IV. CONCLUSION

IVa. Instructional Inputs' Use and Effectiveness

In Chapter II I showed the effects of the Gauteng Online, Khanya and SchoolNet projects on student achievement to generally be statistically insignificant from zero. This contrasts starkly with the most comparable study in the literature discussed in Chapter I, authored by Banerjee and others (2007), which found a substantial improvement of .47 standard deviations in mathematics scores for a computer-aided learning project conducted in India by the Pratham NGO. The qualitative evidence I presented in Chapter III illuminated some of the technical, human and organizational factors which may have been partially responsible for the results in Gauteng and Namibia. Despite the implementation problems associated with these factors, computer use in these areas was still substantial. The Khanya project, however, successfully overcame these implementation issues that proved problematic elsewhere. The Khanya project is also similar to Pratham's in that both focused on mathematics skills of primary school students, whereas in Gauteng and Namibia computers were used across the curriculum and I only studied the effects on secondary-level students.

The prevalent explanation in the literature for the divergent results between the computer-aided instruction project evaluated in India and the evidence from more developed countries is that they are largely the product of differences between developed and developing nation education systems. Both the Banerjee study and that of Machin and others (2006) apply such an explanation, with the former specifically citing lower teacher motivation and training in developing countries. This implies that the successful use of computers as an instructional input is mostly a function of the general context in which they are used. The evidence I present,

however, suggests that there must be something more to the success of computer-aided instruction in India besides its application within developing country schools.

The most significant difference I see between the Khanya project and Pratham's project in India was in the way computer use was applied in the school context. With Khanya as well as with Gauteng Online and to a large degree the SchoolNet project, computers were integrated with traditional classroom teaching. Teachers directed student computer use and thus the technology essentially became a tool used by teachers to present material and content as well as to conduct classroom activities. By contrast, computer use in the Pratham project was *independent* of teachers and traditional classroom instruction. Students played adaptive educational mathematics games which adjusted to their own level of competency and were supervised by instructors who only "encouraged each child to play games that challenged the student's level of comprehension, and when necessary… helped individual children understand the tasks required of them by the game" (Banerjee et al. 2007, p 1241).

Considered together with the existing literature, my results suggest that computer-aided learning may be effective in developing countries when computers are used in a structured way as a supplement to classroom learning, but *not as a tool by teachers in the context of traditional classroom instruction*. It is interesting to note that this finding is consistent with a broader theme in the literature on instructional inputs in developing country schools. Evaluations of projects which provide inputs used in ways analogous to how computers are used in the projects I study—inputs which were dependent on teacher use and integrated into traditional classroom teaching styles—find negligible effects on student achievement. By contrast, school inputs which do more than supplement typical classroom teaching

and which are relatively independent of teacher use have been found to significantly and positively impact student achievement.

Both Glewwe et al. (2004) as well as Tan et al. (1999) conducted randomized studies[8] of the effects of school inputs designed to help teachers more effectively deliver standard lessons to students. Glewwe and others study the effect of flipcharts in Kenya, which were used by teachers as an audiovisual supplement to lessons. The Tan study examines the effect of multi-level learning materials, which are described by the authors as "pedagogical materials designed to help [teachers] pace their teaching according to the differing abilities of their students." Both find little to no impact on student achievement.

In contrast, in addition to the successful computer-aided learning project, Banerjee and others report in the same paper the results of a randomized evaluation of *balsakhis*—young women hired to separately tutor groups of lower-performing students in mathematics and language during class time. Test scores of students tutored by a *balsakhis* increased by .61 standard deviations, while changes in the scores of other students—who enjoy a smaller class size and a more homogenous atmosphere in the traditional classroom setting—were small and statistically insignificant. A study by Jamison and others (1981), found in a randomized evaluation that radio instruction raised student mathematics achievement in Nicaragua by a very large 1.5 standard deviations. This instruction involved a course of 150 twenty- to thirty-minute daily lessons broadcast by radio, which students listened to during the school day.

[8] The study conducted by Tan and others, while randomized, included only a very small number of schools. There was no significant difference in pre-treatment exam scores or drop-out rates, but there were significant differences in some student background characteristics between treated and untreated schools, which suggest the results should be interpreted cautiously. See Glewwe (2002) for a more thorough review of this study.

Giving teachers in developing countries flipcharts, multi-level learning materials, or computers as tools intended to more effectively deliver conventional classroom lessons have generally failed to improve student achievement. In contrast, providing remedial tutoring, radio instruction, or computers for structured independent learning have all succeeded in achieving dramatic increases in test scores; these inputs were all used independently of teacher-directed instruction and in fact all took time away from conventional classroom learning.

