differences between treated and untreated schools in racial composition, as shown in Table IIB-1.

Table IIb-1: Differences Between Treated and Untreated Schools in Gauteng

	Pass Rate	Pass Rate (Male)	Pass Rate (Female)	Poverty Score	Percent White Students	Number of Schools
Treated	-.384	-.338	-.376	41.4	5.0	212 (44%)
Untreated	.306	.273	.309	30.1	32.7	266 (56%)

Notes: Summary statistics of 2002 values for schools which were chosen to participate in the Gauteng Online project versus schools which were not chosen. Senior certificate examination pass rates normalized at the school level to a mean of 0 and standard deviation of 1. Poverty score ranked on a scale from 1-100, with 100 being most poor.

Unlike Gauteng Province, South Africa's Western Cape province has a substantial rural population, and the majority of its schools are located in rural areas. While in Gauteng schools were selected at the provincial level, the WCED selects new Khanya schools at the district level. Four of the province's educational districts are considered urban areas, covering the city of Cape Town and the surrounding metropolitan areas. The remaining three districts cover the province's rural areas.

Table IIb-2 shows differences between treated and untreated schools in the province's urban and rural areas. In the urban districts, schools selected for the Khanya project have lower test scores, higher poverty levels, and a substantially different racial composition than other urban schools. The situation is reversed in the rural areas, however, with treated schools having higher exam scores and lower poverty levels than untreated schools. It is difficult to pinpoint the underlying reason for this differential selection between urban and rural districts.

While selection of schools varied from district to district, both district officials and Khanya staff reported that selection of schools in all districts is largely based on two factors—school poverty and management quality. The differences in treated groups between district types is evidence either that balancing the emphasis on each of these two selection criteria produced very different results across districts or that there are other important selection factors which are unknown. In the analysis to follow, I attempt to control for these differences with district-level fixed effects and by only matching treated and untreated schools within districts.

Table IIb-2: Differences Between Treated and Untreated Schools in Western Cape

		Lit./Num. Scores		Lit./Num. Scores (M)		Lit./Num. Scores (F)		Pov. Score	% White	No. of Schools
Urban	Treated	-.014	.157	-.004	.131	-.015	.184	49.4	3.6	198 (39%)
Urban	Untreated	.191	.375	.164	.361	.177	.350	44.4	11.7	307 (61%)
Rural	Treated	.092	-.048	.072	-.068	.106	-.037	57.0	12.3	234 (40%)
Rural	Untreated	-.218	-.379	-.186	-.338	-.216	-.382	63.1	9.0	354 (60%)

Notes: Summary statistics of 2004 values for schools which were chosen to participate in the Khanya project versus schools which were not chosen, disaggregated into groups of urban and rural schools. Systemic evaluation exam scores for literacy and numeracy normalized at the school level to a mean of 0 and standard deviation of 1. Poverty score ranked on a scale from 1-100, with 100 being most poor.

In Namibia, there was no firm set of selection criteria consistently applied from the beginning of the SchoolNet project. Rather, schools were either chosen for the project as part of a sub-project funded by an outside source or showed interest in receiving a computer lab from SchoolNet by applying directly to the organization and were later chosen to receive computers. SchoolNet did, however, generally focus on schools in historically disadvantaged parts of the country, especially in four of the country's political regions known collectively as the north-central region where a large proportion of Namibia's population resides.

Table IIb-3 illustrates the differences between treated and untreated groups of schools in Namibia's north-central region as well as other regions. The proportion of schools selected into the SchoolNet project was much higher in the north central region. Additionally, treated schools in the north-central region had much higher exam score levels than untreated schools, while in other regions the treated group had only slightly higher scores.

Table IIb-3: Differences Between Treated and Untreated Schools in Namibia

		JSC Scores	JSC Scores (Male)	JSC Scores (Female)	Avg. Class Size	Number of Schools
North-Central Region	Treated	-.111	-.096	-.114	37.2	91 (33.6%)
	Untreated	-.281	-.237	-.271	38.3	180 (66.4%)
Other Regions	Treated	.263	.223	.256	31.0	42 (21.8%)
	Untreated	.239	.205	.237	29.2	151 (78.2%)

Notes: Summary statistics of 2000 values for schools which were chosen to participate in the SchoolNet Namibia project versus schools which were not chosen, disaggregated by region. Junior Secondary Certificate exam scores normalized at the school level to a mean of 0 and standard deviation of 1.

Another important characteristic to note in the Namibia data is that of significant differential trends related to the selection of schools. While schools in the north-central region were more likely to be selected into the SchoolNet project, those schools also improved exam scores over time at a much faster rate than schools in other regions. Table IIb-4 shows the results of a simple regression of the following specification:

$$Y_{it} = \beta_0 + \beta_1 R_i + \beta_2 t + \beta_3 R_i * t \qquad (1)$$

where Y is the normalized exam score, R is a binary variable indicating whether a school is in the north-central region, t indicates the year of the observation in the panel, and R_i*t is an interaction term showing the linear time trend for north-central region schools relative to other schools.

Table IIb-4: Differential Trends in the Namibia Data

	Differential Trend	Region Main Effect	Year Main Effect
Dependent Variable: Normalized Exam Scores	.104*** (.013)	-.776*** (.080)	-.055*** (.010)

* Significant at the p<.1 level, **p<.05 level, ***p<.01 level

Notes: Regression results are specified according to equation (1). Standard errors are adjusted for clusters by school.

The difference in exam score trends between north-central region schools and schools in other parts of Namibia is highly significant both in a statistical and practical sense. North-central region schools improved at an average rate of .104 standard deviations per year over the course of the panel. This example highlights the importance of accounting for differential trends in my attempt at evaluating the Namibia project.

IIc. Identification Strategy

In order to estimate the causal effect of computer availability on student performance in the three projects of interest, my analysis must overcome the challenges induced by the nonrandom selection of schools for treatment. As outlined in the previous section, there are stark observable differences between treated and untreated schools both on outcome variables and other key covariates. Additionally, differential trends in the data related to school selection are also an important source of potential bias which must be considered in any analysis.

It should also be noted, however, that despite the nonrandom selection of schools for inclusion in the projects, the ways in which schools were selected and deployed do offer some advantages in evaluating the causal effect of computer availability on educational outcomes. Due to the rolling computer deployments in each project observed over several years, we can be more confident that differential effects unique to a specific time period are not substantially biasing the estimates. Additionally, evaluating projects where decisions regarding treatment were largely in the hands of education department or NGO officials eliminates many possible sources of endogeneity related to unobservable school characteristics, especially in cases where those responsible for selecting schools do not have much detailed information on individual schools.

For each project, I fit the panel data to a year and state fixed effects ordinary least squares (OLS) regression model. Most importantly, this model controls for school characteristics which do not vary over the length of the panel. It also controls for factors affecting all schools that are year-specific. Additionally, group-year effects are used to control for year-specific changes that act on significant groupings of schools, such as schools within the same circuit, district or poverty quintile. Allowing for such effects in the models controls for some possible differential time trends in the data. Beyond simple time trends, these controls absorb any factors affecting all schools in the given grouping in each year. Finally, important covariates for which data are available on an annual basis are also included in the panel regression models.

In order to demonstrate the robustness of the panel analyses and possibly bring to light potential biases in the estimates, a matching technique is also used to evaluate each project. In the Gauteng and Western Cape provinces, the level of decision-making in selecting schools into the projects is clear, and relatively consistent standards are assumed to be applied in each round of selection. Additionally, information is available from interviews with officials in both provinces on which major factors were considered in making school selections. Propensity score matching is therefore used as a secondary method of estimating the treatment effect in these provinces' respective projects. Propensity score matching estimates the pre-treatment probability of being selected into the treated group based on observable characteristics. The likelihood of treatment (propensity score) is then used to match treated schools to comparable untreated schools[3]. In Namibia, where significantly differing selection criteria may have been applied, a standard matching on observable variables method is used to identify untreated schools which are most similar to treated schools.

Finally, as an additional check for possible bias in the estimates, results are presented on the outcome variable of treated groups compared to control groups in the years prior to treatment. For the panel regressions, this involves adding one-, two- and three-year leads of the treatment variable to the original specification. In the cases of Gauteng Province and Namibia, where several pre-treatment

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[3] Dehejia and Wahba (2002) provide a thorough discussion of the use of propensity score matching for estimating causal effects in nonexperimental settings.

observations are available per school, an interaction term is used to check for pre-treatment differences in trends between treated and untreated schools, conditional on the controls in the original specification. For the matching results, the treatment and constructed control group are compared on outcome variables in the years prior to treatment.

IId. Estimation Results

Gauteng Province

The regression equation used for the Gauteng Online project is:

$$Y_{it} = \beta_0 + C_{it} + C_{i(t+1)} + C_{i(t+2)} + C_{i(t+3)} + H_{it} + \gamma_{dt} + \delta_{qt} + \alpha_i + \lambda_t + W_{it} + \varepsilon_{it} \quad (2)$$

where Y_{it} is the normalized senior certificate pass rate, C_{it} represents a binary variable indicating receipt of computers from Gauteng Online, H_{it} represents a binary variable controlling for presence of Gauteng Online computers in later years, d and q represent districts and poverty quintiles, respectively, and W_{it} represents a set of variables of school characteristics varying annually—racial composition, provincial poverty index score, per-capita funding and number of students sitting for the senior certificate examination. The district and poverty quintile terms allow for district-year and quintile-year fixed effects. The *W* term includes important covariates that change annually for which data are available. This controls for any time trends related to these characteristics and adds parsimony to the specification by explaining some of the variation in test scores not captured by other controls.

