that E1 teachers were more invested in learner-centric processes than their E2 counterparts; and second, that there were no differences between E1 and E2 teachers. And, through these two outcomes, one of three inferences could be drawn: first, that technology fosters constructivism among educators and therefore is effective; second, the two groups of teachers exhibit similar tendencies because the pedagogical component of CAL adequately prepares them for learner-centric teaching processes; and third, a result indicating no difference, between the two groups, would be a consequence of the fact that technology failed to do what was intended.

Research Question

The following research questions guided the course of this study:

1. Are E1 and E2 teachers statistically different in the extent to which they display either constructivist or traditionalist behavior?
2. Does sex of teacher explain differences in the extent to which teachers engage in constructivist or traditional teaching practices? Are these differences prevalent across school type (E1 or E2)?

3. Does educational qualification of teachers explain differences in the extent to which teachers engage in constructivist or traditional teaching practices? Are these differences prevalent across school type (E1 or E2)?
4. Do school type, sex of teacher, and educational qualification explain differences in teaching styles of E1 and E2 teachers?

Data was collected through the administration of a survey instrument to 82 teachers in E1 and E2 schools. The section on pedagogy included items measuring traditional and constructivist teaching strategies. Additionally, eight E1 teachers (as introduced in chapter 6) were selected for in-depth semi-structured interviews to explore the type of pedagogy they engaged in within the classroom.

Table 9: Descriptive Data on the Intervention, and Teacher's Sex, Age, Educational Background, Professional Experience (N=82)

		Frequency	Percent
Intervention			
	Computer and Pedagogy	51	62.2
	Pedagogy	31	37.8
Sex			
	Male	51	62.2
	Female	31	37.8
Age			
	18 – 25 years	28	34.15
	26 – 32 years	32	39.02
	≥ 33 years	22	26.83
Educational Background			
	High School	33	40.2
	Undergraduate	21	25.6
	Graduate	28	34.1
Professional Experience			
	≤ 5 years	59	71.95
	6 – 10 years	17	20.73
	≥ 11 years	6	7.32

Descriptive Statistics

The population of this study consisted of 82 teachers from 37 primary schools. Overall, 51 teachers from E1 schools and 31 teachers from E2 schools filled out the survey. The average class size across the 37 schools was 31 students approximately. Teachers were asked to respond to questions on demography, educational background, and years of teaching experience (see Table 9). Overall, the sample contained 51 male and 31 female teachers. The majority of the teachers or 40 percent held only a high school diploma, followed by 34 percent who had a graduate degree and 26 percent who had acquired an undergraduate degree. Interestingly, most of the teachers were at an early stage in their careers. Approximately, 71 percent of the teachers in the sample had spent 5 years or less in the teaching profession, followed by 21 percent who had spent between 6 and 10 years, and 7 percent who had spent 11 years or more.

Table 10: Age, Sex, Educational, and Professional Background of E1 and E2 teachers

		Computer and Pedagogy (E1)		Pedagogy only (E2)	
Age					
	18 – 25 years	19	(37%)	9	(29%)
	26 – 32 years	23	(45%)	9	(29%)
	≥ 33 years	9	(18%)	13	(42%)
Sex					
	Male	31	(61%)	20	(65%)
	Female	20	(39%)	11	(35%)
Educational Background					
	Higher Education	23	(45%)	10	(32%)
	Undergraduate	10	(20%)	11	(36%)
	Graduate	18	(35%)	10	(32%)
Professional Experience					
	≤ 5 years	37	(73%)	22	(71%)
	6 – 10 years	10	(20%)	7	(23%)
	≥ 11 years	4	(7%)	2	(6%)

In determining the profile of teachers in both groups of schools, the data revealed that while there was substantial variation in age and educational background of the teachers between the two schools, they were relatively similar in sex composition and professional experience. While the majority of teachers in E2 schools were older than 33 years, in E1 schools they belonged to the age group of 25–32 years. It also appeared that on average, E1 teachers were mostly high school graduates, while the majority of E2 teachers had an undergraduate degree.

Although, E2 teachers were slightly older than their E1 counterparts, they were similar in the number of years spent in the teaching profession. As is evident in Table 10, most of the teachers from both groups of schools had spent less than 5 years in the teaching profession. The anomaly between age and years of professional experience exists because for several E2 teachers, earlier professional stints involved working for the private sector, government, and even pursuing their own business.

On examining the educational qualification of teachers further, one issue that emerged was that no one from this sample had any formal training in education or formally accredited. The lack of trained teachers and the high number of teachers with only a high school diploma sheds light on issues such as high teacher absenteeism, and at a more basic level the inadequacy of teaching staff in rural areas.

Data Instrumentation

Overall, I selected 16 items from my survey to measure the pedagogical orientation of teachers. The choice of the survey items was particularly influenced by the contrasts highlighted by Ringstaff and Kelley (2002). As pointed out in Table 11, overall, traditionalists are more inclined to emphasize the teacher as central to the learning process, while constructivists view student as the fundamental core.

Table 11: Features of Instruction versus Constructivism

	Instruction	Construction
Classroom Activity	Teacher-centered didactic	Learner-centered interactive
Teacher role	Fact teller, always expert	Collaborative, sometimes learner
Student role	Listener, always learner	Collaborator, sometimes expert
Instructional emphasis	Facts, memorization	Relationships, enquiry, and investigation
Concept of knowledge	Accumulation of facts	Transformation of facts
Demonstration of success	Quantity	Quality of understanding
Assessment	Norm-referenced	Criterion-referenced portfolios and performances
Technology use	Drill and practice	Communication, collaboration, information access and expression

(Ringstaff & Kelley, The Learning Return On Our Educational Technology Investment: A Review of Findings from Research, 2002, p. 10)

The 16 items captured traditional and constructivist teaching practices in equal measure:

- Teachers must encourage group work among students (C)
- Student needs should determine use of class time (C)
- Students needs should determine progress of syllabus (C)
- I encourage students to memorize course material (T)
- Students can ask me doubts and questions while I am teaching (C)
- The textbook is the primary and only reference (T)
- There can be only a single interpretation of mathematical concepts (T)
- Math problems given to students should be quickly solved in a few steps (T)
- Right answers in math are more important than the process (T)
- Math learning is enhanced by activities which build upon students' experiences (C)
- Teaching math is all about teaching students how to arrive at the correct answer quickly (T)
- If a math answer is wrong, teachers should let students explore why it is wrong (C)
- Teacher should encourage students to present their own arguments while solving math problems (C)
- While lesson planning, the teacher must be cognizant of the student's background (C)
- Teachers must use difficult words and language while giving examples in class (T)
- Pronunciation is more important than comprehension (T)

<u>Reliability</u>

Cronbach' s Alpha was used to describe the association of the items with each other and also to gauge the overall consistency of the scales. Two measures of pedagogy were developed. In the first, a composite measuring constructivism was developed with the 8-item scale using a 5-point response format where 1 = "never" and 5 = "always". In the second, a composite measuring traditionalism was developed with the remaining 8-item scale using a 5-point response format where 1 = "never" and 5 = "always".

Table 12: Composites Measuring Traditionalism and Constructivism

Traditionalism (∞ = 0.659)	Constructivism (∞ = 0.659)
I encourage students to memorize course material	Teachers must encourage group work among students
The textbook is the primary and only reference	Student needs should determine use of class time
There can be only a single interpretation of mathematical concepts	Student needs should determine progress of syllabus
Math problem given to students should be quickly solved in a few steps	Math learning is enhanced by activities which build upon students' experiences
Right answers in Math are more important than the process	If a math answer is wrong, teachers should let students explore why it is wrong
Teaching Math is all about teaching students how to arrive at the correct answer quickly	Teachers should encourage students to present their own arguments while solving math problems
Pronunciation is more important than comprehension	While lesson-planning, the teacher must be cognizant of the student's background

Both measures resulted in moderate reliability as evidenced by the Cronbach's Alpha. Using the 8-item scale to measure constructivism, the resulting Cronbach's Alpha was 0.600. However, on removing the "Students can ask me doubts and questions while I am teaching" variable, the reliability of the scale increased to 0.659. Likewise, using an 8-item scale to measure traditionalism, the resulting Cronbach's Alpha was 0.644. On removing the "Teacher must use difficult words/language while giving examples in class" variable, the reliability of the scale increased to 0.659. As a result, these two items were removed from the constructivism and traditionalism composite respectively. As indicated in Table 12, ultimately both the constructs, measuring traditionalism and constructivism, were made up of seven items each.

Composites

Table 13: Descriptive Statistics for Constructs measuring Traditionalism and Constructivism

	N	Min	Max	Mean	SD
Constructivism	82	2.43	5.00	4.56	.45533
Traditionalism	82	1.29	4.71	2.8	.83998
Valid N (listwise)	82				

Having ascertained the reliability of the two scales, two separate composites were created by summing the values of the variables for each scale as elaborated in Table 13. While the mean for constructivism was 4.56, with a standard deviation of 0.455, for traditionalism it measured 2.8 with a standard deviation of 0.84. In order to determine whether a pattern had emerged between the two groups of teachers and their tendency toward constructivism or traditionalism, the averages for both constructs was disaggregated by school type.

Data Analysis

Table 14: E1 and E2 Teachers' Mean Scores on Traditionalism

ASSIGNMENT	MEAN	STD. DEV	N
E1	2.72	.75	51
E2	2.91	.97	31

Table 15: E1 and E2 Teachers' Mean Scores on Constructivism

ASSIGNMENT	MEAN	STD. DEV	N
E1	4.6	.48	51
E2	4.52	.42	31

The descriptive statistics tables above describe the mean and standard deviation for traditionalism and constructivism across each level of assignment. As is evident in Tables 14 and 15, both groups of teachers displayed slightly different trends in both kinds of pedagogy. E1 teachers scored slightly higher than their E2 counterparts in constructivist behavior and lower in traditional pedagogical traits. This finding resonates with what has often been claimed in the literature that there is an association between technology and constructivism. As one might expect, E1 teachers, who had been trained both in constructivist pedagogy and technology use, slightly outperformed their E2 peers in both categories.

In order to determine whether the differences between the two groups of teachers were statistically significant, two separate one-way analysis of variance (ANOVA) was conducted. One-way ANOVA allows us to analyze mean differences between two or more groups on a "between groups" factor. A "between groups" factor divides the participants into different groups. In this case, ANOVA determines group differences based on the assignment. In order to gauge group differences, I examined differences between E1 (Technology and Pedagogy) and E2 teachers (Pedagogy) and each group's mean score on the two composite variables measuring traditionalism and constructivism.

The ANOVA F test to determine whether significant differences exist between the mean value on traditionalism for E1 and E2 group of teachers revealed no statistical significance. At F $(1, 80) = 0.965$, $p > 0.05$, we failed to reject the null hypothesis that there were no differences between the two groups of teachers. Similarly, the F test to determine whether the groups significantly differed in their mean value on constructivism also revealed non-significant results. At F $(1, 80) = 0.600$, $p > 0.05$, we failed to reject the null hypothesis that E1 and E2 teachers differed significantly in the extent to which they engaged in constructivist pedagogical practices.

While differences between the groups were clearly not statistically significant based solely on school type, I extended the analysis to explore if sex played any role. Thus, a factorial model was examined to gauge if being male or female played a role in a teachers' preference for traditional or constructivist classroom practices. Specifically, the model individually examined if the mean scores on the traditionalism and constructivist composite variable differed for teachers in the two groups and for male and female teachers.

Yet again, the omnibus two-way ANOVA test examining group differences on mean scores of constructivism and traditionalism based on school type and sex was not significant ($p > 0.05$). In the model gauging group differences in constructivist teaching practices, both main effects and interaction effects for school type and sex were also not statistically significant. There was no evidence to suggest that E1 and E2 teachers differed in the extent to which they either engaged or did not engage in constructivist teaching practices. Most importantly, sex of the teacher did not influence their tendency to engage in constructivist pedagogy. Likewise, accounting for sex, the results revealed a lack of evidence to support that E1 and E2 teachers were significantly different in the extent to which they engaged in traditional teaching practices.