To my knowledge, this point has not been previously emphasized in the literature. This theme is perhaps most clear when considering my results in light of Pratham's success. When computers are used to complement classroom teaching we observe no effect on student achievement, but when the same input is used as a supplement to and substitute for classroom instruction, substantial improvements in learning are realized.

These results seem antithetical to much of what we would like to believe about classroom teaching. Teachers—education professionals with the ability to adjust to the level of their students and catch those who are falling behind—should be better equipped to improve student achievement than radio lessons or educational software. But, upon closer inspection, the results of my study and the noted differences in instructional input effectiveness according to usage are consistent with a number of views of developing country education systems. For example, the findings of Kremer and others (2005) suggest that that such education systems are too often characterized by low teacher motivation, and classes may also face low levels of time spent on-task (Mongudhi, 2007). Other work suggests that teachers are accustomed to rote teaching methods and can have difficulty adjusting teaching styles to students' needs (Shaalukeni, 2002). It has also been argued that curriculum structure and delivery in developing countries are often poorly suited to

the typical student (Glewwe et al. 2007). These studies illustrate the wide array of ways in which low student achievement in developing countries has been explained.

The dichotomy in effectiveness between inputs designed to enhance conventional classroom teaching and those which essentially circumvent it highlights the importance of explanations which emphasize the significance of intra-classroom processes and teaching methods. We have been able to measure the change in school outputs for a growing set of instructional inputs, but there is something important going on "inside the box" of the school at the classroom level which is not well understood. It seems that some aspects of typical classroom practice may hold many students significantly below their potential.

In Chapter III I present evidence that some school-level processes were important to adoption of the instructional input that I study. My research falls short, however, of providing a detailed analysis of how and why computers have changed the classroom teaching process, if at all. In 1997 Riddell noted the striking dearth of studies examining classroom processes in developing countries. This shortage of knowledge has not been ameliorated over the past decade. This has the potential to serve as a very fruitful area of future research. A deeper understanding of what goes on inside developing country classrooms would be invaluable to making better sense of why certain inputs work and others do not, as well as where future interventions could be most successfully addressed.

IVb. Implications for Policymakers

Policymakers in many developing countries are eagerly and enthusiastically pursuing opportunities to make computers available in their nations' schools. Considering only the academic literature on the effectiveness of computer-aided learning initiatives, one might wonder why this has become a significant policy goal.

For example, the three projects I study all began when the only evidence on computer use available in the literature showed that it had at best insignificant—and possibly negative—effects on exam performance. Even when the results of Banerjee and others' evaluation of the Pratham project were first made publicly available in 2004 and published in 2007, this was done alongside the results of the *balsakhi* program, which the authors calculated to be substantially more cost-effective.

One possible explanation for this is the incentives that policymakers face. Politicians in developing countries often feel substantial pressure to demonstrate to their constituents that they are playing a role in "modernizing" communities. There is also a political desire by policymakers, especially in countries characterized by severe inequality, to help "level the playing field" between the wealthy and the poor. Placing computers in disadvantaged communities' schools at the very least advances this perception and reassures parents that their children have access to what many consider high-quality educational resources. As Cuban (2001), points out, this was a major factor in decisions by many school districts in the United States to purchase computers for their schools.

Another possible important motivation for policymakers is that computers have the potential for substantial impact beyond what has been measured in academic studies so far. I highlight some of these impacts in Chapter III. Between the Gauteng Online, Khanya and SchoolNet projects, I find evidence that the introduction of computers afforded teachers in rural areas access to professional development, democratized access to information for students in more disadvantaged areas, and allowed students to develop computer skills important to their future employability. All of these effects are related to major policy goals in many developing countries. Yet their impact may be more long-term rather than

short-term, making it difficult for project evaluations based on rapid improvements in test scores to show positive results.

I believe that there are valuable lessons which can be drawn from the results I present for policymakers in developing countries who do decide to pursue such projects. A significant number of governments are either already managing some type of computers-for-education project or have expressed the intention to do so in the near future. If a government is committed to making the investment of putting computers into schools, what is the most effective way to make use of these resources?

The most obvious lesson from my research in South Africa and Namibia is that investing in the integration of computers into standard classroom lessons is not likely to be the best policy option. Not only does such a use of computers fail to boost student achievement, but it has the potential to depress schools' overall computer use; if computers are designated for regular classroom use but teachers are hesitant to use computers with their classes, the lab will often sit empty during the school day. This would also undermine other, secondary goals of computer availability in schools, such as increasing computer literacy among students.