The probit regression used to estimate the propensity score for Gauteng schools is:

$$\Pr(T = 1 \mid Q, R, D, M, F, \Delta E) = \Phi(\beta_0 + Q + R + D + M + F + \Delta E) \quad (3)$$

where T is a binary variable representing treatment, Q is a set of binary variables representing poverty quintile, R is a set of variables controlling for racial diversity[4] and racial composition, D is a set of binary variables indicating school district, M is a set of binary variables controlling for functional status—used as a measure of school management quality, F is a set of binary variables controlling for former educational authority and former model status under the apartheid education system, and ΔE represents the percent change in enrollment from two years prior. Poverty quintile, racial diversity and change in learner enrollment were all explicitly mentioned in interviews with GDE officials as factors which were considered in the selection process. School management quality and schools' former status under apartheid were not explicitly cited by GDE officials as important selection factors, but they are included because I believe they may have significantly influenced selection.

The propensity scores were generated separately by year to allow for different selection criteria by cohort, with observations for schools having been treated in a previous year excluded. To create a control group, each treated school was matched to the untreated school with the nearest propensity score in the given year. The group means between the treatment and control groups were then compared in each of the three years post-treatment as an estimate of the causal effect of treatment. In the case where a treated school is matched to a school which received treatment in one of the subsequent three years, the next-nearest match is substituted for that comparison.

The results of the panel regression and propensity score matching results are shown in Panel A of Table IId-1. The panel regression results show the coefficient and standard error on the binary variable indicating selection into the project in

[4] Racial diversity is operationalized as the probability that two students randomly drawn from a school population are of the same racial group.

each of the three years after computers were received. Standard errors are adjusted for clustering in the set of observations for each school. The propensity score matching results show the difference in means between the treatment and control groups constructed by the matching algorithm[5] in each of the three years post-treatment.

One way to check for potential bias in the estimates presented in Panel A is to use what I will call a "control experiment," which means to test for differences between treated and comparison schools in the years prior to treatment. A major source of potential bias in panel regressions is unobserved dynamic effects which are not independent of treatment, including differential trends. Checking for differences in levels and trends in the outcome variable between treatment and comparison groups in the years prior to treatment can provide an indication of whether such potentially problematic factors have been sufficiently controlled for. While this by no means guarantees to either reveal residual bias or definitively demonstrate internal validity, it does provide some indication of my estimates' accuracy.

Differences in exam score levels between treated and untreated schools in the three years prior to treatment are shown in Panel B of Table IId-1. The panel regression results were generated using three variants of the specification outlined in equation (2), each with an additional set of binary variables $C_{i(t-1)}$, $C_{i(t-2)}$, and $C_{i(t-3)}$ indicating treated groups of schools in the three years prior to treatment. Similar results were generated for the propensity score estimates by comparing the treated and control groups on outcome variables for the previous three years. Finally, the panel regression setup allows for differences in pre-treatment trends, conditional on the independent variables specified in equation (2), to be estimated. This is done by

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[5] The specific matching algorithm used is presented in Abadie and others (2004).

Table IId-1: Estimated Effects of the Gauteng Online Project

Dependent Variable: Senior certificate pass rates, overall and disaggregated by gender, normalized within years

	Panel Regressions			*Propensity Score Matching*		
	Total	Male	Female	Total	Male	Female
Panel A: Treatment Effects						
1 Year Post-Treatment	-.004 (.050)	-.054 (.056)	.035 (.051)	.017 (.105)	-.058 (.107)	.080 (.106)
2 Years Post-Treatment	.041 (.058)	.034 (.065)	.033 (.058)	.037 (.117)	-.007 (.116)	.033 (.118)
3 Years Post-Treatment	-.033 (.066)	.019 (.073)	-.074 (.067)	-.088 (.156)	.086 (.153)	-.088 (.156)
Panel B: Control Experiment						
1 Year Pre-Treatment	-.020 (.047)	-.020 (.052)	-.011 (.050)	.036 (.122)	.000 (.128)	.036 (.119)
2 Years Pre-Treatment	-.011 (.039)	-.042 (.045)	.010 (.041)	-.055 (.110)	0.118 (.110)	-.021 (.115)
3 Years Pre-Treatment	.044 (.038)	.082* (.045)	.005 (.039)	-.094 .117	-.076 (.127)	-.129 (.113)
Preexisting Trend	.001 (.020)	-.004 (.021)	.004 (.020)	--	--	--

* Significant at the p<.1 level, **p<.05 level, ***p<.01 level

Notes: Regression results are specified according to equation (2) and are robust to exclusion of schools for which observations in each year of the panel are not available. The propensity score is specified according to equation (3) and schools are matched to their nearest neighbor; differences between matched treatment and control groups are reported. Regression standard errors are adjusted for clusters by school. Panel A displays estimated treatment effects, while Panel B shows differences in pass rates of treated groups in the years prior to treatment.

adding an interaction term $C'_{it}*t$ in place of the $C_{it} + \ldots + H_{it}$ terms specified in the original equation. C'_{it} is a binary indicator denoting observations of treatment group schools in the years prior to treatment. The new specification also controls for C'_{it} and t main effects.

Taken together, the results in both panels of Table IId-1 provide a good sense of the Gauteng Online project's effects on student achievement given the project's selection method and available data. None of the estimated treatment effects for both the panel regression and matching estimates are statistically significant from zero. Additionally, the coefficients are all relatively small in a practical sense—all below even one-tenth of a standard deviation—and estimated with a good amount of precision, especially in the case of the panel regression results. Treated schools also "look similar" to comparison schools in the years prior to treatment on the outcome variables of interest; only one set of results are statistically significant, and then only at the 90% confidence level. The pre-treatment differences in pass rates are also relatively small in a practical sense, with all coefficients being near or well below one-tenth of a standard deviation. Importantly, the coefficients representing conditional trends for treated schools in pre-treatment years are extremely small and fairly precise.

Western Cape Province

The regression equation used for the WCED's Khanya project is:

$$Y_{it} = \beta_0 + C_{it} + C_{i(t+1)} + C_{i(t+2)} + H_{it} + \gamma_{dt} + \delta_{qt} + \alpha_i + \lambda_t + W_{it} + \varepsilon_{it} \qquad (4)$$

where Y_{it} is the normalized school-level literacy or numeracy exam score, C represents a binary variable indicating receipt of computers from Khanya in a given period, H_{it} represents a binary variable controlling for presence of Khanya computers in later periods, d and q represent districts and poverty quintiles, respectively, and W_{it} represents a vector of school characteristics varying annually—racial composition, provincial poverty index score, per-capita funding and Grade 3 average class size. Since data for the outcome variables in Western Cape are only available in even years from 2002 to 2006, schools treated in an odd year are grouped with schools treated in the year immediately prior.

The probit regression used to estimate the propensity score for Western Cape schools is:

$$\Pr(T = 1 \mid P, R, M, F, S) = \Phi(\beta_0 + P + R + M + F + S) \qquad (5)$$

where T is a binary variable representing treatment, P is a set of variables representing the provincial poverty index score and assigned poverty quintile, R is a set of variables controlling for racial composition of the student body, M is a set of binary variables controlling for functional status—used as a measure of school management quality, F is a set of binary variables indicating former educational authority under the apartheid education system and S represents the number of learners enrolled at the school. School poverty, management quality and the former status of a school were cited in interviews with WCED officials as factors influencing selection into the Khanya project. Racial composition of the student body and school enrollment size were not explicitly cited by WCED officials as important selection factors but which I believe may have significantly influenced selection.

The propensity scores were generated separately by year within districts to allow for selection criteria differing by cohort at the district level. As in the panel analysis, schools treated in odd years are included with previous year's cohort. Observations of treated schools were then matched to the untreated school with the

Table IId-2: Estimated Effects of the Khanya Project

Dependent Variable: Literacy and numeracy assessment scores, overall and disaggregated by gender, normalized within years

		Panel Regressions			*Propensity Score Matching*		
		Total	Male	Female	Total	Male	Female
Panel A: Treatment Effects							
Literacy	1-2 Years Post-Treatment	.048	.054	.051	.134	.079	.165
		(.047)	(.050)	(.052)	(.128)	(.135)	(.122)
Literacy	3-4 Years Post-Treatment	-.057	-.008	-.083	-.003	.013	.023
		(.065)	(.069)	(.072)	(.170)	(.172)	(.160)
Numeracy	1-2 Years Post-Treatment	-.026	-.023	-.011	.098	.105	.087
		(.042)	(.043)	(.050)	(.143)	(.144)	(.140)
Numeracy	3-4 Years Post-Treatment	-.043	-.028	-.053	.094	.126	.127
		(.053)	(.055)	(.061)	(.183)	(.182)	(.179)
Panel B: Control Experiment							
Literacy	1-2 Years Pre-Treatment	-.003	.009	.001	.018	.001	-.034
		(.029)	(.032)	(.032)	(.093)	(.093)	(.094)
Literacy	3-4 Years Pre-Treatment	-.036	-.044	-.036	.081	.006	.065
		(.033)	(.036)	(.035)	(.123)	(.097)	(.126)
Numeracy	1-2 Years Pre-Treatment	.009	.031	-.003	.011	.063	-.036
		(.025)	(.029)	(.028)	(.096)	(.127)	(.097)
Numeracy	3-4 Years Pre-Treatment	.005	-.012	.020	-.032	-.006	-.069
		(.028)	(.033)	(.030)	(.125)	(.129)	(.121)

* Significant at the p<.1 level, **p<.05 level, ***p<.01 level

Notes: Regression results are specified according to equation (4) and are robust to exclusion of schools for which observations in each year of the panel are not available. The propensity score is specified according to equation (5) and schools are matched to their nearest neighbor; differences between matched treatment and control groups are reported. Regression standard errors are adjusted for clusters by school. Panel A displays estimated treatment effects, while Panel B shows differences in pass rates of treated groups in the years prior to treatment.

nearest propensity score within district-year groups. Otherwise, the construction of the treatment and control groups proceeded in the same way as for the Gauteng Province schools.