Table 16: Mean Score on Traditionalism Composite based on Educational Qualification

Educational Qualification	N	Mean	Std. Dev	S.E
HIGHSCHOOL	33	2.85	.78	.14
UNDERGRADUATE	21	2.40	.89	.19
GRADUATE	28	3.02	.80	.15
Total	82	3.21	.84	.09

On ascertaining that both sex and school type did not explain statistically significant group differences in the pedagogical styles of E1 and E2 teachers, a third model was tested. In this instance, the model estimated if the differences in the mean scores on the traditional and constructivist composite variables varied as a function of educational background. Table 16 shows mean scores on the traditionalism composite based on education qualification of teachers. While the results revealed that educational background did not influence the extent to which a teacher was invested in constructivist pedagogy, it seemed to statistically significantly explain their attitudes toward traditional teaching. The one-way ANOVA *F*-test for the overall ANOVA was statistically significant at $F\ (2, 79) = 3.544$, $p < 0.05$. Post-hoc comparisons using Tukey HSD and Scheffe found that the mean difference in scores on the traditionalism composite was statistically significant between graduates ($M = 3.02$, $S.D = 0.80$) and undergraduates ($M = 2.40$, $S.D = 0.89$). Teachers with an undergraduate degree had scored higher on the traditional composites than their graduate peers.

To probe this further, a factorial ANOVA was tested to gauge if the differences in the mean scores on the traditionalism composite variable across educational background varied as a function of assignment. The omnibus two-way ANOVA test was significant ($F = 2.95$, $p < 0.05$), and the model explained approximately 16 percent of the variation in the mean score of the traditionalism composite variable. Yet again, while the main effect for educational qualification was statistically significant, at F (2, 76) = 4.856, $p < 0.01$), the main effect for assignment was found not significant ($p > 0.05$). The interaction between assignment and educational qualification was also not statistically significant ($p > 0.05$).

Based on these findings, we can infer that there is a difference between educational groups in their perception of traditional teaching practices (undergraduates have a more traditional view of education) but no difference in the perceptions of E1 and E2 teachers. Moreover, differences in perceptions between the educational groups do not depend on whether the teacher belongs to an E1 or E2 school.

Part 3: Does technology foster more exploratory or more student-center practices on teachers?

Previous research has established that teachers with access to technology are more inclined to engage in constructivist teaching practices—namely encourage greater teacher-student interaction, student-student interaction, collaboration, co-operation, and differentiation than other who do not have access to such tools. However, for the sample in this study, the analysis above suggests a different inference. The study analyzed teachers' self-reported scores on traditional and constructivist pedagogy. Through the analysis, two inferences were obvious. First, E1 and E2 teachers do not significantly differ in their attitudes toward constructivist pedagogy. The minor differences observed in the mean scores were not statistically significant. Second, some statistically significant differences in attitudes toward traditional pedagogy exist, but these are not associated with school type. Educational qualification becomes the demarcating factor that establishes these differences in attitudes toward traditional pedagogy. Teachers with a graduate degree have the lowest scores on the traditionalism composite, while teachers with an undergraduate degree have the highest scores.

Clearly, both groups of teachers are similar to one another in that they are engaging in as much or as little constructivist practices within the classroom. Further, given the overlap between the pedagogical objectives of MGML and CAL, any positive inference singularly attributable to CAL would be suspect. But, what is obvious from the survey responses and subsequent interviews is that teachers are now aware of constructivism, as a pedagogical concept and what it constitutes. This finding resonates with the endline analysis conducted by the Foundation, which found teachers to respond differently to the same attitudinal questions asked in the baseline. The baseline in 2008 had tried to capture teacher perceptions about teaching in general. It had found that, on the whole, teachers were more inclined toward traditional teaching practices. For instance, teachers believed that classrooms needed to be quiet environments, wherein the knowledge would flow from the teacher to the student. Likewise, teacher-student and student-student interactions, to them, were undesirable classroom traits. The baseline also revealed that the majority of teachers believed not all students were capable of learning. Students who performed poorly did so because they were unintelligent and incapable.

In 2011, during the closing stages of CAL, an endline was conducted. These very same items were asked once again. This time around, however, teachers responded differently. There was overall support for concepts like collaborative environment, cooperation, interaction, and differentiation. Teachers agreed that classrooms needed to be dynamic learning environments, allowing students to proactively engage with the learning process. However, as mentioned above, it is unclear whether CAL or MGML resulted in these desired changes. It is likely that a combination of both interventions resulted in the change in attitudes.

A similar trend was also observed in E1 teachers' self-reported scores on items measuring traditional and constructivist pedagogy. Notably, contrary to teacher beliefs in the baseline, approximately 78 percent of teachers agreed that students' needs should always determine use of class time and progress of syllabus. Changes were also visible in teacher perception about classroom interactions. Majority of E1 teachers (approximately 57 percent) agreed to encouraging students to ask doubts in class. 63 percent stated that deducing the process was far more important than simply arriving at the correct answer. Teachers also agreed (approximately 80 percent) to using students' own backgrounds to help convey academic concepts and contextualize concepts.

Likewise, some changes were also noted in teachers' attitudes toward traditional pedagogy: 69 percent agreed that knowledge transfer must be simplified, 63 percent responded that an academic concept could have multiple interpretations, and 25 percent agreed that the textbook was not the only source of information.

Based on these results, the question that emerges is: is technology necessary to sway teachers' pedagogical practices toward constructivism? Given that differences between E1 and E2 teachers was not statistically significant, shouldn't efforts simply be focused on changing pedagogical practices of teachers rather than exploring how technology might support the process?

<u>Learning environment: Classroom versus Computer Laboratory</u>

The usefulness of technology in CAL was oddly borne out of the reality that, in actuality, there was very little difference between an E1 and E2 classroom. For instance, CAL training for both E1 and E2 teachers had stressed on the need to create a learning or lesson plan for classroom instructions. However, from observations made in some E1 and E2 schools, which were not following the MGML system, it became apparent that majority of teachers favored coming into class, opening the textbook and teaching verbatim. There was very little evidence to suggest that teachers made adequate preparations prior to lesson delivery. Inside the classroom, the only tools they resorted to were the blackboard, some chalks and the textbook. They taught to a classroom full of girls and boys who sat in separate columns, with very little opportunity to interact. Although, the CAL training had thrown in ideas such as play acting, using objects to explain concepts, classroom observations did not reveal teachers engaging in any such practices. In the end, the difference between the schools simply amounted to the presence or absence of technology in the schools.

From interviews conducted with teachers from both groups, it appears that E1 teachers at least spent some more time planning their lessons for class than their E2 peers. The planning was simply geared toward exploring ways to integrate technology with the lesson of that day. Most E1teachers settled into a pattern of sending children to the computer laboratory after the completion of a class period to work on modules that tested students' grasp of what had been taught that day. This strategy seemed to work relatively well for teachers and, in their opinion, influenced better affective outcomes among students. "Children were perennially excited about using an additional tool. And because it was the computer, they felt a certain sense of enthusiasm," said Akash.

Visualization

Uniformly, APF staff and E1 teachers extolled the benefits of computers as a means to lend a visual component to academic concepts. This was especially pertinent in the case of those concepts that teachers found particularly difficult to explain. Anuj explains:

> Computers made some teachers happy because concepts that they found particularly difficult to visualize to their students would not be a problem anymore. To give you an example: usually, when explaining place value to their students for a number like 34, they would make columns for units and tens on the blackboard and place the numbers in the appropriate column. They could never explain to students why '3' is placed in the tens' column. When teachers themselves cannot clearly explain these details of place value, children are obviously in the dark. They can resort to memorizing, but clearly they haven't comprehended the real meaning.

In these circumstances, computer modules proved very useful. Visually, children could see for themselves how 34 contained three bundles of 10 each and 4 individual counts. Through the use of animation, the computer modules explained to students the meaning of units and tens, and concepts like “carry-over”.

The advantage of computers in visually representing academic concepts emerged as a recurring theme in most teacher interviews. Vimal explained:

> I have noticed that my students are more curious and attentive when working at the computer than they are in the classroom. They like computers because it is a visual medium. They get attracted to all the color, animation, text, etc. They can paint if they feel like, they can add text and color. The computer is a new tool for them. Once they realize they can do so many different things with the computer, they feel attracted to it.

Akash’s experience is similar to Vimal’s and he described:

> Classroom lectures tend to become very monotonous after some time. We teach the same way every day. And when we teach, we are not always able to show live examples to our students. Take any math problem for instance. We can only tell children that 2 + 2 makes 4. But when we show the same thing to students on the computer, then we can explain the same concept using flowers or birds. We can ask, there are two birds; if two more come, then how many birds are there. In this manner, children can visually see what is going on. I strongly feel they learn better that way.

However, one might argue that teachers could use easily obtainable tools like sticks or pebbles to explain the same concept to students. While Nisha agreed that this was a possibility, she argued that the process would still lack the quality of engagement a computer module would afford. She explains:

> I can use matchsticks to create three bundles of 10 sticks each and 4 loose matches for the number 34. You can say this is visual too. But where is my student’s involvement in the process? Computer modules contain animation and children can themselves create different groups of tens and units until they gain clarity. There is active engagement. And in my opinion, that makes a difference.

Seema’s example in Chapter 5 is also a case in point. Although she attempted to explain solar eclipse to her students by getting them to role play, the exercise proved futile. Children found it difficult to relate to humans as the Sun, Moon, and Earth, and were unable to comprehend rotation and revolution. That changed significantly when Seema used PowerPoint to explain the phenomenon. She put her technical skills to good use by using animation, color, and images to explain to her students how a solar eclipse occurs when the Moon comes between the Sun and Earth, causing the day to darken temporarily.

Visualization was a recurring theme in teacher interviews. Consistently, all E1 teachers praised computers for its ability to visually represent concepts.

Non-threatening feedback

The benefit of technology also lay in its ability to offer instant feedback to students in a manner that is non-threatening and non-condescending. In the event that students give an incorrect answer, the prompt usually encourages students to try once again. This is usually in stark contrast to classroom situations where teachers are constricted by time and the number of students to offer constant support and encouragement. During one particular school visit, I observed an E1 teacher jot down a few mathematical questions on the board for her students to solve. After giving them sometime to work on the sums, she called out students by their name to give the answer. When one student failed to give the correct answer, she threw the chalk at him, admonishing him for his failure to answer such a "simple" question. While the student giggled embarrassingly, the teacher proceeded to solving the question on the board. Her action proved disparaging on two counts: she humiliated the student in front of the entire class and an outsider; and she did not give the student another chance to work the problem himself. Later, on being asked to explain her outburst, the teachers said: "I personally believe I am over-qualified for these primary grades. I should be reassigned to higher grades. Children in primary grades tend to be very restless. They get bored easily. You keep teaching them but their mind wanders.

Sometimes, I get so frustrated that I just walk out of the class." Clearly, she failed to see the prolonged repercussions of her actions.

APF staff concurred that some teachers were extremely didactic in their approach to teaching. Their methods were especially detrimental to the enthusiasm, motivation and academic performance of weaker students. Poor-performing students in such classrooms tended to become more and more introverted and withdrawn. The computer, in such situations, was tremendously useful. During computer laboratory observations, children were fearless and had even let their guard down. If an answer was incorrect, it was the collective responsibility of everyone in the group. They felt no shame in uttering the wrong answer. Further, rather than reproach them for their wrong answer, the audio prompt only encouraged them to try again. Maya said "There was a marked difference in the attitudes of weaker students when they were in the computer laboratory. Unlike the classroom, they were not afraid to speak up in the laboratory. These are all friends sitting together and learning together. So there was no fear or shame. This made them try harder."

A second aspect that worked to the advantage of weaker students was the opportunity to spend equal amount of time in front of the computer as the stronger children in class. What was noticeable during classroom observations was that stronger children exuded more confidence and boldness when answering questions in class. They were the first ones to raise their hands and relentless in their effort to catch the teachers' attention. Weaker students, on the other hand, exhibited reticence and hesitance. As a result, every time a stronger student answered questions in class, the teacher proceeded with the lesson without enquiring if everyone understood how the answer came to be. Weaker students did not have the opportunity to express doubts or seek clarity if they were unclear about the concept being taught.

That changed in front of the computer because first, there was less number of students at each terminal and second, students progressed together. Unless the group collectively arrived at the correct answer, the module would not let them proceed forward. Further, by divvying up the task amongst themselves, each student got a chance to work at the questions.