The Khanya project invested significantly in overcoming the human factors which can stand in the way of computer use by hiring facilitators who worked closely with a small number of schools. But while the project's sustained human support allowed for higher levels of computer integration into classroom lessons, this came at substantial cost and still failed to improve student achievement. In the 2006 fiscal year, Khanya spent about 30 South African Rand (USD 4.41) per student in a Khanya school on personnel alone, in addition to operating and equipment expenses. As a basis for comparison, this is equivalent to 10% of the direct cash subsidies provided to public schools by the Western Cape Education Department, which

reached roughly R 300 (USD 44.12) per student that year. There was also a significant opportunity cost to this training effort in that it required a substantial investment of teachers' time. Overall, this was a relatively costly undertaking, even for South Africa's wealthiest province. It is expensive to change teachers' habits and routines in a sustained way, and this aspect of computer investment did not pay dividends in the end for Western Cape's students.

Implementers would also be wise to pay careful attention to technical factors related to computer use in schools, which I show are especially problematic in developing countries. When these issues are not adequately addressed, computer use can falter significantly. Without strong technical support offered by the implementing organization, schools often find it difficult to support their new technology. Schools similarly find it difficult to deal with major setbacks, such as computer theft, and need some type of insurance against serious losses. Technical support seems to be most effective when it is decentralized, locally available, and quickly responsive to problems. Many schools gave up on fixing damaged machines when projects' technical support staff did not adequately respond to complaints. It seems that projects of this type would be most effective if they offered schools support for the full range of technical problems they face. This would mean not only technical support of defects covered by manufacturers' warrantees but also losses due to causes such as vandalism and theft which cash-strapped schools are not able to adequately cope with on their own.

A related issue is that of sustainability, particularly in a financial sense. Schools, especially those in poorer areas, can face serious difficulties in absorbing even the small, indirect costs associated with maintaining computer equipment. This could be anything from purchasing printer ink to replacing a broken keyboard to the cost of a technical support telephone call. Careful attention must be paid to

ensuring that schools are capable of supporting every aspect of computer use expected of them, if policymakers want that use to be sustained. The evidence I present in the previous chapter does not offer a clear solution to this problem, but does suggest a possible way forward. Khanya was able to deal with this issue by helping schools develop short- and mid-term plans of financial support for their computer labs that fit within the broader budget of the schools. In other contexts, however, schools may not have nearly as much flexibility in their budgets as the relatively well-resourced schools of the Western Cape. Direct cash subsidies may be necessary to support the cost of consumables and maintenance costs for more poorly-resourced schools. Many schools simply are not in the position to subsidize such costs given their existing budgets, and computer use in developing country schools is very sensitive to even relatively small technical and financial difficulties that cannot be remedied quickly at the school level. While it may be tempting for policymakers to ignore these costs when planning computer deployments to schools, in the end an expensive investment may be for naught without the much smaller complementary investment in sustainability.

The most important decision facing policymakers is deciding how computers should be used in schools. In Chapter III I address some of the specifics related to this question, such as how software and internet availability shape use. Let me address the question here in a more general sense. Between the evaluation of Pratham's computer-aided learning project and those that I evaluated, we only know the effects of a very narrow set of policy-relevant questions related to computer use in schools. It is clear that independent computer use by students in India made significant impacts on mathematics scores, and that computer integration with classroom lessons failed to improve student achievement in the projects I studied.

This provides a good starting point for policymakers looking to make the most of computers, but there are still important details to be worked out.

Can computer-aided learning be useful for subjects besides mathematics? What are the most useful pieces of software? How can independent student use be most effective? All of these questions are important and largely unanswered. Once computers are deployed to schools, policymakers should dynamically experiment with different applications of their use. A randomized trial of a specific software program, for example, would be relatively simple and inexpensive to implement once computers are in place[9]. The same would be true for determining the appropriate amount of time during the school day to dedicate to computer-aided learning. Policymakers should test different permutations of computer use in a systematic way and scale up those which prove effective, in order to make the most of these educational resources.

Now that we have this clearer picture of how computers can be used effectively, the many NGOs and governments in developing countries that have already invested in school computers can benefit by reforming the way this existing equipment is used. The projects I study alone include roughly 2500 schools and over one million students that can realize dramatic improvements in learning outcomes if these projects make relatively small adjustments. In many ways they are in the enviable position that a small marginal investment can make a significant impact in project effectiveness. By installing some new software and helping schools use computers as a teaching supplement rather than a lesson-delivery tool, it is likely that the overall quality of schooling can be improved considerably.

[9] Duflo and others (2006) provide a toolkit for implementing such randomized trials which may be useful to officials responsible for policy research.