The results of the panel regression and propensity score matching results are presented in Panel A of Table IId-2. Due to the alternate-year structure of the data, results are shown for observations one and two years as well as three and four years post-treatment grouped together.

Differences in exam score levels between treated and untreated schools in the periods prior to treatment are shown in Panel B of Table IId-2. These results were generated using the same method as for Gauteng Province. For Western Cape province, however, data are available for at most three observations per school and do not begin until the year after the inception of the Khanya project; a substantive comparison of preexisting trends for treated and untreated schools is not possible.

The results for the Khanya project are very similar to those of Gauteng Online. The estimated treatment effects are relatively small in a practical sense and estimated to a good degree of precision. None of the estimated coefficients are statistically significant at any conventional threshold. In the years prior to treatment, treated schools look similar on outcome variables to untreated schools both conditional on the regression controls and after propensity score matching—all of the estimated pre-treatment differences are near or well below one standard error from zero.

Namibia

The regression equation used for the SchoolNet Namibia project is:

$$Y_{it} = \beta_0 + C_{it} + C_{i(t+1)} + C_{i(t+2)} + C_{i(t+3)} + H_{it} + R_{it}*t + t + \gamma_{dt} + \alpha_i + \lambda_t + W_{it} + \varepsilon_{it} \qquad (6)$$

where Y_{it} is the normalized school-level junior secondary certificate examination score index, C_{it} represents a binary variable indicating receipt of computers from SchoolNet in a given year, H_{it} represents a binary variable controlling for presence of SchoolNet computers in later years, $R_{it}*t$ is an interaction term allowing for differential trends for rural schools, d represents circuits, and W_{it} represents a vector of school characteristics varying annually—average class size, teacher qualification levels, teacher experience, the number of students sitting for the JSC exam and the percent change in the number of students sitting for the JSC exam from the previous year.

I use a slightly different matching strategy in evaluating the SchoolNet project than the other projects. In Namibia, treated schools were selected into the SchoolNet project using several different sets of largely unknown selection criteria. In order to find comparable untreated schools, therefore, I adopt a nearest-neighbor matching strategy. Treated schools are matched within circuits to the untreated school with the closest average teacher qualification levels, used in this case as a measure of school quality. This is done using values for teacher qualification levels in the year of treatment.

The results of the panel regression and matching results are presented in Panel A of Table IId-3. Coefficients for the matching results are bias-adjusted for inexact matches in the matching variable, teacher qualification levels, as per Abadie and Imbens (2002). Differences in exam score levels between treated and untreated schools in the periods prior to treatment are shown in Panel B of Table IId-3. These results were generated using the same method as for the Gauteng project.

The results for the SchoolNet project are very similar to those of Gauteng Online and Khanya. The estimated treatment effects are also relatively small in a practical sense and estimated to a good degree of precision. Again we see that none

Table IId-3: Estimated Effects of the SchoolNet Namibia Project

Dependent Variable: Junior secondary certificate exam results, overall and disaggregated by gender, normalized within years

	Panel Regressions			*Propensity Score Matching*		
	Total	Male	Female	Total	Male	Female
Panel A: Treatment Effects						
1 Year Post-Treatment	-.052 (.060)	-.026 (.065)	-.070 (.061)	-.058 (.119)	-.063 (.120)	-.055 (.118)
2 Years Post-Treatment	-.028 (.069)	-.046 (.076)	-.016 (.069)	-.013 (.140)	-.067 (.143)	.012 (.137)
3 Years Post-Treatment	.029 (.093)	-.027 (.107)	.045 (.089)	-.003 (.215)	-.029 (.232)	.010 (.199)
Panel B: Control Experiment						
1 Year Pre-Treatment	-.010 (.059)	-.031 (.066)	-.004 (.059)	.040 (.112)	-.063 (.120)	.038 (.114)
2 Years Pre-Treatment	.034 (.053)	.043 (.058)	.024 (.053)	.052 (.122)	-.067 (.143)	.015 (.123)
3 Years Pre-Treatment	-.070 (.048)	-.072 (.051)	-.053 (.050)	-.036 (.129)	-.029 (.232)	-.005 (.128)
Preexisting Trend	-.019 (.020)	-.026 (.022)	-.012 (.020)	--	--	--

* Significant at the p<.1 level, **p<.05 level, ***p<.01 level

Notes: Regression results are specified according to equation (6) and are robust to exclusion of schools for which observations in each year of the panel are not available. Matching is done using a nearest-neighbor method within circuits on teacher qualification levels; differences between matched treatment and control groups are reported. Regression standard errors are adjusted for clusters by school. Matching coefficients are bias-adjusted as per Abadie and Imbens (2002). Panel A displays estimated treatment effects, while Panel B shows differences in pass rates of treated groups in the years prior to treatment.

of the estimated coefficients are statistically significant at any conventional threshold. In the years prior to treatment, treated schools look similar on outcome variables to untreated schools both conditional on the regression controls and after pairing down the sample using a matching technique—none of the estimated pre-treatment differences are significantly different from zero. Additionally, the preexisting differential trend for treated schools conditional on the regression controls is relatively small and statistically insignificant.

Treatment Effect Heterogeneity

Possible treatment effect heterogeneity is an important consideration when a given treatment may affect portions of the treatment population in different ways. There is ample evidence in the literature that the provision of educational inputs to developing country schools can disproportionately benefit students based on their pre-treatment levels of achievement (Glewwe et al., 2007; Banerjee et al., 2007). If only initially high- or low-achieving students are affected by computer availability, and the effects of computer availability are relatively modest, then the average effect on all treated schools could still be small and statistically insignificant in the face of such heterogeneity in the treatment effect.

I am able to check for treatment heterogeneity based on pre-intervention student achievement among the schools in the Gauteng Online and SchoolNet projects. School-level achievement data are available for schools in Gauteng and Namibia prior to the inception of each area's respective computer deployment project, but such data are not available for Western Cape schools. To perform this analysis, I divided the schools along tertiles based on exam scores two years prior to the inception of their area's computer deployment project. This yields groupings of schools initially in the top higher third, middle third or lower third of the exam score

Table IId-4: Estimated Effects by Pre-Project Student Achievement

Dependent Variables: Exam results, overall and disaggregated by gender, normalized within years

	Gauteng Online			*SchoolNet Namibia*		
	Higher Third	Middle Third	Lower Third	Higher Third	Middle Third	Lower Third
Panel A: Treatment Effects						
1 Year Post-Treatment	.009 (.047)	-.003 (.082)	-.070 (.091)	.172* (.096)	.067 (.123)	-.181 (.126)
2 Years Post-Treatment	-.034 (.088)	.013 (.096)	.010 (.109)	.096 (.123)	.080 (.165)	-.215 (.144)
3 Years Post-Treatment	.011 (.046)	-.014 (.114)	-.168 (.123)	.172 (.149)	-.062 (.207)	.024 (.178)
Panel B: Control Experiment						
1 Year Pre-Treatment	-.016 (.044)	-.013 (.074)	.001 (.078)	.011 (.076)	-.034 (.134)	.004 (.122)
2 Years Pre-Treatment	.026 (.028)	-.108* (.056)	.038 (.067)	.076 (.130)	.029 (.116)	.020 (.078)
3 Years Pre-Treatment	-.048 (.042)	.058 (.062)	.028 (.060)	-.048 (.064)	-.123 (.104)	-.037 (.097)
Preexisting Trend	.006 (.010)	.019 (.018)	.000 (.027)	.018 (.029)	-.033 (.027)	-.007 (.042)

* Significant at the p<.1 level, **p<.05 level, ***p<.01 level

Notes: Regression results are specified according to equation (2) for Gauteng and (4) for Namibia and are robust to exclusion of schools for which observations in each year of the panel are not available. Regression standard errors are adjusted for clusters by school. Panel A displays estimated treatment effects, while Panel B shows differences in pass rates of treated groups in the years prior to treatment.

distribution. I then fit the regression models outlined in equations (2) (for Gauteng) and (6) (for Namibia) within each subset of schools. I also present a set of regressions comparing treated and untreated schools in the years prior to treatment, as I do above for the full sample of schools.

Table IId-4 shows the results for this subgroup analysis. Panel B of the table shows that within subgroups, treated schools are similar to untreated schools subject to the regression controls—only one coefficient in this panel is significant and only at the 90% confidence level. The estimated treatment effects of computer receipt across the distribution are mostly small and statistically insignificant. There is some minor evidence that initially higher-performing schools in Namibia may have moderately benefitted from the project; all the coefficients of having computers are positive and of moderate magnitude for this subgroup, and the estimated effect of computers one year after their receipt is significant at the 90% confidence level. The estimates are relatively imprecise due to the smaller subgroup size. In an attempt to improve precision, I estimated an alternate specification which collapsed treatment indicators into a single indicator variable which is turned on in every year post-treatment. This resulted in a smaller standard error of .079 and a coefficient of .137, yielding a p-value of .088—a result which is also moderately positive and only marginally significant.

IIe. Interpreting the Results

The most important aspect of interpreting the results presented in the previous section is considering potential sources of bias not accounted for in the models used. The Gauteng Province results are likely the most internally valid for several reasons. In Gauteng, schools were selected for the phases of the Gauteng Online project I examine in large numbers and at the provincial government level.