Though most teachers agreed that weaker students shed their inhibitions in front of the computer, Vimal argued otherwise. He said:

> Clearly children were happy to go to the computer laboratory. But intelligent children have a way of monopolizing computer time. For my classes, I paired intelligent children with the weaker ones. I did so deliberately because I thought weaker children would benefit from the experience. But gradually I noticed that intelligent children did not have the patience to wait until their friends understood the question or worked out the answer themselves. They would simply solve the questions, unilaterally click on the right option and progress through the module. So I don't think the weaker students experienced anything different in the computer laboratory.

But, Vimal's testimony was an aberration among the majority of E1 teachers who expressed that weaker students were expressive and comfortable in front of the computer.

Revising curriculum before examinations

The computer modules were of immense help to students prior to an impending examination. As mentioned earlier, E1 teachers, along with CAL officials, designed a timetable such that each classroom period for math was followed by an equal amount of time in the laboratory. According to teachers like Seema, Mala, and Vimal, sending children to the computer laboratory immediately after a class period helped reinforce concepts. Classroom sessions introduced theory to students, while the computer modules allowed them to apply the knowledge. This approach, according to the teachers, worked particularly well before quarterly, half-yearly and annual examinations when children could revise everything that was taught prior.

Additionally, grouping children in front of the computer terminal allowed for collective reinforcement of concepts, which was both fun and engaging for the students.

CAL attempted to replicate a similar model in E2 schools, which would allow children to revise classroom concepts, albeit without technology. A board game was introduced. Questions from the textbook were written down in cards. Children would roll a dice and pick up the first card from the stack. Each correct answer would allow the student to progress through the board. If a student answered incorrectly, then the next person would be given a chance to solve the problem. If no one from the group succeeded in answering correctly, all the students would collectively look for the answer in the textbook. Yet again, by creating a game around educational concepts, CAL hoped there would be peer-to-peer learning. But APF staff, Divya, contends most teachers simply preferred writing questions on the board and asking students to answer them. "In doing so, children did not really engage with the process", Divya argued.

Summary

Technology and pedagogy formed the bulk of the CAL intervention for E1 schools. Teachers were not only trained in ways to innovate with technology, they were also introduced to concepts like "interaction", "collaboration", "differentiation", and "activity-based learning", among others. The objective was for them (teachers) to engage in such constructivist practices within the classroom, while also being mindful of how technology could be used to ensure the learning environment was inclusive of such practices. The focus for E2 schools, on the other hand, was strictly pedagogical. Instead of technology, teachers in E2 schools were offered ideas and non-technological tools to espouse these very same practices.

While the above analysis establishes a lack of a statistically significant difference in the teaching attitudes of E1 and E2 teachers, it also demonstrates that the adoption of constructivism among teachers from both groups was relatively minimal. This finding supported the endline analysis conducted by the Foundation, which found that although teacher attitudes had changed, those changes were very minimal. For instance, teachers had come to change their opinion of what constituted an "ideal" classroom. They understood that a classroom devoid of student-teacher or student-student interaction was inadequate. Likewise, teachers had altered their view that all children were not capable of learning. They now believed that all children could learn, however, at differing paces. But this change in belief did not necessary manifest into changed teaching practices among teachers.

Most importantly, however, in my sample technology is clearly not associated with stronger constructivist teaching practices among E1 teachers. We can ask therefore: what is the use of technology? If the end goal of an educational intervention is to present to students a learning environment that is rich in constructivist traits, then why not simply focus on changing the pedagogical practices of teachers?

Interviews with E1 teachers and APF staff and observations in both E1 and E2 schools revealed several important findings. In both schools, the classroom experiences of students were relatively similar. However, the learning experience for E1 students in the computer laboratory was in marked contrast to their experiences in the classroom. Consistently, E1 teachers agreed that computers led to better affective outcomes among students, as evidenced by greater enthusiasm toward their studies and a heightened sense of curiosity in the computer laboratory. Teachers also extolled the benefits of technology in offering a visual face to the content being conveyed to students. Further, majority of E1 teachers agreed the peer-to-peer learning occurring in the computer laboratory made weaker and shy students more interested in the education process and even shed their reticence. While these affective outcomes are encouraging, the question still remains if such results warrant the costs of technology-based education.

Chapter 7: Conclusion, Implications, and Recommendations

Introduction

Instructional technologies or ICTs for education have for some time now been endorsed as truly transformative. The premise is that technological tools will substantially alter teaching and learning and provide students with a learning environment that is contextual, engaging, and interactive, in true contrast to traditional classroom, which are didactic and where knowledge creation is simply a one-sided accumulation of facts. Taken in by these perceived benefits, countries have been quick to wire schools and deploy the requisite infrastructure. The assumption here is that once the question of access has been dealt with, usage will follow smoothly and seamlessly. Likewise, once technology usage starts, classrooms will automatically be transformed into constructive learning environments.

However, in so many decades since calls for ICT use in education started, whether we have attained these outcomes remains a matter of debate. This is partly due to the fact that prior to ascertaining linkages between inputs and outputs, we need to gain clarity on what is being done with the technology? How is technology being integrated in the classroom? Are the conditions conducive for teachers to effectively integrate technology? As demonstrated in this study, technology integration is complex. The ability of teachers to integrate technology with the curriculum depends greatly on the interaction of a set of factors that are often not in their control. These factors are both endogenous and exogenous and work in tandem to either hinder or enable the process of technology integration. The complexity is perhaps more acute in developing regions, where clarity on fundamental issues such as infrastructural readiness, teacher training, and policy are still evolving. Technology-based reform processes are also complex to implement because they constantly challenge traditional teacher-student roles. It is believed that teachers who are more inclined toward creating constructivist, student-centered learning environment are more likely to embrace reform. On the other hand, teachers who prefer hierarchy within the classroom are averse to technology-based innovation because they fear a sense of loss of control and reversal of roles where students might become more knowledgeable about computers than them. Such contextual and cultural factors become vital in our efforts at understanding technology integration as a phenomenon.

For most policymakers, the logical first step toward technology-based educational reform has been to provide “access” to technology. But as is evident in this study, access alone does not guarantee use. For that to happen, certain favorable conditions must exist that allow teachers the opportunity to fully exploit these tools. These conditions range from policy-level clarity to institutional support. Teacher reservation regarding technology adoption has also partly been due to a sense of alienation from the reform process. The general sentiment is that there is a disconnect between policy formulation and execution. Teachers often perceive themselves as “small potatoes” (Fox & Henri, 2005) who are simply told what to do without being made a crucial part of the decision-making process.

As mentioned earlier, our current understanding of what motivates or inhibits teacher use of technology is largely based on research conducted in high-income nations, mainly from the United States of America and Britain. Given the current policy foci for ICTs in development, the lack of similar studies in developing countries is unfortunate. My study examines the notion of technology integration in a major developing country, and does so by asking two broad questions:

1. What are the factors that influence teacher ability to integrate technology with the curriculum?
2. Are teachers, with access to technology, necessarily engaging in constructivist teaching practices?

The setting for my research was the Indian state of Chhattisgarh, where sixty schools participated in a three-year research study, called CAL, aimed at examining the role of instructional technologies on education. These sixty schools were divided into three groups: the first group of teachers also referred to as E1 teachers, were offered both technical training and pedagogical intervention; second group of teachers also referred to as E2 teachers, who were only offered pedagogical inputs; and the third group of teachers served as control or were also referred to as C teachers. The units of analysis for my study were E1 and E2 teachers, who taught in grades 3, 4, and 5. Data for both questions came from self-reported scores on a survey instrument designed by me, in-depth interviews with eight E1 teachers, APF documents, and classroom observations.

I traveled to Chhattisgarh between June and September, 2011 to examine how teachers in E1 schools were using technology in their day-to-day teaching activities. I also examined whether the teaching practices of E1 teachers were more associated with constructivism than their E2 peers. During my field visit, I traveled to 40 schools, of which 37 (19 E1 and 18 E2 schools) allowed me access. Below, I summarize the key findings for both research questions.

Research Question One:

How are teachers, with access to technology, using the tools? What are the factors that influence their ability to integrate technology with the curriculum?

By the time CAL ended in March, 2011, and when the data collection for the study started, the majority of E1 teachers had stopped using computers in their schools. To gauge how teachers used technology, they were requested to base their survey responses on technology-related activities conducted in the previous academic year. The majority of E1 teachers used the CAL modules to help children reinforce classroom concepts. The modules were designed in a manner to complement the existing MGML system of education in most schools. For schools that decided against MGML implementation, the modules supplemented the textbook-based curriculum. In addition to working on the CDs, programs like "Drawing", "Tux Paint", "Tux Math", and "Word" were run. "Drawing" was especially popular among students, because it allowed them the opportunity to give a face to their imagination.

While most teachers limited their use of technology to running the programs provided to them by CAL, a very small group of teachers used their technical training to create new content for students. Three teachers stood out in their efforts—Seema, who used PowerPoint to create a presentation on Solar Eclipse; Dibakar, who created a lesson on fractions using Word; and Mala, who used Excel to create an assessment module on mathematical shapes.

Based on these two observations: 1) majority of teachers not using computers immediately after the closure of CAL; and 2), the clear distinction between a very small group of teachers who used their technical training to innovate and create new content, compared to the larger majority of their peers, the overarching question that emerged is—what were the factors motivating teachers either to use technology or not use technology? The data revealed interplay of four domains, as critical to teacher ability to integrate technology with the curriculum. These domains were: 1) policy-related, 2) innovator or teacher-related, 3) innovation or project-related, and 4) context or school-based factors. Figure 28 depicts the complexities and inter-relationships between the four domains of policy, innovation, innovator, and school context.

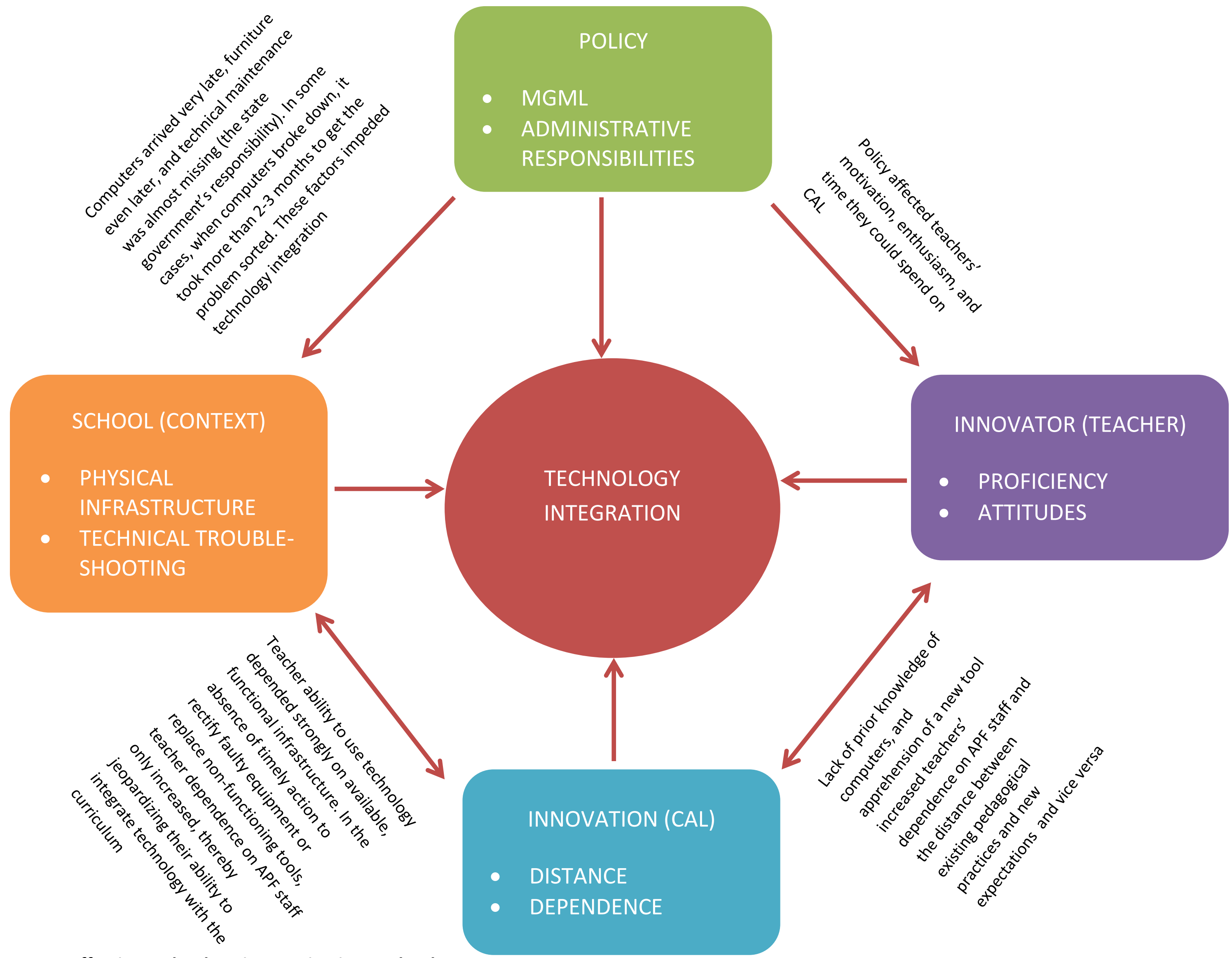


Figure 28: Factors affecting technology integration in E1 schools

Perhaps of the greatest consequence on teacher motivation not to use technology was the unintended parallel introduction of MGML and the relentless infrastructural problems confronting schools. CAL's implementation was a joint effort between the AP Foundation and the state government of Chhattisgarh. While the Foundation worked on content creation, teacher training, and on-site support, the state government was responsible for ensuring timely delivery of the requisite infrastructure and technical trouble-shooting. Further, to determine and single out the impact of CAL on teaching and learning, the Foundation had requested that the government refrain from introducing other policies in the schools partaking in the study, and not transfer participating teachers to other schools. Unfortunately, both of these conditions were violated, and infrastructure deployment became a long drawn affair.

Policy-related decisions made during CAL resulted in delays in project implementation, while also influencing the time, effort, and motivation teachers could afford to the project. Within a year of CAL's introduction, the state government introduced MGML in primary schools. While CAL focused on grades 3, 4, and 5, MGML was designed to combine grades 1 to 4. The sudden decision to introduce MGML led to several challenges. The Foundation was now forced to focus their attention on creating content that would complement the new MGML system. This resulted in implementation delays. For teachers it meant learning a new system of teaching (MGML) and then comprehending how technology would complement it. From the testimonies, it is evident teachers were demoralized by being forced to implement a system that they found complicated and which clearly, in their opinion, was doing more harm to student's academic quality than good. Teacher resentment was further compounded by the lack of support accorded to them at the government sponsored in-service training sessions. Time and again, teachers complained their concerns were not adequately addressed and time and again, master trainers put the onus of MGML implementation on teachers.

The inadequacies observed in MGML training also brought to light the challenges associated with para teacher recruitment and training. As mentioned earlier, the concept of para teachers was first endorsed on grounds that it would address issues of universal access in education. The rationale being that recruiting local youth as para teachers would counter challenges arising out of teacher shortages in remote locations and provide educational access to children who would otherwise have to forego one altogether. Most importantly, however, their recruitment was meant to aid and support regular teachers, not replace them. Unfortunately, the picture that we have in front of us today is one where para teachers are increasingly becoming the norm and in many instances even replacing regular teachers. Detractors repeatedly highlight the implications on quality of a policy of this nature.

Some critics argue that the discrepancies observed between educational access and quality in India highlight severe overall challenges that exist in the educational system. Not only does the shift toward para teachers minimize the fundamental educational qualifications necessary for a teaching job, it also downplays training requirements, both pre-service and in-service. As things stand today, para teachers do not undergo any pre-service training; instead participate in an induction program that has been found severely wanting in quality.

The challenge that has emerged on account of such policies is that para teachers find themselves inadequately prepared for the rigors of everyday teaching. In my study, the shortfalls experienced at the training sessions were more detrimental to the implementation of MGML because the majority of teachers were para teachers, who had neither a formal background in teaching nor were accredited. Quite naturally, the lack of pre-service training for these teachers coupled with sub-par in-service training meant they were unprepared and under qualified to confront the sudden changes being forced upon them by the state government. This, in turn, was a tremendous setback to technology integration efforts. As most teachers were forced to divert all their attention to MGML, it left them with very little time and motivation to explore ways in which technology would complement the curriculum. As a result, technology integration suffered in these schools. Importantly, teachers' continued inability to acquire clarity on the particulars and specifics of MGML jeopardized their capability to fully explore how technology would complement students' learning experience.

Teacher ability to integrate technology also suffered due to the lack of readiness at the school level. Several challenges arose on account of infrastructure deployment, lack of functional infrastructure and absence of timely technical support. CAL's implementation was replete with infrastructural challenges. Although the MoU between the state government and AP Foundation was signed in March 2008, and schools were expected to have received the necessary tools, actual computer installation began only in October 2009. Instruments like headphones and audio multiplexers arrived much later, in June 2010. Further, schools received the furniture for computers much later, and in some cases, these never arrived. As a result, not only were teachers unable to make optimal use of computer time, students' use of technology were also delayed.

Likewise, when computers broke down, schools had to depend on outside resources to get the problem rectified. This also often resulted in unnecessary delays. Because teachers were relatively new at handling computers, and schools lacked the presence of a technical support person, often computers lay idle for months before someone from the block office came to rectify the problem. Eventually, the delays became so acute and detrimental to CAL, that AP

Foundation signed an AMC (annual maintenance contract) with its parent company, Wipro, to remedy broken computers. However, once CAL ended, and the contract expired, schools were left without a go-to person for every technical problem.

Power supply was a constant challenge for the schools, especially during the summer and rainy months. Although AP Foundation had requested the state government to install battery back-ups in every school and ensure that they lasted at least two hours, eventually schools were furnished UPS's that lasted only 10 minutes. During the summer months, the lack of power back-up proved especially challenging for teachers. Power supply was erratic and every time the electricity would go off, teachers had only limited time to shut down the systems. Additionally, computers broke down due to the intermittent power supply.

For technology-based efforts to succeed, necessary infrastructure is an absolute must. Quite naturally, unless the basic tools and peripheral supports are in place, such efforts will be severely challenged from the start. Likewise, one cannot take for granted that once the tools are in place, take-off will follow. As was demonstrated in my study, the lack of technology integration observed among teachers was not a result of a lack of technology equipment, but a lack of functional equipment.

While MGML and the lack of infrastructural readiness were the most cited reasons for the lack of computer use in schools, it also emerged that the very nature of CAL and teachers' own attitudes toward technology influenced the extent and kind of technology integration in schools. In CAL's context, two factors were at play: dependence and distance. The novelty of the project, especially in its use of computers, was a crucial impediment. Because they had never worked with computers before, they were severely dependent on APF field staff on a day-to-day basis. While one might argue that some degree of dependence was not only desired but also essential, challenges arose when the dependency led to complacency. Field staff criticized teachers' tendency to rely on them for tasks that were clearly in their (teachers') domain. For instance, the integration of CAL modules with the MGML system required teachers to be aware of where each student was in the competency ladder and offer them the appropriate technology component. From interviews, it emerged teachers were often oblivious and instead relied on field staff inputs to come abreast with academic progress of their students. This was clearly not sustainable in the long term.

The other manifestation of "dependence" is closely related to the infrastructural concerns raised earlier. Teachers had to depend on outside resources for technology deployment and day-to-day maintenance. Not only did this lead to massive delays, the inability of the government to resolve technical issues in a timely manner resulted in a deadlock of sorts. Computer laboratories became non-functional. In certain schools where only a fraction of computers remained in working condition, the resulting lopsided computer-student ratio rendered the entire experience meaningless.

Mediating the relationship between CAL-related factors and technology integration were teachers' own attitudes toward technology. The ability to integrate technology closely depended on teachers' perceptions about the effectiveness of these tools. More specifically, as long as teachers believed computers were in alignment with their pedagogical beliefs, chances that the tools would be used more optimally are strong. However, one must keep in mind that given the background of the teachers in my sample, any form of informed decision regarding the efficacy of ICT-based educational tools will require time and constant engagement. As mentioned earlier, the majority of teachers in the study were para teachers, without any prior background in teaching. For most of these teachers, the better part of their lives was spent in classrooms that were heaped in traditional pedagogy. Their knowledge of computers or even proximity to the tools was as old as CAL itself. Thus for them to undergo a sea change and transform their pedagogical mindset to accommodate the benefits of technology, will require time and effort. Unfortunately, both time and effort were severely challenged by teachers being forced to adopt an entirely new system of pedagogy in the form of MGML and relentless delays in technology deployment. Unless teachers engage with technology continually and in a systematic manner, their ability to coherently explore and grasp its efficacy, will remain undeveloped.

While the interplay of policy, school, teacher, and CAL explained the lack of computer use in most E1 schools, for some teachers the support from their school principals was enough incentive to put to use their technical training to create new content for their students. By and large, all E1 schools were similarly affected by the sudden enforcement of MGML, with teachers uniformly expressing resentment to the new system. While some teachers found the system chaotic, others vehemently opposed it on the grounds that it was harming students' academic progress. Although officially all primary schools were required to implement MGML, unofficially, it emerged that school principals, in response to teacher concerns, took the final decision whether to implement MGML or not.

In those schools, where principals were receptive to teachers' views on teaching and sympathetic to the challenges faced by them on account of MGML, teachers displayed a tendency to spend the time and effort to use the skills acquired as part of CAL to create new content for students. Principals, in these schools, circumvented the system, allowing teachers to explore ways in which technology could enhance the learning experiences of their students. In being released from the forced obligation of having to implement MGML, these teachers displayed a kind of motivation and enthusiasm otherwise missing in their peers. This explained why a very small group of teachers distinctly differed from a larger majority of their peers in the ways in which they used technology to change how their students learned.

Research Question Two:

Are there observable differences between teachers with access to technology and those without in the extent to which they engage in constructivist pedagogy in the classroom?

CAL had two major foci. First, it explored the role of technology in supplementing classroom curriculum while making learning a fun and useful exercise for the students. Second, and perhaps more pertinently and significantly, it addressed teachers' attitude toward teaching, with the intention of exposing them to a whole new possibility of constructivist pedagogy. The purpose of research question 2 was to examine whether E1 (teachers with technology) and E2 (teachers without technology) differed in their attitudes toward pedagogy, the premise being that E1 teachers would perhaps exhibit stronger patterns of constructivist behavior because they had access to technology. If this were true, then the study would have resonated with what has already been observed in the literature. Several studies have repeatedly demonstrated that teachers who truly believe in constructivist ideals are more likely to utilize technology to enhance the quality of the learning environment.

In order to understand group differences between E1 and E2 teachers, the study analyzed teachers' self-reported scores on traditional and constructivist pedagogy. The output variable for the above analysis was the pedagogical orientation of E1 and E2 teachers, which was further broken down into constructivist and traditional pedagogy. The mean data for teacher responses on the constructivist composite revealed that E2 ($M = 4.52$) teachers scored slightly lower than their E1 ($M = 4.60$) counterparts on self-reported scores of constructivist pedagogy. Since the scale moved from 1 = "never" to 5 = "always", a higher score corresponded with greater regard for constructivist practices. Likewise, the mean data for teacher responses on the traditionalism composite also revealed differences between the two groups of teachers. E1 ($M = 2.72$) teachers scored slightly lower on the traditionalism composite than their E2 ($M = 2.91$) peers. A lower score on the traditionalism composite corresponded with a lesser regard for didactic pedagogical practices. Combined, these results resonated with what has been found in previous research, where teachers with access to technology exhibit a stronger tendency toward constructive pedagogy.

While these mean scores differed, it was imperative to gauge whether these differences were statistically significant. In order to determine the statistical significance of the mean scores, a one-way and two separate two-way ANOVA models were tested on the data. A simple one-way ANOVA model assessing group differences on the constructivism composite functional solely on assignment (whether E1 or E2) revealed no statistical significance. Subsequently, two separate one-way ANOVA models were run; while one examined the role of sex in mean score differences, the second assessed if educational qualification of the teachers had any bearing on their attitude toward constructivist pedagogy. All three omnibus models were not statistically significant, leading to the inference that individually, the three variables of assignment, sex, and educational qualification did not statistically significantly explain the groups differences observed in the mean scores of teachers on the constructivism composite.