While there is clearly a strong selection bias, it would be difficult to make the case that the office within the GDE responsible for choosing schools into the project would have any substantial amount of intimate knowledge on the over 1,900 schools in the province. Additionally, the vast majority of school-level data used for planning purposes in Gauteng comes from the Annual School Survey and similar sources of data used in my analysis.

The selection method of schools into the Khanya project leaves more room for potential bias in the Western Cape estimates. For example, several WCED officials cited school management quality as a selection factor. While this was accounted for in my analysis, the data available on school management quality was fairly coarsely measured as the degree to which schools could spend their provincial funding autonomously. This was determined by the province according to management quality, with schools placed into one of three categories. However, district officials may have had more specific information on the quality of a school's management. Additionally, selection decisions in Western Cape were made at the district level rather than at the province level, and it is more plausible that district officials had some personal knowledge of these substantially smaller groupings of schools beyond the available data. This could lead to selection on unobservable factors which may not have been adequately controlled if these unobserved factors vary significantly over time. Another important factor to consider in interpreting the Western Cape results is that we do not have observations of preexisting trends before the inception of the Khanya project as with Gauteng Online and SchoolNet. This leaves us without an important check for differential trends related to treatment that are the most serious potential threats to validity throughout my analyses.

Validity threats specific to Namibia are also related to the selection of schools into the project. Especially problematic in the case of the SchoolNet project is that in some cases, schools influenced their own selection into the project by appealing to the NGO for inclusion. One would assume that there are unobserved school-level characteristics associated with whether a school applied to the project, and application is certainly correlated with selection. If these unobserved characteristics vary substantially over time, my estimates could be biased as a result. One could imagine a scenario in which some schools applied and were in turn chosen to participate in the project after a new principal took over school management who was very enthusiastic about the use of computers. The estimates would then include the effect of new school management as well as that of computers. It is impossible to speculate with a high degree of certainty about whether such factors would bias estimates upwards or downwards. I would argue that the more plausible assumption is that changes at a school making it more likely to seek additional educational resources would tend to bias student achievement upwards.

Despite some project-specific potential sources of bias, I believe we can infer with a high degree of certainty that, in the context studied, computer availability has no substantial impact on student achievement. Across all three of these relatively similar projects my results estimate that the treatment effect is never significantly different from zero.   The estimates across all three projects are relatively small and estimated to a good degree of precision using two very different methods of estimation. Using these same methods, treated groups in all three projects are statistically and practically similar on outcome variable levels and trends in the years prior to treatment.   We also observe that computer availability is not very likely to have significantly affected subgroups of schools when divided according to pre-project levels of average student achievement; the evidence that initially higher-performing Namibian schools improved as a result of the project is tenuous at best.

To compare my results to that of the only similar project studied in a developing country in the literature, the randomized evaluation by Banerjee and others (2007) found a large improvement of .47 standard deviations as a result of a computer-assisted learning project in India. These results were found after just two years of computer availability in schools. Had the effects of the projects I evaluate been anywhere near that level of magnitude they would have easily been evident in my estimates, even allowing for very substantial amounts of downward bias. This raises the question of why my results are so starkly different from those found in another developing country. I address this question in Chapter IV.

III. Analyzing Project Implementation

The previous chapter looks broadly at the effects of the Gauteng Online, Khanya and SchoolNet projects on student achievement and estimates that none of these projects significantly improved exam scores. A number of things could be driving this effect, however, and in this chapter I will use qualitative evidence to disentangle the different forces affecting computer use in these three projects' schools. First, I will examine the degree to which different aspects of project implementation may have facilitated or impeded the adoption of computer use within schools. I discuss these factors in light of the literature on organizational change and computer use in American schools reviewed in the next section. Section IIId then focuses on identifying specific mechanisms through which computer availability could influence the teaching and learning process, including ways in which computers may have had positive benefits that would not be reflected in the previous chapter's quantitative analysis.

By the conclusion of this chapter, I will have presented a clear view of the factors which influenced how successful each project has been at harnessing technology in an attempt to improve learning within its participant schools. With this established, I then turn my attention to Chapter IV, where I apply my analyses of the quantitative and qualitative data to reconcile my findings with the earlier literature and to discuss the implications of my results for policymakers.

IIIa. Implementing Technology Change in Schools

There has been little formal academic work done on the introduction of new technology to schools in developing countries, and the work aimed at examining under which circumstances such changes can be effective is especially scarce. Instructive lessons can be drawn, however, from literature on organizational change and studies of technology implementation among schools in the United States. This section will review the relevant literature, and subsequent sections in this chapter will use the literature as a lens through which to examine and compare the effectiveness of the Gauteng Online, SchoolNet and Khanya projects. I will first focus on studies which are generally relevant to the implementation of change in organizations and then discuss three studies which examine the specific case of implementing technology change in schools.

Kanter and others (1992) outline the importance of dynamics between implementers and end-recipients in efforts to bring change to organizations. In the projects I study here, many implementation decisions were made by policymakers far removed from the schools, although teachers were expected to use the new technology in the end. This essentially creates a principal-agent problem, where those making decisions about the nature and structure of educational interventions are likely to have different motivations and incentives than those who are ultimately responsible for implementation. According to the authors, "for more effective change efforts, it usually makes sense to include recipients among the implementers and strategists" (Kanter et al., 1992, p 16). This claim is reinforced by Kanter's 1983 study , which found that change with support at the grass-roots level of an organization is generally more successful than change rigidly enforced top-down. The degree to which the three projects succeeded in eliciting support from teachers and principals should therefore play an important role in determining both the level and effectiveness of computer use at recipient schools.

Another important factor in the take-up of computers is their effect on existing routines within the school context. Argyris (1985) argues that interference with existing routines is a potential source of resistance to change efforts. When such routines or the status quo within an organization are threatened by change, individuals will tend to act defensively. According to Argyris, this defensive reaction also often leads to behavior which is counterproductive to such change. Kanter (1985) asserts that routine disruption is due in part to the “costs of confusion” imposed by workplace changes. Routines are especially problematic for the adoption of new technology, as they serve to create a “self-reinforcing cycle of stability” around existing technologies and methods (Edmondson et al., 2001). Teachers who are expected to integrate computer use in their lessons and are unfamiliar or uncomfortable with such integration may be major sources of resistance to change. The same would be true for principals or other administrators hesitant to change school-wide schedules and routines to better accommodate the use of these new educational resources.

Kanter outlines many other reasons that change recipients may come to resist change. Three of these are especially relevant to the context of computer use in South African and Namibian schools: concerns about competence, “loss of face” and an increased workload. Kanter points out that change recipients often express concern about competence in their roles after a change is implemented. Many teachers and administrators had little to no personal experience with computer use until the machines were installed at their schools. This could clearly be problematic to adoption of change if these individuals did not feel prepared to use computers with their students. A related problem is what Kanter refers to as “loss of face” resulting from change implementation—the fear of appearing unskilled in computer use before one’s peers or students could lead teachers to avoid computers altogether. A final point of Kanter’s work which is important to consider is the simple increase in work and energy demanded from change recipients during the implementation process. Learning to change one’s teaching practices and use new technology requires effort and time that some educators could be unwilling or unable to dedicate.

The literature on organizational change also demonstrates that changes specific to the implementation of new technologies pose challenges related to knowledge and its transfer within organizations (Attewell,1992; Moreland, 1999). Personal technical knowledge is the most obvious example of this, but access to such technical knowledge through social networks has also been demonstrated as extremely important, including within the school context. Frank and others (2004) show that, controlling for personal technical skill, social access to a high-skill colleague is a very strong predictor of computer use among teachers. This suggests a potential difficulty in achieving high levels of computer use in developing country schools where levels of technical skill are generally very low for all teachers. Without reservoirs of knowledge within their schools to draw upon, teachers in developing countries will be especially dependent on outside sources of knowledge, such as formal training.

The work of Larry Cuban (2001) on the adoption of computer use for educational purposes in American schools confirms many of the potential implementation problems discussed above. His book's title—*Oversold and Underused*—indicates the running theme throughout his findings—that computer use has been generally low across the board for schools in the United States. Cuban points to the principal-agent problem discussed earlier as a major factor—school boards often push for computers to be adopted in schools as a signal to communities that students are being provided with the most advanced educational resources. The role of teachers in facilitating use of computers is often an after-thought, according to Cuban, and they therefore have little personal or professional investment in using the computers once they turn up in classrooms. The end result is what he terms "token compliance"—computers appear in the classroom to technically comply with edicts from above, but they are rarely if ever used by teachers. The result is that no meaningful change occurs in the teaching and learning process.

Cuban also cites teachers' traditional work routines as limiting their computer use in the classroom. Even teachers considered to be among the most effective computer integrators in the schools he surveys only made very small changes to their teaching practices in response to computer availability. In another work, Cuban (1986) looks more broadly at several education technology interventions over the past several decades and concludes similarly that they only resulted in marginal changes in typical classroom teaching, and even then only for some teachers. In general, no piece of educational technology—from radio to television to computers—"revolutionized" teaching in the ways many education policymakers initially expected each to.

Finally, Cuban also partially attributes low levels of computer use by teachers to a series of smaller-scale, more practical issues that typically are not sufficiently addressed by implementers. Teachers cite a general lack of both personal and class time to plan and implement computer use with their students. Additionally, many cite a lack of training offered to them by their schools. Accessibility and technical issues also create barriers to successful and widespread computer use—lack of useful software, equipment shortages and long turnaround times for equipment repair pose problems in many schools.