Taking this analysis further, two factorial ANOVA models were also tested. The first model examined whether group differences on the constructivism composite could be explained by the individual and combined effects of assignment and sex. The second assessed the role of assignment and educational qualification on teacher attitudes toward constructivist pedagogy. Yet again, both factorial models did not result in statistical significance.

However, the results revealed that while the difference in the mean scores on the traditionalism composite did not statistically significantly differ between assignment and whether the teacher was male or female, it did vary for teachers with different educational backgrounds. This difference was significant at the 0.05 level. The results of the post-hoc comparison revealed that the mean difference in scores on the traditionalism composite was statistically significant between undergraduate and graduate teachers. Teachers with a graduate degree had scores statistically significantly lower on the traditionalism composite than their peers who had an undergraduate degree. The importance of educational background also persisted in the subsequent two-way factorial models.

With educational background emerging as critical to understanding teachers' approach toward pedagogy, from a policy point of view, it raises questions about the efficacy and need for technology-based educational interventions. As noted above, observations from E1 and E2 classrooms revealed very similar teaching mechanisms at play. Given the similarities, I asked E1 about their perceptions about technologies and its worth. Uniformly, all respondents agreed technology was "good" and even necessary. Four themes emerged, as teachers alluded to the benefits of instructional technologies. These were: an interactive environment, visualization of concepts, non-threatening environment, and a revision tool. Through interviews, what also became evident is that teachers' believed instructional technologies played a role in students' affective outcomes. Consistently, all the respondents agreed students were more enthusiastic while working on computer modules, less likely to miss school, and generally more attentive than they normally are in the classroom.

Implications for Policy and Practice

The debate in favor of ICTs in education is one of access and quality. Since the 1990s, when ICTs first became to be suggested as potential tools for education access and quality, proponents argued these tools would enable the education reform process both in advanced and developing nations around the world. Since then, and over the past few decades, declining costs of technological devices and increased diffusion of computers has fueled this belief. However, despite so many decades of ICT investment in education, success stories have been few and far in between. The reasons for the high failure rate have been plenty. Particularly, the tendency of policy-makers to give credence to technology and technology-literacy, rather than clarity on how these tools might meet broader educational objectives and goals is partly to blame. What is increasingly becoming obvious is—simply equipping schools with computers and focusing on technical training are insufficient. Rather, the emphasis has to be on ways to integrate technology with the curriculum in a manner that would permit the accomplishment of broader educational goals.

CAL's novelty lay in the fact that it addressed the issue of technology integration directly. It concentrated on empowering teachers to use technology in innovative ways that would enhance the quality of the learning environment. Content creation was closely tied to the curriculum. Most importantly, it did not sidestep teachers, instead emphasizing their role in the whole ICT-for-education process. But, as demonstrated in this study, implementation challenges rendered sustainability a moot issue. Clearly, the promise of ICTs can truly be achieved only when certain fundamental conditions are fulfilled. As established in this study, these include the availability of functional infrastructure, timely support services, congruence between teachers' pedagogical philosophies and what these tools purport to achieve, and micro and macro level policy and planning that aid the process. Based on the findings from this study, the following section discusses the implications for policy and practice.

<u>Recommendation One: Make available functional infrastructure</u>

Quite naturally, the success of any ICT-based educational project depends on the presence of available and functional infrastructure. Ironically, however, often times such projects fail not for the want of available infrastructure, but for the lack of functional infrastructure. While in CAL's case, the hardware deployment ended up becoming a long drawn affair, usage of the equipment was made even more difficult by the lack of electricity, battery back-up, improper buildings, lack of requisite furniture, peripheral equipment, and rodent infestation.

As the findings from my study point out, while these are very basic requirements, they are extremely vital to the success and sustainability of any ICT-based effort. With ICT-led developmental efforts, what is often missed is that, an initiative of this nature is not always only about the technology. It is equally, if not more importantly, about putting in place the processes that will make technology use viable and worthwhile. Simply equipping schools with computers without putting in place appropriate rooms, proper furniture, and constant power supply is tantamount to signing up the project for failure from the start. For instance, inconsistent power supply is a reality in most parts of the developing world. As a result, a power back-up system is absolutely critical if students and teachers are to be allowed uninterrupted, valuable use of computer time. In its absence, computer sessions are reduced to sporadic, inadequate, and insignificant time spent in front of the computer, which clearly adds no value to the students' learning experience. Similarly, for computers to function uninterrupted it is essential that they are housed within appropriate rooms, with proper ventilation, and free of dust and rodents.

Unless these conditions are provided for, low and inadequate infrastructure will impede teachers' and students' access to these tools, thereby rendering the goal of ICT-based education unattainable.

Recommendation Two: Provide technical support

Besides the availability of functional infrastructure, policymakers must consider recurring maintenance issues when planning for ICT use in schools. Aside from budgeting for hardware/ software deployment, policymakers must also plan for maintenance costs and instate a technical support team in schools. Surprisingly, time and again, policymakers tend to fail to factor in this aspect when planning for technology-based educational programs. The nature of technology is such that technical issues are a constant. Computers will break down, will be attacked by viruses, develop the need to be reconfigured, run into memory issues, or simply crash. Most of these issues can be easily and instantly fixed. However, for timely repairs, it is essential schools have a ready technical support team that addresses these issues in a judicious manner.

As demonstrated in this study, technical issues are a key obstacle for teachers and successful technology integration. Teachers often do not possess the expertise to fix these problems on their own and instead have to depend on outside resources for troubleshooting. However, the greater the dependence on outside sources, the likelihood of delays and interruptions increase. Complications also arise when teachers are unclear whom to approach for technical issues. For technology integration to succeed, schools must be provided with a dedicated team of technical staff who can attend to issues arising out of a computer laboratory.

If appointing a school-level team does not seem a viable option, then policymakers might consider a central team that tends to the technical issues of a cluster of schools based on geographic proximity. In the likelihood that teachers do not possess the competency to fix technical issues, they must at least have clarity on whom to approach for troubleshooting such problems. Another aspect for policymakers to consider is to introduce a system wherein government-employed technicians conduct regular equipment inspections to pre-empt future breakdowns.

Recommendation Three: Institutional support is critical to teacher ability to integrate technology

Research in the past has emphasized principal's roles as leaders and the impact that has on improving teacher performance (Cuban, 1988). The differences observed in the types of technology-based efforts attempted by teachers in my study, were partly due to the differential behaviors of their principals. Supportive environments, which manifested in the forms of clear communication between teachers and the school administration, and especially a tendency on part of principals to be receptive to teacher concerns and feedback was instrumental in encouraging and inspiring teachers to make efforts at technology integration. On the other hand, those school teachers who experienced a sense of loss of control on decisions of school reform and felt pressured and coaxed into implementing policies that were clearly not tenable in their opinion reacted to technology integration unfavorably. The differences in the reactions to technology-based innovations and efforts within the classroom underscore the critical role principals and school administrators play in creating a conducive environment for ICT-based innovation.

Principals must be encouraged to play a leadership role that supports innovation among teachers. Importantly, there is a critical need for constant dialogue between teachers and school administrators and school administrators and policymakers that pays cognizance to teacher feedback and concerns.

The lack of consensus between teachers, school administration, and policy makers on broader educational goals and reforms are formidable challenges to technology integration. When reform processes become prescriptive affairs, as opposed to outcomes of a process that solicits teacher feedback while they (reforms) are still at the nascent stages, challenges are bound to arise. This is especially true for technology-based school reforms because to what extent students gain access to technology depends on their teacher and whether s/he believes these tools will support pedagogical goals.

As noted in my study, often the expectation is for teachers to modify their teaching style to accommodate policies established by the government. If we want teachers to adopt innovation, then it is imperative they be made equal stakeholders in the decision-making process. Additionally, any reform must be constantly evolving, taking into continuous consideration teacher opinions and concerns. The system must make teachers feel they are integral to the process for reforms to succeed.

Recommendation Four: Determine link between technology and pedagogy

A formidable barrier to successful technology integration is the lack of professional development opportunities following the introduction of ICTs in schools. Professional development programs need to have an equal emphasis on technology and pedagogy for teachers to reach a level of self-reliance, apart from imparting concept knowledge. A comprehensive professional development program can also be instrumental in helping teachers overcome their fear toward technology or change any negative perceptions they might have. Professional development programs must be cognizant of the fact that teachers with no background in technology use are bound to approach such projects with apprehension, suspicion, and even trepidation. If not addressed, such beliefs will mediate the extent of teacher involvement in technology integration.

That said, professional development programs must make a clear distinction between technology for computer literacy and technology as a supplement to pedagogy. For technology-based educational projects to succeed and be truly transformative, teachers must acquire the capacity to use these tools effectively, and in a manner that aligns with their own pedagogical goals and the broader objectives of the program in question. There are two issues at play here: 1) the ability to possess the requisite technical prowess to be able to use the technological tools effectively; and 2) the identification of ways in which these tools will support their own pedagogical philosophies. While for the former, it is essential that ICT-based projects have a strong technical training component, perhaps more crucially, the latter highlights the need for adequate professional development programs that equip teachers with the ability to make informed decisions about how technologies might support teaching and learning. However, the two are not mutually exclusive. The technical training offered to teachers as part of any ICT-for-education project must be closely linked to the educational goals established by them.

The importance of professional development programs could not be stressed more, especially when faced with a situation where the governments address teacher shortages by recruiting contractual teachers. In recent times, para teachers have become a reality in most parts of India and other developing countries. In India, in particular, the concept of para teachers enjoys tremendous government support when viewed in the light of economic arguments made in its favor. This is an unfortunate development given their limited or no training and background in teaching. In addition, the pre-service training requirement for these teachers is waived and instead the government focuses on in-service training programs that are often found to be inadequate and substandard. The learning curve for such teachers to adopt new reforms like technology-based education is steep, and requires time, training, and prolonged support.

ICT-based reforms are particularly challenging for teachers in developing countries because of their lack of prior exposure to these tools. Substantial progress is possible only when teachers acquire adequate technical expertise to integrate technology with the curriculum and design course structure and delivery in a manner that transforms teaching and learning. However, to be able to do that, teacher preparation must be mandatory and must be provided. It is not enough to simply introduce a sudden reform and expect teachers to adopt it instantly. Likewise, policymakers should understand that ICT-based educational reforms involve much more than just hardware and software deployment and a short technical course. Training programs have to be more rounded, helping teachers acquire subject-specific know-how, effective pedagogical practices, and innovative ways in which technology complements the process of teaching. It is imperative that training programs equip teachers with ways to make the connection between technology and curriculum. Most importantly, these training programs need to be on-going initiatives, if technology integration efforts are to be successful.

Given the background of teachers and the novelty of technology-based interventions, policymakers should calibrate the goals and objectives of technology-based educational reforms. These are teachers who, for the most part of their own student lives, were exposed to extremely didactic, traditional pedagogy, which was devoid of technology. To expect them to instantaneously espouse and champion technology-based educational reform is unrealistic and unwise. Such changes require time and constant engagement in the form of on-going professional development programs and support.

A relevant lesson from CAL was the importance and effectiveness of lesson planning on the day-to-day teaching of teachers. Training programs must endeavor to make the connection between technology and lesson planning. As evident in my sample for this study, the culture of lesson planning was clearly absent. Teachers relied on impromptu and unplanned lesson delivery, which often resulted in extremely pedantic and abstruse classroom environments. Of course, appropriate and effective lesson planning is closely tied to appropriate and relevant content knowledge. Policymakers need to determine whether contractual teachers have the much needed content knowledge to teach a classroom full of students, much less plan lessons for effective classroom delivery using technology.

Recommendation Five: Articulate teacher responsibilities

In rural India's context, the issue of teacher shortages has primarily been dealt with the recruitment of para teachers. But, the shortage of teaching staff in schools has also meant that apart from teaching, teachers get involved in other activities that result in time clashes and constant reprioritization of duties and responsibilities. No wonder, teachers feel saturated, demotivated and inundated with responsibilities, and left with no time whatsoever to pursue technology innovations. The complexity of the situation is further compounded when teachers are faced with situations wherein they are required to implement parallel policies, with no overlapping and very unique goals. This only exacerbates their sense of frustration.