The literature outlines a number of difficulties in implementing change within schools in the form of new technology use. In order to examine the degree to which these factors presented in the literature are relevant to the context I studied, I collected data from schools participating in the Gauteng Online, Khanya and

SchoolNet projects. Since teachers were the major recipients of change, the bulk of my data was collected through direct interviews with teachers. I discuss my methods of data collection in the next section, and the subsequent section discusses these data in the context of the literature I have reviewed.

IIIb. Methods of Data Collection

I collected the data used in this chapter through interviews and classroom observations conducted at schools participating in each of the three projects. I developed a semi-open interview protocol which was used with all the teachers I interviewed. Teachers were asked questions regarding methods of computer use, benefits and drawbacks of that use, personal attitudes toward computer use and their respective computer deployment project, perceptions of colleagues' attitudes toward computer use, perceptions of students' attitudes toward computer use, benefits and problems surrounding the use of computers and any computer training received by teachers. I also conducted interviews with the principals at every school visited regarding the general use of computers at their school. Finally, two to three computer-aided lessons were observed at different schools per project. As I collected all of these data between the months of July and November 2007, they are not necessarily indicative of conditions over the life of the projects.

In Gauteng, I interviewed a total of 13 teachers at 6 different schools. Schools were selected so that the sample would represent a diverse cross-section of all schools in the Gauteng Online project. Two schools were chosen from among the bottom third of senior certificate examination pass-rates, two from the middle third and the final two from the top third. No two schools were from the same educational district in the province, of which there are 12 in total. The majority of schools had predominantly Black student populations, which was representative of the total population of schools selected for participation in Gauteng Online. One school had a majority Coloured population while another had a majority White population with a substantial Black population. Five of the schools were secondary schools and one was a combined school. Provincial education officials familiar with the Gauteng Online project were also interviewed to collect information on some of the more logistical aspects of the project, such as training services and technical support.

I visited six primary schools participating in the Khanya project in Western Cape province and 11 teachers were interviewed in total. These schools were spread throughout 6 of the region's 7 education districts—three were located in the Cape Town metropolitan area and 3 were located in or near large towns in rural areas. The demographic make-up of each school's student body was overwhelmingly Black and Coloured. Khanya project staff consisting of district coordinators and school facilitators were also interviewed regarding overall logistical support of the project as well as their personal roles in supporting individual schools.

Selection of Namibian schools focused on the north-central region of the country, which was also the focus of SchoolNet's computer lab deployments. I interviewed fifteen teachers at five different combined and junior secondary schools. Four of the schools were selected from rural areas and large towns across the north-central region while the final school was located in the capital city of Windhoek. The student body in each school was made up nearly exclusively of Black students. Interviews were also conducted with current and former SchoolNet staff members. I also present data from a survey I developed and administered to each school with Grade 10 students which received SchoolNet computers between 2000 and 2006. This is the same sample of schools used in the quantitative analysis in Chapter II. My survey's questions focused on the various ways in which computers were used at each school and yielded a response rate of 98 percent. Logistical and time constraints prevented me from surveying schools participating in the Gauteng Online and Khanya projects.

IIIc. Factors Affecting Successful Computer Use

Technical Factors

Technical factors related to computer use played a very significant role in the projects I study, and appear to be more significant for these projects than the literature would suggest for developed countries. Cuban (2001), for example, cites technical factors as limiting teacher use, but they are primarily treated as secondary concerns. In the South Africa and Namibia projects, however, such factors appear to have been extremely important determinants of project take-up within schools.

Access to technical support is the first and perhaps most obvious of these factors. The ability to secure quick, reliable services for repairing damaged computers and troubleshooting software problems varied substantially across schools and between projects. Schools in the Gauteng Online and SchoolNet projects appeared to be most adversely affected by such issues. One teacher in Namibia complained that the combination of long support turnaround times and the inability to deal with simple technical problems at the school level were constant challenges for his school; "small problems become large problems here… we are not trained on fixing even little things, and so we must [always wait] for SchoolNet."

The results of my survey, which only included SchoolNet project schools, yields a more complete picture of the pervasiveness of technical problems in Namibia. Only 46% of schools reported that all their computers were functioning at the time of the survey, and 23% of schools reported that at least a quarter of their computers were non-functional[6]. Teachers universally expressed their frustration

[6] The downtimes reported do not appear to be exclusively of computers that are broken for very long periods of time. In a survey that took place the year prior to mine, the Namibian Ministry of Education

with often not being able to use a large proportion of their already low computer resources. The uncertainty associated with frequent downtimes can also exact its own toll on computer use. In the words of one teacher at a Gauteng Online school,

> You never know if they will be functioning on that day you want to use them… many teachers have become so frustrated by the [outages] that they are now avoiding the computers completely.

In Gauteng, major technical support issues appeared to be less widespread but still significant. Another teacher described her especially difficult time trying to secure repair services for the school's server,

> I first called GautengOnline and they sent a technician, but the problem returned after two weeks. It was repaired once again but then broke for the third time around a month later. After that they were much more hesitant to come… we were dealing with the problem for almost a year.

This school eventually hired its own technician to perform the necessary repairs. The teacher later added that a school with fewer resources or in a more remote area would not have been able to resolve a similar problem on its own. Two other schools in Gauteng reported technical problems that had at least moderately limited computer use that school year.

In contrast, none of the Khanya project schools that I visited reported any significant technical problems that persisted for more than a few days. There were a few differences in how Khanya managed technical support that may account for this difference. Khanya was unique among the projects I study in that it assigned a facilitator to each of its project schools. Facilitators are each personally responsible for overseeing a small group of Khanya schools. These facilitators check-in with

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collected data on the number of non-functioning computers at its schools and received responses from 87% of the schools that I survey. Schools in the common sample reported a mean 19 percentage point change in the amount of non-functioning computers. There was evidence of a downward trend in functionality; the overall proportion of broken computers rose 6.2 percentage points from 2006 to 2007.

schools regularly, and part of their job involves following up on technical issues. Additionally, Khanya's technical support services were de-centralized by district, and in some cases Khanya's district coordinators even worked with groups of nearby schools to create technical support partnerships with local IT businesses. Finally, unlike in Gauteng, repair services were run through existing support services of the provincial government rather than an outside contractor. Khanya's staff often personally knew the individuals responsible for technical support in their schools' area, and in practice it seemed that this allowed Khanya to more carefully exert quality control in its technical support.

A second problem faced by many schools was that they saw their use of computers limited for financial reasons. The most significant example of this was regarding internet access in Namibia. While Khanya and Gauteng Online were in the financial position to provide internet at no cost, SchoolNet charged each school a flat monthly rate of 300 Namibian Dollars (USD 44.12)[7] for access. The two Namibian schools I visited without internet access expressed strong desire for it, saying it would make the computers "more useful to the school and to the learners," but explained that the school management had decided it was too costly. Schools with internet access universally expressed satisfaction with its availability, with teachers claiming that "it shows our students there is a world beyond [our village]" and that "teachers have access to up-to-date resources for the first time." Poorer schools in Namibia thus seemed limited in at least this dimension of potential computer use as a direct result of the lack of community resources.

There were also miscellaneous technical problems that affected schools on an ad hoc basis that were not remedied for financial reasons. In Western Cape, one

[7] I use the exchange rate 1 Namibian Dollar (NAD) = 1 South African Rand (ZAR) = 6.8 United States Dollars (USD) throughout this thesis, which reflects the approximate average exchange rate in 2006.

teacher reported that she and her fellow teachers complained to the school management about lack of software for certain topics but were told the school could not afford to purchase more. In Gauteng, one school could not afford to augment the electrical supply to its computer lab, so only 16 of its 30 computers could be used without tripping the circuit breaker. In Namibia and Gauteng, teachers complained that they were limited in printing computer content to use in their classes because toner cartridges were too expensive. These issues are indicative of a larger problem that while project-implementing agencies made many of the up-front investments in computers, schools had trouble dealing even with the relatively small costs associated with their upkeep. Such problems reveal underlying sustainability issues associated with computer use. They also demonstrate that despite the donation of equipment, computers were not "free" for the school—soon after the receipt of computers, administrators were confronted with the decision of diverting very scarce funds to maintain and augment computer resources.

The third important technical issue is that of security. Theft was a problem for schools participating in all three projects, however some were affected more than others depending on their location. Gauteng Online schools were by far the most adversely affected by crime. In addition to the six schools I visited in the province, I contacted two which told me not to bother coming—all of their computers had been stolen. GDE staff members cited this as one of the biggest problems they faced in the project and reported that a substantial amount of their budget was dedicated to replacing stolen computers. SchoolNet and Khanya schools were not as seriously affected, but computers did make the schools targets for criminals—I visited one school in each project which had experienced the theft of several computers. The Namibian school's computers were never replaced since the school could not afford the expense. Khanya encouraged its schools to purchase theft insurance, however, so the Western Cape school's computers were replaced fairly quickly.

While the effects of outright theft are self-evident, student vandalism was also an internal security issue that affected several schools. Some teachers and administrators complained that their students would damage the computers when allowed into the computer lab. As one teacher in Gauteng explained,

> You have to watch the learners very carefully during your lessons [in the computer lab]. We are lucky after each day if only something small is broken. Many of our earphones are [no longer] working and the learners cannot use some software where they are required.

Vandalism affected use both directly through damaged equipment and indirectly since administrators and teachers expressed more hesitation to bring students into the computer lab when they expected vandalism to be a significant risk.

Software and Internet

The role of software and internet is unique among technical factors in that it both affected schools' level of computer use and also significantly shaped how teachers used computers with their students. In this section I will restrict my discussion of software and internet to their effects on take-up of computer use within schools. Section IIId will focus on how these factors influenced the ways in which computers were used by schools.