ICT-based reforms require time and effort. If teachers are to succeed in technology integration, they need to be assigned very clear responsibilities. One solution to easing up time for teachers is for principals to take over the administrative load. In my study, some schools were so severely understaffed that principals had to take over teaching duties. Instead, the government should recruit the requisite number of teachers and assign administrative and management work to principals solely. Unless school administration is removed from teachers' list of responsibilities, teachers will either need to devote long and extra hours to pursue innovation or disregard innovation entirely.

Recommendation Six: Public Private Partnerships

Of the many rationales behind public private partnerships (PPPs) in ICT-based educational efforts, the two that are most cited by the government are cost sharing and the perception that the private sector is more competent at handling "innovative" areas like ICT-use in education (Trucano, 2010). Such partnerships are especially relevant at the implement stage of ICT-based projects, infusing greater accountability into the process by ensuring that each party delivers on their set of goals and responsibilities. That said, while there are advantages to PPPs, they also run the risk of failure, especially when there is a lack of synergy or break down in communication between the involved parties. Lessons from CAL are testament to the fact that challenges arise not simply because of a breakdown in communication but also when one party gets away without entirely respecting its side of the bargain.

Successful PPPs require good leadership, project management expertise, an open communication channel, and very clear distribution of responsibilities. Challenges will emerge when the distinction between roles and responsibilities becomes distorted, as was the case for CAL. In CAL's case, each party had a set of responsibilities—APF was in-charge of training, content creation, and on-site support, while the state government was responsible for infrastructure deployment. However, with time, in addition to their own set of responsibilities, APF staff also became involved in maintenance issues. Gradually, teachers' dependence on one party (APF staff) increased exponentially. This resulted in severe implementation challenges, with repercussions on sustainability, especially once the project ended in 2011. In addition to implementation, a significant take-away from the CAL experience is that PPPs need to have well-established exit strategies to offset any issues that might arise when a significant partners decide to depart the project. Most importantly, who takes over the responsibilities of the partner that leaves is a necessary issue to ponder over.

Recommendation Seven: Realize technology-based reform takes time

One of the reasons ICT-based educational projects fail is because they tend to be short interventions punctuated by circumstances beyond the control of teachers and/ or project personnel. Sudden emergencies, teacher strikes, impromptu holidays, personal obligations, and academic vacations are only some among many reasons that result in a break in teachers' continuous use of technology. As evidenced in my study, teachers have a tendency to forget after every long break and are forced to relearn everything that was taught prior. This not only results in delays, it also interferes with their ability to use technology. Crucially, prolonged engagement is especially essential when we are looking at altering the pedagogical styles of teachers who have no formal background in education, let alone experience in ICT use. Policymakers must factor in the reality that contract teachers, for the most part of their student lives, were exposed to extremely didactic forms of education. For them to accept and internalize the existence of a constructive form of pedagogy and further understand the role technology might play in its delivery will take time. Becker (1994) argued that although there is no rule of thumb, it is safe to expect teachers to take up to 5 years to actually start using technology appropriately. And this, he argued in a developed country context. In developing countries, I would argue, this time frame is much longer.

Future Research

This study creates opportunities for further research. The first recommendation is to look closely at how teacher training programs in developing countries prepare teachers for technology-based pedagogy. This is very important because, as noted several times in this study, often ICT-based educational projects fail because training programs are insufficient and unsuitable to teachers' needs. Research in this area will enhance our understanding of the kinds of professional development programs that need to exist for teachers to reach a level of self-sufficiency in ICT use.

Further, given the complexities and demands of ICT-based projects, research should explore in what way does the policy climate support or frustrate teachers' efforts? As demonstrated in this study, the lack of unity in multiple policies only serves to thwart efforts and place avoidable pressure on teachers that discourages and demotivates them.

A third suggestion for future research would be to investigate more closely the implications of technology-based resources on constructive pedagogy. As observed earlier, if educational policies emphasize the need for student-centered learning in the classroom, what is technology achieving that a more holistic professional development program wouldn't attain? This would have tremendous implications for ICT policy and practice and help us formulate strategies that are coherent and fill the gaps between what works and what doesn't.

Appendices

Appendix A: E1 Survey Instrument

छत्तीसगढ़ में शिक्षकों का सर्वे

प्रिय शिक्षक,

"बच्चों को सीखने और सिखाने की प्रक्रिया में कम्प्यूटर का उपयोग करने के कारण आपकी शिक्षण प्रक्रिया पर क्या प्रभाव पड़ा है ?" इस शोध में भाग लेने के लिये हम आपसे अनुरोध करते है । इस शोध में शोध कर्ता यह जानना चाहती है कि **"कम्प्यूटर सीखने और सिखाने की प्रक्रिया का एक महत्वपूर्ण उपकरण है"** इस पर आप कितना विश्वास करते है । इस सर्वे को पूरा करने में आपको 45 मिनट का समय लगेगा । आप जब इस फ़ार्म को भर रहे हो तब उन बातों को को याद करिये जब CAL कार्यक्रम आपकी शाला में संचालित था । सभी प्रश्नों का अनिवार्य रूप से उत्तर देना है । यदि किसी प्रश्न का उत्तर देने में आप संशय में हो तो उसे रिक्त न छोडकर आप वही उत्तर को लिखे जो उस समय आपके मन में चल रहा हो । 1–4 तक के प्रश्नों का उत्तरों को गुप्त रखा जायेगा इस बात की पूरी गारंटी दी जाती है ।

1. नामः------------------------------
2. उम्रः ------------------वर्ष
3. लिंग :----------
4. शाला का नाम -----------------
5. अकादमिक योग्यता ------------------
6. शिक्षण अनुभव -------------------वर्ष
7. वर्तमान शाला में कार्यकाल -----------------वर्ष
8. क्या आपके काम में स्थानांतरण होता है ? -----------------हाँ/नही

   यदि उत्तर हाँ है तो

   1. आपका स्थानांतरण कितनी बार हुआ है ?
9. आप कौनसी कक्षाओं मे अध्यापन का कार्य करते है ?(सभी कक्षाओं को पढ़ाते है तो बताये)

   ----
10. आप कौनसा विषय पढ़ाते है? (सभी विषयों को पढ़ाते है तो बताये)

    ----
11. आपने कम्प्यूटर का उपयोग करने के लिये कोई प्रशिक्षण लिया है?

    ----
12. आपकी कक्षा में कुल कितने छात्र है ?

    ----
13. क्या आपकी शाला में कम्प्यूटर लेब है ?

    यदि उत्तर हाँ है, तो कृपया बताइये ।

    - आपके कम्प्यूटर लेब में कितने कम्प्यूटर है ?--------------------
    - एक औसत कम्प्यूटर छात्र अनुपात कितना है ?--------------------

14. कम्प्यूटर कितने पुराने है ? 2 वर्ष से कम--- 2 वर्ष से अधिक--

15. क्या आपके घर में कम्प्यूटर है ? हाँ\नही ---------------

16. आप घर पर कितनी देर तक कम्प्यूटर का उपयोग करते है ?----

17. एक सप्ताह में शाला कार्य अवधी के दौरान कितनी बार बिजली गुल होती है ?----------

18. क्या शाला में पावर बेक अप की कोई सुविधा है ? हाँ\नही

19. क्या कम्प्यूटर मे पावर बेक अप की कोई सुविधा है ? हाँ\नही

- कम्प्यूटर को बेटरी कितनी देर का बेक उप देती है ?

20. आप कम्प्यूटर को शाला में किन किन कार्यों के लिये उपयोग करते है ? जिनका उपयोग किया हो उसके सामने निशान लगायें ।

उपयोग किये गये साफ़्टवेयर का नाम		उपयोग किये गये साफ़्टवेयर का नाम	
वर्ड		ड्राइंग	
एक्सेल		जी. कम्प्रिस	
पावर पाईन्ट		सी मेप	
फ़ोटो स्टोरी		टक्स पेंट	
सी.डी.		टक्स मेथ	
बर्हा हिन्दी टयपिंग		अडासिटी	
अन्य (उसकी जानकारी देवें)-------------------			

21. छात्र सप्ताह में कितने घंटे कम्प्यूटर का उपयोग करते थे ?

22. आपके विधार्थी क्या कार्य करने के लिये शाला में कम्प्यूटर का उपयोग करते है?

उपयोग किये गये साफ़्टवेयर का नाम		उपयोग किये गये साफ़्टवेयर का नाम	
वर्ड		ड्राइंग	
एक्सेल		जी. कम्प्रिस	
पावर पाईन्ट		सी मेप	
फ़ोटो स्टोरी		टक्स पेंट	
सी.डी.		टक्स मेथ	
बर्हा हिन्दी टयपिंग		अडासिटी	
अन्य (उसकी जानकारी देवें)-------------------			

23. आपके विधार्थी कम्प्यूटर का सह्योग से क्या कार्य करते है ? इसे विस्तार से बतायें ।

24. आप कम्प्यूटर के सहयोग से क्या कार्य करते है ? इसे विस्तार से बताये ।

25. अपने शिक्षण कार्य के बारे में चिंतन करते हुए यह बताने का प्रयास करें कि जिन विषयों को आपने कम्प्यूटर के सह्योग से पढ़ाया उसमे और ऐसे विषय जिन्हें आपने कम्प्यूटर का उपयोग किये बिना पढ़ाय उसमे क्या अंतर था ?

यदि उत्तर हाँ है तो कृपया बताइये

1. ये अंतर क्या है ?

2. आपके मत से ये अंतर क्यों थे ?

निम्न संदर्भों से आप कितने सहमत, थोडे सहमत, न सहमत न असहमत, थोड़े असहमत,असहमत कृपया इसकी जानकारी भरें आप का जो मत हो उस डिब्बे के नीचे निशान लगायें ।

		पूर्णतः सहमत	आंशिक रूप से सहमत	न सहमत न असहमत	असहमत	पूर्णतः असहमत
26	कम्प्यूटर से मेरी शिक्षण प्रक्रिया अधिक प्रभावी होती है ।	1	2	3	4	5
27	मैं वह सब काम भली भांती कर सकती हूँ जिस प्रकार से कम्प्यूटर करता है ।					
28	कमप्यूटर के कारण मेरी कक्षा के बच्चों का ध्यान भंग होता है					
29	कमप्यूटर मेरे बच्चों के सीखने के तरीके को बदलता है ।					
30	कम्प्यूटर मेरे बच्चों के काम की गुणवत्ता में वृद्धी करता है ।					
31	कमप्यूटर शिक्षण के लिये एक महत्वपूर्ण उपकरण है ।					
32	कमप्यूटर उपयोग करने में आसान है ।					

33	कमप्यूटर मेरे बच्चों को भ्रमित कर देता है ।					
34	मैं पूरे विश्वास के साथ सहायक शिक्षण सामग्री निर्मित करने के लिये कमप्यूटर का उपयोग करता\करती हूँ ।					
35	कम्प्यूटर बच्चों के साथ विषय पर होने वाली बातचीत को बढ़ा देता है ।					
36	यदि कमप्यूटर मे काम करते समय कुछ गड़बडी हो जाती है तो मै जानती\जानता हूँ कि उसे किस प्रकार ठीक करना है।					

शोध पत्र के इस भाग में कृपया इस बात की जानकारी दें नीचे दिये गये कथन आपके अनूसार सत्य है असत्य है

		पूर्णतः सत्य	आंशिक रूप से सत्य	तटस्थ	आंशिक रूप से असत्य	असत्य
37	मैं यह जानती हूँ कि कमप्यूटर का उपयोग करना मेरे लिये एक अनिवार्य कौशल है ।	1	2	3	4	5
38	मुझे सामान्य रूप से कम्प्यूटर पसंद है ।					
39	सामान्य रूप से मैं कमप्यूटर का उपयोग नहीं करती ।					
40	शिक्षण के दौरान मुझे कम्प्यूटर का उपयोग करना पसंद है ।					
41	मै यह जानती/ जानता हूँ कि यदि मैं कमपुऊटर सीखने में ज्यादा मेहनत करूँ तो मै अच्छा प्रदर्शन कर सकती हूँ ।					
42	मै यह मानती\मानता हूँ कि कम्प्यूटर उतना ही महत्वपूर्ण है जितना कि पाथ पुस्तक ।					
43	मै यह विश्वास करती\करता हूँ कि कमप्यूटर बच्चों की सीखने को आसान कर देता है।					
44	मै यह विश्वास करती\करता हूँ कि कम्प्यूटर कभी भी ब्लेकबोर्ड जितना प्रभावी नही है।					