Software and internet served two major functions across all three projects: as a source of classroom activities and as a source of educational content. The internet falls largely into the former category as it gave teachers access to a virtually unlimited quantity of material relevant to their work. Some types of software also served as a source of content in that they provided educational information organized according to the established curriculum. This had an added advantage over simple internet access in that the content was typically more comprehensive and in a format more useful to teachers. Some software also had specialized activities that allowed students to practice and reinforce certain skills and competencies.

In Gauteng, all schools had high-speed internet access, but teachers expressed frustration with the lack of useful software for some subjects and the inability to add new software to their lab's computers. Little software specialized for educational purposes was provided by the Gauteng Online project. The reasoning for this provided by project decision-makers was that the government had designed an "E-learning Framework" which guided schools in their use of computers and internet as learning tools, and this framework provided for use which was independent of specific educational software. Security restrictions on the system also prevented the installation of any additional software. Gauteng Online project staff explained that this was done for a variety of reasons, including ease of technical support and to maintain equity between schools. One teacher recounted his frustration with the arrangement,

> The education department sent me to a subject training for accounting, and there they introduced us to a software useful in our accounting classes… when I tried to put it onto the Gauteng Online computers I was unable because of the security… the GDE was giving me software, but I could not use it on the computers the GDE provided us.

The Khanya project similarly offered high-speed internet to all of its schools, and also made a wide array of educational software available which included both content software and software-based learning activities. When Khanya began deploying a computer lab to a new school, a project staff member would consult with the school management on the range of software available and help the school decide for itself which to purchase. Khanya also had staff members design its own computer-based content that fit the South African curriculum. As a result, principals and teachers generally expressed satisfaction with the software available to them. The only source of frustration reported was in one case when a school could not afford to purchase additional software for a certain subject. One teacher offered this example of how she found the software relevant to her lessons,

> If I talk to them in the classroom about a number line, then maybe I will take them into the computer lab and the program will show them a number line. The number line will be missing some places…. The learners must be able to complete the number line on the computer screen so they [better] understand [the topic]….

Namibian schools were typically equipped with software which focused on providing educational content and also included some learning activities. Teachers generally expressed satisfaction with the software available. My survey also indicated that two-thirds of the schools had internet access. Lack of access to internet was by far the most cited source of frustration by teachers in Namibian schools, and in many cases internet was unavailable because schools could not afford the associated monthly service fee. Teachers at schools where internet access was available often expressed frustration with the slow speed of the internet connection.

Human Factors

Cuban's (2001) study of computer use in American schools provided the only basis for comparison in the literature regarding the effect of technical factors on computer use in the schools I study. There is a much broader body of literature, however, relevant to the human and organizational implications of introducing new technology into schools. In this section, I will draw from the framework developed in the literature to provide an outline of the human factors most important to computer implementation in Namibian and South African schools.

Perhaps the most substantial of the human factors in these projects is that of teacher training. In general, South Africa and to a greater extent Namibia are characterized by low levels of computer literacy in the population. Teachers are no exception, as the vast majority in service today do not use computers in their households and have little to no formal computer literacy training or experience with computer use. This is especially true of schools in poorer communities which were a focus of all three projects.

Each program offered its own method of formal training for teachers. SchoolNet placed out-of-school youth with good computer literacy skills at new project schools for two to three months. New Gauteng Online schools were offered a 16-hour training course for all teachers plus a 16-hour more advanced course for two teachers per school. The Khanya project followed a similar model of fundamental training for all teachers and more intense training for two "LAN administrators." Khanya, however, also included extensive follow-up in-classroom training by project facilitators for up to one year after initial training. The different strategies had dramatically divergent impacts on teachers' confidence in using computers and in turn on overall within-school use.

Teachers in Namibia and Gauteng complained about training availability and quality in substantial numbers. The phrases "very basic," "too limited," "not satisfactory," "not comprehensive," and "just an introduction" were each used by teachers at different schools in both projects when asked to describe the project's training quality. Teachers often linked lack of confidence in computer use to a hesitation toward using computers with their students. According to one Namibian teacher,

> My colleagues who have difficulty using the computers… they do not use [computers] much with the learners…. The SchoolNet trainer only

> showed us basics and [my colleagues] do not practice on the computers as I do.

We see that much as in Cuban's (2001) work, lack of training plays a substantial role in reducing computer use at schools. The extent to which a large majority of teachers focused on training issues in their interviews suggests that in developing countries this is likely a more significant factor than in the United States.

The Khanya project showed remarkable success in addressing the issue of teacher training. "Khanya taught us what we needed to know to use the computers properly," commented one teacher in the Western Cape, and many others shared this sentiment. A Khanya facilitator described her role as "working with every teacher in my schools until they are comfortable teaching a class in the [computer] lab," and added that she would often join teachers during their first lessons in the lab. While the training support in Gauteng and Namibia would end completely after a period of a few weeks, Khanya training would last for a year and training support would continue long afterward. "Every project school still has a facilitator assigned to be the face of Khanya at that school…. We check in on our schools every week or two and review the usage logs," commented one Khanya facilitator. This disposition toward long-term training support was reflected among the Khanya interviewees. Teachers at one school expressed dissatisfaction over high facilitator turnover in its particular district; otherwise, sentiments toward training were positive and teachers said they and most of their colleagues were generally comfortable with computer use.

A final dimension of training worth considering is the effect of computer knowledge already available within schools. The work of Frank and others (2004) discussed earlier would predict that the availability of just one teacher with substantial computer literacy should lead other teachers to gain from their colleague's knowledge and use computers more themselves. There was some evidence for this. As one teacher commented, "I am not confident enough yet to [use the] internet with learners. I need to practice with Mr. Banay first to learn more." This school, however, had received its computers nearly two years prior, which suggests that learning computer skills through colleagues is at best a very slow process. At one other school, the two teachers who had received more advanced training initially offered training workshops for other teachers after school, but interest for these diminished after a few weeks. In general, teachers with more advanced computer skills did report some instances of offering help for specific problems, but never anything that could be construed as substantial training.

Why do computer skills not diffuse more successfully to teachers within these schools, which are typically characterized by very small faculties? The answer in the schools I studied is related to another human factor important to successful computer deployment—teacher attitudes. Drawing on Kanter's (1985) framework, there are some reasons why teachers might be initially resistant to a change such as the introduction of computers—fear of competence in their post-change roles, "loss of face" at seeming inexperienced or unknowledgeable, and the extra effort needed to adapt to the change. At schools where the overall level of computer skill among the staff was low, each principal could still name a handful of teachers on her staff who used computers very frequently with their students. These teachers often described to me an enthusiasm and natural curiosity toward computers. Their combination of strong enthusiasm and initial attitudes led them to take what little training they had and make the personal effort to adapt computers into their teaching.

For many teachers, however, this was not the case. One Namibian teacher explained, "Some of my colleagues are afraid to use [computers]… there is nothing to fear, but they have not made the effort to try…." Another teacher in Gauteng commented, "…if [teachers] have an interest [they] will come practice computers on their own… many say that they are already too busy." In an environment where computer use was left largely to each teacher's own initiative, some took enthusiastically to the new teaching tools while others' initial hesitation to change led them to avoid computer use.

Motivating computer use by teachers who were not initially very enthusiastic about it thus was an important challenge for the three projects I study. This is where within-school leadership came to play a critical role. Proper leadership raised overall levels of technology use within the school by acting to motivate all teachers—even those initially hesitant. The most obvious source for such leadership was from those in formal positions of authority within a school. At schools where the principal extolled to me the benefits of computer use for education or proudly brandished the school's computer lab timetable, teachers reported they were encouraged by school management to use computers and that such use was adopted broadly among the faculty. One Western Cape teacher put it quite succinctly, "We all use computers with the learners… it is part of the school policy."

Leadership from more informal sources proved just as important, however. One school in Gauteng hired a recent Grade 12 graduate to assist in supervising the computer lab, who explained,

> When I began here I knew some teachers [were] not good at [using] the computers… I gave these teachers extra practice, showed them how to type assignments, and told them to bring in their classes…. Now many are using the computers more.

The most substantial source of leadership across all the schools I visited was that of Khanya's facilitators. Since many worked with the schools they were assigned to for months and even years, they typically built a good rapport with teachers. Several

Khanya facilitators explained that they would spend extra time working with teachers who were most uncomfortable with or resistant toward computer use. Whether an enthusiastic school aide or project facilitator, any force of collective motivation within the school was associated with much higher use of the available computers; such a force propelled initially resistant teachers to make the effort of using computers with their students. Without this source of motivation for teachers, however, schools had a hard time living up to their potential levels of computer integration.

Organizational Factors

The literature reviewed earlier in this chapter predicts that organizational factors should play an important role in the success of computer implementation efforts. I will focus here on two issues. The first is the principal-agent problem discussed by Kanter (1992) and Cuban (2001). I will also discuss the importance of interfacing computer use into schools' existing routines, which Argyris (1985), Edmondson and others (2001) and Cuban (2001) all suggest should be an important aspect of implementing such change.

The motivation for computer availability in schools in both Gauteng and Western Cape was largely top-down. Both projects were initiated by the provincial governments, and both were driven by the goal of using computers to enhance education by integrating their use with teaching across the curriculum. This project-level goal was often in conflict with schools' first instinct of how to use their new computers. "At first we were using the Gauteng Online lab for [Computer Application Technology] classes… [however] Gauteng Online told us that we must use the lab for all subjects," said one principal. This was indicative of a sentiment expressed by several principals, many of whom wanted to use computers solely for teaching computer literacy when they first arrived. But this misalignment of initial interests did not appear to cause the "token compliance" Cuban describes in American schools' adoption of educational technology. While teachers and administrators did suggest that they would like to use computers in ways different than planners intended, they were generally excited to be included in these projects and therefore fit their use to project parameters. Since schools ultimately accepted the use of computers as dictated by project implementers, the initial misalignment of intentions did not seem to significantly impact implementation success.

In Western Cape, implementers worked with schools to involve them in the implementation process in a way not seen in Gauteng. Principals were included in the selection of educational software, and schools were asked to make small contributions to give them a sense of ownership over the project. In the words of one district coordinator, "In my presentations [to the school leadership] I tell them, 'Even if you just bring beer and we bring champagne, at least you've come to the party.'" Throughout the schools I visited in Western Cape, principals and teachers always spoke favorably of the Khanya staff working with their schools. Schools often praised the close relationship with their assigned Khanya facilitator, and many schools even commented positively on the work of the Khanya coordinator for their education district. The initiative on the part of Khanya to actively involve schools and tailor labs to their needs has left teachers and administrators with a very favorable impression of the project and its work.

Namibia's SchoolNet project had a different set of goals from that of Gauteng Online and Khanya. It did not direct schools to use computers solely for classroom instruction but rather provided computers as a resource to be used by schools at their discretion, with the expectation that students should have regular access to the computers. In this way, schools were by default given some of the decision-making power in the implementation process, diminishing any potential tension between the wishes of change implementers and recipients. The result in Namibia was substantial diversity in schools' use of their new technology. While 82% of schools report student computer use during subject classes or after-school, they also report substantial amounts of computer use for student computer literacy training and internet-based research as well as administrative purposes.

SchoolNet's relatively hands-off approach in prescribing methods of computer use was significant for other organizational reasons as well. By allowing schools to decide for themselves how to use their new equipment, teachers and principals could find the best fit for the application of educational technology into existing school routines and practices. Nearly a third of schools opted against in-class use altogether, most choosing instead to offer students computer access after school. One principal explained his choice to focus on after-school use in this way: "Asking teachers to bring students to the computer lab is very disturbing to the class schedules," adding, "teachers are accustomed to their classrooms." This is consonant with some of Cuban's (2001) findings—teachers grow comfortable teaching in their classrooms and often hesitate to substantially change their traditional routines and practices around the use of a new technology.

The Khanya project's approach offers a marked difference with that of SchoolNet. We have seen that Khanya, through its facilitators, was very hands-on in reaching out to teachers and administrators and shaping their use of computers. Khanya schools were required to have a timetable for computer lab use. This ensured that the school's resources were used to their fullest potential, but more importantly built computer use into the routine of the school. Through in-class training, facilitators helped teachers adapt their teaching style when in the computer lab with their students. Both the school's macro-routine in the form of its schedule and teachers' micro-routines within their classrooms were adjusted around the regular use of computers. This was obviously much more resource-intensive than SchoolNet's approach, but there were two substantial benefits; Khanya appeared to achieve higher levels of computer use and that use was better integrated with classroom teaching and curriculum delivery.

In summary, a variety of technical, human and organizational factors played an important role in determining the level of computer use take-up between projects. Technical factors appear to have been much more significant determinants of project success in South Africa and Namibia than Cuban (2001) finds in the United States. This is perhaps because of the relative lack of resources available to the schools I study, and the difficulty of providing services such as technical support in a developing country. The significance of human factors was fairly consistent with what the literature would suggest; there is substantial evidence that teachers' concerns surrounding the implementation of these new teaching technologies may have created a general hesitation to use computers. Human factors were also very difficult to overcome; only in Western Cape did teachers seem generally satisfied with the training they received, and Khanya typically offered a year or more of training support. Finally, while organizational factors did demonstrate the potential to cause substantial implementation difficulties, these difficulties seemed relatively straightforward to overcome. To take the example of Khanya again, simply building computer use into a school's timetable helped incorporate such use into institutional routines.

IIId. Mechanisms Through Which Learning is Affected

The previous section helps paint a picture of which factors affect computer deployment project success. Throughout, I treat project success as the degree to which teachers use computers with their students. The ultimate goal of all three projects I study, however, is to positively impact the quality of learning. In this section, I consider evidence on possible mechanisms through which computer availability could affect student learning. First, I discuss how differences in software and internet availability between projects interact with schools' environments to shape computer use. I then discuss mechanisms through which computer use might adversely affect student achievement in the short-term, and finally turn my attention to possible longer-term effects of computer availability.

Software, Internet and School Characteristics

As discussed in the previous section, the Gauteng Online, Khanya and SchoolNet projects varied substantially in their approaches to deploying software and internet to their participant schools. Gauteng Online provided internet access without much specialized educational software, Khanya provided both internet access and specialized software, and SchoolNet provided low-speed internet to schools on a fee basis as well as some specialized software. The ways in which software and internet availability shaped computer use were determined in part by other school characteristics.

One consistent form of use across all three projects was the use of computers as an instructional aid—a tool for delivering typical classroom lessons. This type of use was the stated focus of the Gauteng and Western Cape projects as well as a major reported use of SchoolNet-provided computers in Namibia. Most of the computer use across all three projects involved a teacher taking his class into a computer lab during the school day with a specific plan in mind for using the computers to deliver a lesson. The ways in which teachers were able to do this varied between projects, however, depending on the type of resources available through their schools' computers.

Gauteng Online schools' general lack of specialized educational software left them to draw most of their resources from the internet and the digital encyclopedia on the computers. Much of the in-class use in the schools I visited was characterized by research on the part of students under the supervision of teachers. Teachers would often have previously chosen a topic from the curriculum for which they knew information was available on the internet or digital encyclopedia. Students would then be brought into the lab with the goal of finding information on the given topic.

The availability of more specialized software in Western Cape allowed teachers to shape their use of computers in a different way. Teachers in Khanya schools tended to use computer lessons as an extension of classroom lessons. Students would often be presented with new material and were then given the opportunity to practice it using computer-based assignments. Thus, in Western Cape computer use was more often an extension of the sort of teaching that would be found in a typical classroom setting. With ample educational software relatively tailored to the curriculum, teachers could often find activities specific to most areas of their subject's curriculum.

Many Namibian teachers used computers in a way similar to Gauteng Online schools—students would be brought into the computer lab as part of a lesson and supervised by their teacher as they searched for information on a specific topic. A much different mode of computer use also emerged which was unique to Namibian schools, however: many teachers began utilizing computers to find content they could use in the traditional classroom setting. This use resulted from a lack of other educational resources within Namibian schools, which was not a problem for their counterparts in Gauteng and Western Cape. Updated textbooks can often be a very scarce resource in the poorer and often remote Namibian schools typically served by SchoolNet. As a result, computer software and the internet became much more important as sources of curriculum content among SchoolNet schools, relative to schools in the other two projects. Several Namibian teachers reported that they appreciated having computers available because it allowed them to present curriculum content not otherwise available to them through other sources. These teachers would typically find information via content software or the internet and use it to form the basis of a classroom lesson taught without the aid of computers.

It also seems that there are important differences in computer use between primary and secondary school students. In Namibia and Gauteng, where I focus on schools with secondary grades, teachers and principals frequently reported that students were allowed to use the computers independently during breaks or after school. Among Western Cape's primary schools, students were always supervised while they used the computers, and none of the schools I visited reported use outside of normal class time.

Short-Term Effects on Learning

The ways in which schools used computers for educational purposes across the projects I study can be grouped into three broad categories. All three used computers as an instructional aid, although this took on a somewhat different form from one project to the next. In Namibia alone computers were used by teachers as a content outlet in the absence of other adequate curriculum materials. Finally, in Gauteng and Namibia secondary school students used the computers independently for significant amounts of time during school breaks and after classes.

Each of these modes of computer use could plausibly impact student achievement, and their effects would likely appear in a relatively short amount of time. It seems, therefore, that none likely had a major effect on education quality as measured by exam performance when considered in the context of the results in Chapter II. We can be especially confident of this inference with regard to computers as a classroom teaching aid since this was a major use in all three projects. While implementation issues in Gauteng and Namibia discussed earlier could plausibly be at least partially responsible for the lack of observed impact, such issues were not a major impediment in Western Cape.

Negative effects of computer availability on student achievement are not entirely implausible. It is important to consider the possibility that computer use may have benefits which are offset by its initial drawbacks, leading to a net zero effect on short-term student achievement. The most substantial mechanism for short-term negative effects is related to computer literacy levels of students, which universally were very low prior to computer availability at school. This becomes a potential problem when the focus of computer use is for classroom instruction. Since students have difficulty with the basic operation of computers—especially early-on in their introduction to a school—this results in teachers taking substantial amounts of class time to teach students how to perform tasks such as logging in to the computers. I observed one 45-minute class in Western Cape where students were using computers for the first time. Twenty minutes into the class the teacher was showing students how to double-click and log in. Thirty minutes into the class, only a small number of students had managed to log in. By the end of the class a minority of students had been able to successfully open the program their teacher intended to use with them during that class.

Even after many sessions of computer use, these technical problems tended to persist. Observing a class that had used computers many times before, some students still had difficulty with aspects of operating the computers. Small technical problems also kept students from benefitting from the lesson for a substantial portion of class time as they first struggled with their problems and then waited for their computers to restart. Students who had learned the fundamental skills necessary to use computers with ease and had managed to avoid technical issues of their own also suffered; much class time was lost at the start of their class as everyone logged in and the teacher struggled to address the technical problems of others.