	शोध पत्र के इस भाग में कृपया आप अपनी शाला के बारे में बताइये	हमेशा	नियमित रूप से	कभी–कभी	बहुत मुश्किल से	कभी नहीं
45	जब कभी कमप्यूटर खराब होता है तो शाला में तकनीशियन है जो मेरी मदद करता है।	1	2	3	4	5
46	मै शाला में लिये गये निर्णयों पर अपनी प्रतिक्रिया देती \देता हूँ ।					
47	मै शाला में लिये जाने वाले निर्णयो पर अपना सुझाव देती\देता हूँ ।					
48	मुझे अपनी मर्ज़ी के अनूसार पढ़ाने की पूरी आज़ादी है ।					
49	मुझे कम्प्यूटर द्वारा गतिविधियों के निर्माण के लिये दिशा निर्देश मिलते हैं।					
50	मुझे सरकार के द्वारा शिक्षण के लिये दिये गये निर्देशों का सख्ती से पालन करना चाहिये ।					
51	मेरी शाला की अनिवार्य प्राथमिकता बच्चों का परीक्षा में बहत अच्छा परिणाम आये ।					
52	मेरी शाला की अनिवार्य प्राथमिकता है कि पाठ्यक्रम पूर्ण हो जाये ।					
53	मुझे अपनी कक्षा में नई सी.डी. आदि के प्रयोग को प्रोत्साहित किया जाता है ।					
54	शाला समय के अतिरिक्त भी बच्चों को कम्प्यूटर का उपयोग करने के लिये प्रोत्साहित किया जाता है।					
55	मै पाठ्यक्रम स्वयं बनाती हूँ ।					
56	कमप्यूटर के माध्यम से शिक्षण के तरीकों ओ खोजने के लिये मै शाला समय के अतिरिक्त समय भी देती हूँ)					

	हमेशा	नियमित रूप से	कभी–कभी	बहुत मुश्किल से	कभी नहीं
मैं कम्प्यूटर का उपयोग अपना पाठ्यक्रमग्लिखने के लिये करती हूँ ।	1	2	3	4	5
मैं कम्प्यूटर का उपयोग कक्षा में पढाई गयी अवधारणाओं में बच्चों की शंकाओ का निवारण करने के लिये करती\करता हूँ ।					
बच्चों के समूह में कार्य को प्रोत्साहित करने के लिये मैं कम्प्यूटर का उपयोग करती हूँ ।					
मै बच्चो की आपस में बातचीत को बढ़ाने के लिये कम्प्यूटर का उपयोग करती हूँ ।					
कक्षा का आकलन करने के लिये मै कम्प्यूटर का उपयोग करती हूँ ।					
खेलों के माध्यम से मुख्य अवधारणाओं को समझाने के लिये मै कम्प्यूटर का उपयोग करती हूँ ।					
बच्चों को शैक्षणिक खेलों को खेलने के लिये मै कम्प्यूटर का उपयोग करती हूँ ।					
बच्चों में सम्स्याओं को हल करने और तर्क श्क्ती को बढ़ाने के लिये मैं कम्प्यूटर का उपयोग करती हूँ ।					

65	मै कम्प्यूटर के सहयोग से पाठ योजना का निर्माण करती हूँ					
66	मै बच्चों की उपस्थिती भरने के लिये कम्प्यूटर का उपयोग करती हूँ ।					
67	मै समय सारणी को व्यस्थित करने के लिये कम्प्यूटर का उपयोग करती हूँ।					
68	मै कक्षा के दौरान कम्प्यूटर का उपयोग करने के लिये छात्रों को प्रेरित करती हूँ ।					

शोध पत्र के इस भाग में कृपया आप अपनी शाला के बारे में बताइये।

		हमेशा	समय अंतराल में	कभी कभी	लंबे समय में	कभी नहीं
69	शिक्षक को हमेशा अपनी कक्षा में समूह कार्य को प्रोत्साहित करना चाहिये ।	1	2	3	4	5
70	शिक्षक कक्षा के लिये निर्धारित समय का इस प्रकार उपयोग करें कि बच्चों की जरूरतों के अनुसार सभी बच्चों की संकल्पना पर पूरी समझ बन सके।					
71	बच्चे की जरूरत के अनुसार निर्धारित पाठ्य क्रम की सभी संकल्पनाओं पर समझ बनाना ज्यादा जरूरी है न कि निर्धारित पाठ्यक्रम को पूर्ण कराना।					
72	मै छात्रों को पाठ्यक्रम की विषयवस्तु याद करने के लिये प्रोत्साहित करती हूँ ।					
73	मेरे शिक्षण के दौरान बच्चे मुझसे प्रश्न पूछते है।					
74	मै केवल पाठ्यपुस्तक से ही अध्यापन का कार्य करता\करती हूँ ।					
75	मै गणित की अवधारणाओ को समझाने के लिये केवल एक ही तरीका अपनाती\अपनाता हूँ ।					
76	गणित की समस्याओं को बहुत जल्दी और कुछ चरणों मे तुरंत हल करना चाहिये।					
77	गणित में प्रक्रिया से अधिक सही उत्तर ज्यादा आवश्यक है।					
78	बच्चों में गणित सीखने को गतिविधी के अनुभवों के आधार पर प्रोत्साहित किया जाना चाहिये ।					
79	गणित सीखाना गणित की समस्याओं को तुरंत हल करके सही उत्तर प्राप्त करना है।					
80	यदि कोई गणित की समस्या का उत्तर गलत हो तो शिक्षक को यह पता लगाना जरूरी है कि यह कैसे गलत है।					
81	शिक्षक को बच्चों की ऐसी समझ के लिये प्रोतसाहित करना चाहिये कि वे गणित को हल करने के लिये अपने स्वयं के विचार प्रस्तुत करें ।					
82	अक्षर को पहचानने से ज्यादा जरूरी शब्दों का अर्थ जानना है।					
83	बच्चों की पृष्ठभूमि को ध्यान में रखकर शिक्षक अपने पाठ स्वयं बना सकता है।					
84	शिक्षक को उदाहरण देते समय कठिन शब्दों का उपयोग करना चाहिये।					
85	समझ से ज्यादा उच्चारण जरूरी है ।					

TEACHER SURVEY ADMINISTERED IN CHHATTISGARH

Dear Teacher:

You are requested to participate in a research study on how the introduction of computers in your school has influenced your teaching practices. The researcher is especially interested to know whether you believe the computer is a valuable teaching and learning tool. As you fill out the survey, please think back during the time that the CAL program was being implemented in your school. The survey should not take you more than 45 minutes to complete. Answering all the questions is compulsory. If you are unsure of any question, please provide the best response that comes to your mind rather than leaving it blank.

Your responses to Questions 1 – 4 will be kept confidential and will not be disclosed to anyone.

1. Name: ____
2. Age: ____________________ years
3. Gender: ________________
4. Name of your school: ___________________________
5. Your highest educational degree: ________________________
6. Years of teaching experience: __________________years
7. In which year did you start working in this school? _______________years
8. Is your job transferable? Yes/No

    If your answer to (8) is yes,

        How often are you transferred? ____________________years
9. Which class do you teach? (state all classes) _______________________
10. What subject do you teach? (state all subjects you teach) _________________________
11. Have you had any training in using the computer? Yes/No

        If answer to (11) is yes, then list

    a. For how many years have you been using the computer? _______________years
    b. State all your computer skills ____
12. How many students are there in your class? ___________________________
13. Does your school have a computer laboratory? ____________________

        If answer to (14) is yes, then please indicate:

    a. How many computers are there in the computer laboratory? _________________
    b. On an average, what is the student to computer ratio? ____________________
    c. How old are the computers? Less than 2 years   2 – 5 years   More than 5 years

14. How many times a week do you use the computer in school? _____________________
15. During a given week, how many times is there a power outage in school? ___________
16. Does the school have power backup? Yes/No
17. Do the computers have battery backup? Yes/No
    a. For how long does the battery back-up work?
18. What do you use the computer in school for? Tick all that apply

1) Word Document 2) Excel 3) CD 4) Draw/Paint

5) PowerPoint 6) Tux Paint 7) Tux Math 8) G Compress 9) Audacity

10) Photostory 11) C Map 12) Baraha for Hindi typing

13) Other (please specify)____

20. For how many hours a week do students use the computer? ______________hours
21. What do your students use the computer in school for? Check all that apply

1) Word document 2) Excel 3) CD 4) Draw/Paint

5) PowerPoint 6) Tux Paint 7) Tux Math 8) G Compress 9) Audacity

10) Photostory 11) C Map 12) Baraha for Hindi typing

13) Other (please specify)____

22. What do students use the computer for? Please describe in detail

____

____

23. What do you use the computer for? Please describe in detail.

____

____

24. Thinking about all the teaching you do, do you think you teach differently those subjects that have a computer component and those where there is no computer component? Yes/ No

If answer to (24) is yes, please state

a. What are the differences?

____

____

b. In your opinion, why do these differences exist?

____

____

Do you strongly agree, agree, feel neutral, disagree, or strongly disagree with the following statements. Please bear in mind the scale moves from 1 = strongly agree to 5 = strongly disagree

		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
26	Computers make my lectures more engaging	1	2	3	4	5
27	I can do what the computer can do equally well	1	2	3	4	5
28	Computers distract my students	1	2	3	4	5
29	Computers change the way my students learn in class	1	2	3	4	5
30	Computers enhance the quality of my students work	1	2	3	4	5
31	The computer is a valuable tool for teaching	1	2	3	4	5
32	I find the computer easy to use	1	2	3	4	5
33	I find the computer extremely confusing	1	2	3	4	5
34	I can confidently create teaching material using the computer	1	2	3	4	5
35	Computers increase my interaction with students	1	2	3	4	5
36	If something goes wrong with the computer, I do not know how to fix it	1	2	3	4	5

In this section, please indicate whether the following statements are true or untrue about you. Please bear in mind the scale moves from 1 to 5, with 1 meaning 'very true of me' and 5 meaning 'not at all true of me'

		Very true of me	Somewhat true	Neutral	Somewhat	Not at all true of me
37	I believe knowing how to use computer is a necessary skill for me	1	2	3	4	5
38	I like computers in general	1	2	3	4	5
39	In general I don't use computers much	1	2	3	4	5
40	I like using computers while teaching	1	2	3	4	5
41	I know that if I work hard to learn about computers, I will do well	1	2	3	4	5
42	I believe computers is as important as the text book	1	2	3	4	5
43	I believe computers make learning easier for students	1	2	3	4	5
44	I believe the computer can never be as effective as the blackboard	1	2	3	4	5

In this section, please rate the following statements about your school. Please bear in mind, the scale moves from 1 to 5 with 1 meaning always and 5 meaning never.