The previous section describes how schools' extent of computer use was limited when they could not afford to replace a printer cartridge, purchase software or repair damaged machines. It is also important to consider the impact on schools with very limited financial means that did decide to bear the costs of sustaining computer use, diverting funds from other uses. This could lead to a net increase in learning if computer use was more effective than the other activities which had their funding cut. However, schools may have diverted resources from higher-return uses if they felt pressured to maintain their computer lab. This may have been the case in Gauteng or Western Cape where there was a clear perception by schools that computer use was being prioritized by the provincial governments. Even if school managers judged that computer maintenance funds would have been better spent on other activities, worries about how their school might be perceived by higher-level officials had it not attempted to maintain its computer donation may have led to inefficient resource allocation decisions.

Longer-Term Effects

The qualitative data suggest several ways in which computer availability may have desirable long-term effects, despite the lack of an observed effect on short-term student achievement. One of these is the impact of computer availability on distance learning and professional development on the part of teachers. In Namibia, every school I visited reported that at least a handful of teachers were using computers to take distance courses. No schools reported this in Western Cape, and in Gauteng this was the case for only one teacher. This discrepancy is likely due to the fact that Namibia's schools, which are mostly in remote areas, have substantially less access to institutions of postgraduate education than those in South Africa. Computer availability may offer opportunities for teachers in more remote schools to upgrade their skills and formal qualifications, which would not otherwise be possible. This may not have a very large short-term benefit, but could affect learning outcomes in the medium- and long-term.

The way in which access to professional development activities in more remote schools could affect learning is ambiguous. The natural assumption would be that such access would lead to longer-term learning gains as teachers improve their skills and in turn are more effective at educating their students. Another possibility is that the accumulation of formal qualifications via distance learning makes little difference in teaching ability. This could lead to a net loss in education quality as the government is now obliged to pay these teachers at higher rates from education funds that would presumably earn higher returns elsewhere. Greater access to distance learning for teachers in remote areas could also lead to a draining of more motivated teachers from remote schools as they become better able to compete for sought-after jobs in larger towns and cities. It is not possible to determine with the data I have available which of these possible scenarios is true in reality.

Finally, the projects I study may have taught students skills which do not raise exam scores in the short-term but which nevertheless have practical value. The most obvious such benefit is that disadvantaged students learn basic computer literacy skills which could provide them an edge in the job market after leaving school. Each teacher I interviewed was asked to name the single most significant benefit of computer availability at their school; the majority answered that it was the opportunity for their students to learn how to use computers. One Namibian teacher reported,

> Computer skills were more helpful to my learners than their Grade 12 certificate. Nobody had high [enough] marks to start at [any Namibian tertiary institution]…. I know two that are working with computers…. [One as] a lodge receptionist and [the other with] a local IT company.

Another Namibian school principal mentioned that some students had asked for letters from the school certifying their computer literacy, to use when seeking employment. Both of these schools were located in or near larger towns.

In Gauteng, teachers offered similar evidence of an impact on students' employment preparedness. Some also cited an impact on students' access to information about post-graduation opportunities. "The Grade 12s are always researching courses, universities, scholarships. It helps them to determine what they will do after [leaving school]," says one Gauteng teacher. In South Africa, many opportunities exist for high school graduates but disadvantaged schools often do not offer guidance counseling services. Computers with internet access provide students with a way to access such information which was previously very difficult to find.

The case of Namibian teachers' professional development and students' access to important basic technical skills and information about postgraduate opportunities indicate an important *indirect* effect of computer availability. Both are examples of computer availability disproportionately benefitting disadvantaged students and communities. Teachers in more remote Namibian schools benefit from professional development opportunities which are more easily accessed in towns and cities, and students in schools without formal guidance counseling resources benefit most from information available through the internet. In both of these cases computers serve to democratize information availability—more disadvantaged schools differentially benefit from information obtained through computers because they have less access to information through other means.

Finally, many teachers across all three projects reported that students were noticeably more motivated about their classes when computer use was involved. One teacher in Western Cape commented,

> [Our students] say, 'take us to the computer lab, teachers, we want to use them….' When they know we are going to the computers after the break, you will find them there even before the break is finished.

In Gauteng, another teacher stated, "during computer period, learners make it a point to be in school" and a Namibian teacher said she thought students were more likely to attend school on days they knew they would have an opportunity to use computers. Such increased student motivation could plausibly increase attendance rates and students' longer term intrinsic interest in education without necessarily raising exam scores in the short-term.

IIIe: Discussion

The data elicited on the Gauteng Online, Khanya and SchoolNet projects through interviews and classroom observations offer a variety of valuable insights. Looking across projects, the data show that technical, human and organizational factors all acted in different ways to impede or advance project goals. Most significantly, a model for successful computer integration in developing country schools can begin to be induced from the analysis I provide in this chapter.

Technical factors are clear prerequisites for successful technology use in the schools I study. Schools that struggled to secure their computers or to support them technically and financially had a difficult time using computers to their fullest potential. Without proper support structures put in place by project implementers, it seemed that it was only a matter of time before something went wrong with the computer lab that the school could not repair in a timely manner within its means. It is inevitable that computers will eventually break and printers will need maintenance. It is also inevitable that valuable resources in communities plagued by high crime rates will be at risk of theft. Poorer schools in more remote areas without the resources to handle such eventualities seriously struggled when there was no mechanism put in place by project implementers to receive the necessary support. These are issues which Cuban (2001) showed to be of moderate severity in American schools, but which are substantially amplified in the relatively resource-poor context of a developing country.

When these more technical issues were addressed or had not yet caused difficulties for a school, implementers still faced a set of human and organizational challenges which in many ways were more difficult to manage. The data illuminate a process through which these issues can be addressed most effectively. Initial training helps provide teachers with the fundamental technical literacy to use computers effectively. However, teachers must practice these skills independently to truly feel comfortable using computers with their students. The most motivated teachers will often accomplish this for themselves, but most teachers require some additional motivating factor to sustain practice. In the schools I study this motivation was provided by some source of leadership within the school.

Once most teachers in the school have achieved a certain mastery of computer use after training and practice, organizational factors often create friction when attempting to integrate their use into established school routines. In order for computer use to be sustained beyond the very short-term, schools and implementers need to adjust school routines in a way which supports such use. The most simple and effective solution to this was to schedule computer lab use as part of the overall school timetable. This, coupled with computer lab usage logs, ensured that each teacher used computers with his students on a regular basis. Teachers could then plan overall curriculum delivery knowing when they would be expected to deliver lessons with the aid of computers.

The three projects I study employed different permutations of this model to varying degrees of success. Gauteng Online, with its focus on using computers as a teaching aid for mainstream subjects, appears to have achieved moderate levels of overall use at best. Gauteng Online schools struggled with the combination of relatively low levels of initial training and little active follow-up support on the part of project implementers. Much variety was therefore observed in how schools took to computer use; this was determined by a collection of factors such as the enthusiasm of school management toward the new technology and the initial interest of a school's teachers toward using new technology with their students. A sizeable number of teachers were therefore left feeling underprepared to use computers, and schools' use of their computer resources was far below the potential.

In Namibia, unlike the other two projects, SchoolNet did not focus exclusively on computer integration into classroom lessons, but instead allowed schools to decide how to use their new computer lab. Like Gauteng, teachers did not feel comfortable enough with computer use after the training offered by the NGO. While training did last longer, generally for two to three months, teachers unanimously reported that they felt it was insufficient and too basic. However, schools' flexibility in using their computers allowed them to sidestep the necessity of broad teacher training and integration of computer use into school routines. Many schools do integrate computers into standard lessons, but others use their computers most after school hours when only a handful of teachers are needed to supervise independent student use. This made it possible for less enthusiastic teachers to avoid substantial computer use, while more enthusiastic teachers could still ensure this resource was available to students. As in Gauteng, Namibian schools are using their new technology in substantial amounts, but use still falls significantly below potential.

The Khanya project managed to achieve high levels of computer use in its schools with a broad base of teachers using computers regularly. It did this by laying the important technical foundations for computer use and finding ways to effectively address the human and organizational factors which are often sources of resistance to change. Schools were assisted in planning for the sustainability of their computer lab from the very beginning of the deployment process. A project manager worked with school management to create financial and technical sustainability plans with the school, and technical support was often available locally. Schools in Western Cape also had the added advantage of per-student financial subsidies from the government which were larger than in Gauteng and far greater than resources provided to Namibian schools. This left schools with a degree of financial flexibility which may have made computer use easier to sustain.

The most remarkable accomplishment of the Khanya project was its use of project facilitators to integrate computer use into the culture of a school. This was done primarily through the role of Khanya facilitators, each of which was only responsible for about roughly 10-15 schools in the project. Facilitators provided intensive training, in-classroom support and long-term training support to all Khanya schools and teachers. They also worked with schools to integrate computer use into their timetables and checked over logs of computer use and technical difficulties at each school on a weekly basis. This combination of individual and institutional support played an important role in maintaining very high levels of computer use throughout schools' time in the project.

This qualitative look at the Gauteng Online, Khanya and SchoolNet projects has set forth a framework for the determinants of success regarding computer deployment projects in developing country schools. It has also provided a look behind the regression analyses conducted in Chapter II to highlight some of the more nuanced ways in which computers may affect teaching and learning in such schools. However, an important question remains unanswered. The Khanya project appears to have addressed many of the pitfalls faced by schools in Gauteng and Namibia, but the estimated effect on student performance for all three projects is the same—zero. Khanya is similar in many respects to the computer project in India studied by Banerjee and others (2007)—both projects involved primary schools, and both include a focus on mathematics skills; what explains the wildly different results? I turn to addressing this question, among others, in the final chapter.