		Always	Frequently	Sometimes	Rarely	Never
45	Whenever the computer breaks down, a technician from school is there to help me	1	2	3	4	5
46	I give feedback on school decisions	1	2	3	4	5
47	I am allowed to be part of school decisions	1	2	3	4	5
48	I have complete freedom to teach the way I want	1	2	3	4	5
49	I am provided guidance on ways to use the computer for my teaching activities	1	2	3	4	5
50	I must follow strict teaching guidelines set by the government	1	2	3	4	5
51	My school's foremost priority is to ensure that students do well in exams	1	2	3	4	5
52	My school's foremost priority is to finish the syllabus	1	2	3	4	5
53	I am encouraged to experiment with new educational CDs in my class	1	2	3	4	5
54	Students are encouraged to use the computer outside of school hours	1	2	3	4	5
55	I design my own syllabus	1	2	3	4	5
56	I have to spend extra time in school to find ways to use computers for teaching	1	2	3	4	5

In this section please indicate how you would rate the following statements. Please bear in mind that the scale goes from 1 to 5, with 1 meaning never and 5 eaning always

		Never	Rarely	Sometimes	Frequently	Always
57	Teachers must encourage group work among students	1	2	3	4	5
58	Student needs should determine use of class time such that all students understand concepts being taught in class	1	2	3	4	5
59	Student needs should determine progress of syllabus such that comprehension of concept is more important than covering the entire syllabus	1	2	3	4	5
60	I encourage students to memorize course material	1	2	3	4	5
61	Students can ask me doubts and questions while I am teaching	1	2	3	4	5
62	The textbook is the primary and only reference	1	2	3	4	5
63	There can be only a single interpretation of mathematical concepts	1	2	3	4	5
64	Math problems given to students should be quickly solved in a few steps	1	2	3	4	5
65	Right answers are more important than the process	1	2	3	4	5
66	Math learning is enhanced by activities which build upon students' experiences	1	2	3	4	5
67	Math learning is being able to get the right answers quickly	1	2	3	4	5
68	If a math answer is wrong, teachers should let students explore why it is wrong	1	2	3	4	5
69	Teachers must encourage students to build their own math ideas	1	2	3	4	5
70	Understanding the meaning of words is more important than recognizing the letters	1	2	3	4	5
71	Teachers must build their lessons keeping in mind their students' context	1	2	3	4	5

72	Teachers must use examples to relate difficult words to their students	1	2	3	4	5
73	Pronunciation is always more important than comprehension	1	2	3	4	5

In this section, please indicate how you use information technology. Please bear in mind that the scale is from 1 to 5 with 1 meaning always and 5 meaning never

		Always	Frequently	Sometimes	Rarely	Never
74	I use the computer to write my syllabus	1	2	3	4	5
75	I use the computer to clarify student doubts about concepts taught in class	1	2	3	4	5
76	I use the computer to encourage students to work in groups	1	2	3	4	5
77	I use the computer to encourage students to interact with each other	1	2	3	4	5
78	I use the computer to conduct classroom assessments	1	2	3	4	5
79	I use the computer to show simulations and games that explain core concepts	1	2	3	4	5
80	I use the computer to make students play educational games	1	2	3	4	5
81	I use the computer to build problem-solving and reasoning skills among students	1	2	3	4	5
82	I use the computer to create lesson plans	1	2	3	4	5
83	I use the computer to record attendance	1	2	3	4	5
84	I use the computer to record timetable	1	2	3	4	5
85	I encourage students to use the computer during class time	1	2	3	4	5

Appendix B: E2 Survey Instrument

छत्तीसगढ़ में शिक्षकों का सर्वे

प्रिय शिक्षक,

"शिक्षण से क्या आशय है?" इस शोध मे भाग लेने के लिये हम आपसे अनुरोध करते है । विशेष रूप से हम यह जानना चाहते है कि आप कक्षा गत प्रक्रिया में सीखने और सिखाने की कौनसी प्रक्रियाओं का उपयोग करते हैं, बच्चों के साथ किस प्रकार बातचीत करते है और आपके अनूसार एक प्रभावी शिक्षक की विशेषतायें क्या होनी चाहिये ?

इस सर्वे को पूर्ण करने में आपको 15 मिनट का समय लगेगा । सभी प्रश्नों का अनिवार्य रूप से उत्तर देना है । यदि किसी प्रश्न का उत्तर देने में आप संशय में हो तो उसे रिक्त न छोडकर आप वही उत्तर लिखे जो उस समय आपके मन में चल रहा हो ।

1–4 तक के प्रश्नों का उत्तरों को गुप्त रखा जायेगा इस बात की पूरी गारंटी दी जाती है ।

1. नाम : ---------------------------------------
2. उम्र: --------------------------वर्ष
3. लिंग :----------
4. शाला का नाम ----------------
5. अकादमिक योग्यता ------------------
6. शिक्षण अनुभव ------------------वर्ष
7. वर्तमान शाला में कार्यकाल ----------------वर्ष
8. क्या आपके सेवा काल में स्थानांतरण होता है ? ----------------हाँ/नही

   यदी उत्तर हाँ है तो

   1. आपका स्थानाँतरण कितनी बार हुआ है ?
9. आप कौनसी कक्षाओं मे अध्यापन का कार्य करते है ?(सभी कक्षाओं को पढ़ाते है तो बताये)

   ----
10. आप कौनसा विषय पढाते है? (सभी विषयों को पढ़ाते है तो बताये)

    ----
11. आपकी कक्षा में कुल कितने छात्र है ?

    ----
12. एक सप्ताह में शाला कार्य अवधी के दौरान कितनी बार बिजली गुल होती है ?-------- ---
13. क्या शाला में पावर बेक अप की कोई सुविधा है ? हाँ\नही

शोध पत्र के इस भाग में कृपया आप अपनी शाला के बारे में बताइये।

		हमेशा	समय अंतराल में	कभी कभी	लंबे समय में	कभी नहीं
14	शिक्षक को हमेशा अपनी कक्षा में समूह कार्य को प्रोत्साहित करना चाहिये ।	1	2	3	4	5
15	शिक्षक कक्षा के लिये निर्धारित समय का इस प्रकार उपयोग करें कि बच्चों की जरूरतों के अनूसार सभी बच्चों की संकल्पना पर पूरी समझ बन सके।					
16	बच्चे की जरूरत के अनूसार निर्धारित पाथ क्रम की सभी संकल्पनाओं पर समझ बनाना ज्यादा जरूरी है न कि निर्धारित पाथक्रम को पूर्ण कराना।					
17	मै छात्रों को पाथक्रम की विषयवस्तु याद करने के लिये प्रोत्साहित करती हूँ ।					
18	मेरे शिक्षण के दौरान बच्चे मुझसे प्रश्न पूछते है।					
19	मै केवल पाथपुस्तक से ही अध्यापन का कार्य करता\करती हूँ ।					
20	मै गणित की अवधारणाओ को समझाने के लिये केवल एक ही तरीका अपनाती\अपनाता हूँ ।					
21	गणित की समस्याओं को बहुत जल्दी और कुछ चरणों मे तुरंत हल करना चाहिये।					
22	गणित में प्रक्रिया से अधिक सही उत्तर ज्यादा आवश्यक है।					
23	बच्चों में गणित सीखने को गतिविधी के अनुभवों के आधार पर प्रोत्साहित किया जाना चाहिये ।					
24	गणित सीखाना गणित की समस्याओं को तुरंत हल करके सही उत्तर प्राप्त करना है।					
25	यदि कोई गणित की समस्या का उत्तर गलत हो तो शिक्षक को यह पता लगाना जरूरी है कि यह कैसे गलत है।					
26	शिक्षक को बच्चों की ऐसी समझ के लिये प्रोतसाहित करना चाहिये कि वे गणित को हल करने के लिये अपने स्वयं के विचार प्रस्तुत करें ।					
27	अक्षर को पहचानने से ज्यादा जरूरी शब्दों का अर्थ जानना है।					
28	बच्चों की पृष्ठभूमि को ध्यान में रखकर शिक्षक अपने पाठ स्वयं बना सकता है।					
29	शिक्षक को उदाहरण देते समय कठिन शब्दों का उपयोग करना चाहिये।					
30	समझ से ज्यादा उच्चारण जरूरी है ।					

TEACHER SURVEY ADMINISTERED IN CHHATTISGARH

Dear Teacher:

You are requested to participate in a research study on what teaching means to you. We are especially interested to know your pedagogical practices within the classroom, interaction with students, and what you believe are the characteristics of an effective teacher.

The survey should not take you more than 15 minutes to complete. Answering all the questions is compulsory. If you are unsure of any question, please provide the best response that comes to your mind rather than leaving it blank.

Your responses to Questions 1 – 4 will be kept confidential and will not be disclosed to anyone.

1. Name: ____

2. Age: ____________________ years

3. Gender: ________________

4. Name of your school: ___________________________

5. Your highest educational degree: ________________________

6. Years of professional experience: __________________years

7. In which year did you start your current employment? _______________years

8. Do teachers get transferred in your school? Yes/No

    a. If answer to above is yes, how many times have you been transferred?

    ____________ times

9. What grade/ grades do you teach? (state all grades) _______________________

10.What subjects do you teach? (state all subjects you teach) ____________________

11. How many students are there in your class? ___________________________

12. During a given week, how many times is there a power outage in school____________________

13. Does the school have power backup? Yes/No

In this section please indicate how you would rate the following statements. Please bear in mind that the scale goes from 1 to 5, with 1 meaning never and 5 meaning always

		Never	Rarely	Sometimes	Frequently	Always
14	Teachers must encourage group work among students	1	2	3	4	5
15	Student needs should determine use of class time such that all students understand concepts being taught in class	1	2	3	4	5
16	Student needs should determine progress of syllabus such that understanding concepts is more important than covering the entire syllabus	1	2	3	4	5
17	I encourage students to memorize course material	1	2	3	4	5
18	Students can ask me doubts and questions while I am teaching	1	2	3	4	5
19	The textbook is the primary and only reference	1	2	3	4	5
20	There can be only a single interpretation of mathematical concepts	1	2	3	4	5
21	Math problems given to students should be quickly solved in a few steps	1	2	3	4	5
22	Right answers are more important than the process	1	2	3	4	5
23	Math learning is enhanced by activities which build upon students' experiences	1	2	3	4	5
24	Math learning is being able to get the right answers quickly	1	2	3	4	5
25	If a math answer is wrong, teachers should let students explore why it is wrong	1	2	3	4	5
26	Teachers must encourage students to build their own math ideas	1	2	3	4	5
27	Understanding the meaning of words is more important than recognizing the letters	1	2	3	4	5

28	Teachers must build their lessons keeping in mind their students' context	1	2	3	4	5
29	Teachers must use examples to relate difficult words to their students	1	2	3	4	5
30	Pronunciation is always more important than comprehension	1	2	3	4	5

Appendix C: Interview Protocol E1 Schools

1. Please tell me a little bit about yourself?
    a. When did you first start teaching?
    b. What grade do you teach in?
    c. What subjects do you teach?
    d. How long have you been teaching in this school?
    e. Have you had any pre-service training?
    f. Describe to me the in-service training programs that you attend?
        i. How often do you have to attend these programs?
        ii. Do you find them satisfactory?
2. Did you use computers before CAL?
    a. Do computers scare you?
    b. What do you like/ dislike about computers?
3. What were you taught as part of CAL?
    a. Tell me something about the training program
    b. How did you integrate CAL components with MGML?
    c. How was CAL different from your style of teaching?
4. Tell me something about MGML
    a. Are you implementing MGML in your school?
    b. How are you implementing MGML in your school?
    c. Do you like MGML?
    d. What are your concerns?
    e. Have you shared those concerns with the master trainers? What is their response?
    f. Have you shared those concerns with your principal? What is his response?
5. Apart from teaching, what additional responsibilities do you have in school?
    a. How much freedom do you have to pursue your pedagogical goals?
    b. Do you give feedback to the principal on students, teaching, and concerns on a daily basis?
    c. Is the feedback appreciated?
6. Does your school have a functional computer laboratory?
    a. How many computers are there in your school?
    b. How often would the computers break down?
    c. Who would you approach to get it rectified?
    d. How long would it take to get the problem sorted?
    e. What were the challenges you faced when computers stopped working?
    f. Does the school have power back-up?
    g. Do the computers have battery back-up?
    h. What are the other challenges you faced in trying to use computers daily

i. Are you using computers in this academic year?
j. How often did children use computers in the previous academic year?
k. What did they use computers for?

7. Apart from the prescribed textbooks, what are the additional resources that you use for your teaching activities?
8. In what way did you use computers to enhance your teaching goals?
9. In the absence of computers, please describe to me the manner in which you would go about lesson planning, instructional delivery, and student assessment?
10. With computers, how do you think that has changed the manner in which you conduct lesson planning, instructional delivery, and student assessment?
11. In your opinion, do you believe computers are necessary?
12. What does teaching mean to you?
13. What do you believe is the best way to teach students academic concepts?
14. Do you believe the computer enhances the learning environment?
15. Do you, in your capacity as a teacher, engage in pedagogical practices that emphasize collaborative, cooperative, and differentiated learning?
    a. Please give me examples
16. Do you think the computer is more of a distraction than learning tool?
17. Do you observe differences in the classroom environment between now and prior to the introduction of computers in your school?
    a. Please describe how

Appendix D: Observation Guidelines

Date: ________________________

Time of Observation: ________________________

Location: ___________________________________

Teacher observing: ___________________________

Description of physical setting (classroom):

Description of activity (ICT-enabled educational activity): What are the goals of the activity/ what does the activity entail?):

Description of interactions within the classroom:

Analysis of interactions, goals, and outcomes:

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