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ABC, 123: Can you text me now? The Impact of a Mobile Phone Literacy Program on Educational Outcomes

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Abstract: We report the short-term results from a randomized evaluation of a mobile phone literacy and numeracy program (Project ABC) in Niger, in which adult literacy students learned how to use mobile phones as part of a literacy and numeracy class. Students in ABC villages showed substantial gains in numeracy exam scores. There is also evidence of heterogeneity in program effects across regions, suggesting the impact is context dependent. These results were stronger in one region, for women and for participants younger than 45. There was also evidence of persistent impacts: six months after the end of the first year of classes, students in ABC villages retained what they had learned better than the non-ABC students. These effects do not appear to be driven by differences in teacher quality and motivation, nor student attendance.

Keywords: Education; literacy; information technology; program evaluation; Niger
JEL Codes: D1, I2, O1, O3

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1. Introduction

Few topics in the economics have received as much attention as the social and private returns to human capital investments (e.g., Acemoglu 1996, Becker 1962, Galor and Moav 2004, Schultz 1961). Decades of econometric wrangling with measurement error and endogeneity bias have produced compelling evidence that education that effectively builds cognitive skills can improve productivity, earnings, health outcomes, and social networks (Case 2005, Akerlof and Kranton 2002, Hanushek 1995, Hanushek and Woessmann 2008, Krueger and Lindahl 2001). Moreover, human capital investments have been found to improve an individual's ability to "deal with disequilibria" (Schultz 1975) by refining one's ability to acquire and process information and to discover and benefit from new technologies (e.g., Foster and Rosenzweig 1996).

Yet despite the importance of education in the development process, educational achievements in some of the world's poorest countries remain remarkably low. It was estimated that over 880 million adults worldwide were unable to read and write in 2000 (UNESCO 2001).[1] Such figures have long spurred major educational investments to address supply-side constraints (school infrastructure and inputs) and demand-side factors (conditional cash transfers, school feeding and scholarships). Children are the common focus of these investments, but governments in developing countries have also invested in adult literacy and numeracy programs with the hopes of reaping more immediate private and social returns. Despite decades of efforts, however, adult literacy and numeracy programs have largely failed to meet expectations.[2] There is limited evidence suggesting that such programs have improved the functional literacy of adult

[1]At the most basic level, literacy entails the skills of (1) recording information of some kind in some code understood by the person making the record and possibly by other persons in some more or less permanent form; and (2) decoding the information so recorded. Similarly, numeracy is defined as "the skill of using and recording numbers and numerical operations for a variety of purposes" (Oxenham et al., 2002).

[2]Abadzi notes that during the 1970s, literacy programs surveyed had success rates of 12.5 percent, though in the 1980s these rose to a median of about 60 percent of adults acquiring basic literacy skills.

populations, and any literacy gains have depreciated quite rapidly (Oxenham et al., 2002).[3] These disappointing gains may be partly due to the lack of reading materials in local languages: once an adult learns how to read or write in his or her local language, there are few opportunities to use this newly acquired skill on a daily or even weekly basis. Even if reading material is available, there may remain an important disconnect between the information available and the information required for livelihood pursuits. Herein lies a fundamental challenge of adult literacy efforts: Whereas children can become functionally literate based simply on innate curiosity and some instruction, illiterate adults may need to see a direct livelihood benefit from literacy to muster the motivation to obtain and maintain literacy skills (Oxenham, et al., 2002). Mobile phones and Short Message Service (SMS) provide a unique opportunity to address these constraints to literacy adoption.

SMS – more commonly known as text messaging - allows adults to practice their reading and writing skills in local languages, either by contacting family or friends or by requesting information. In addition, the pricing scheme of mobile phone services in Niger provides a financial incentive to use mobile phones as a natural platform for literacy and numeracy. The original motivation for this project was based precisely on this SMS-based literacy incentive, which was observed in action by one of the authors: the large cost difference between sending simple text messages and calling encouraged some previously illiterate grain traders to teach themselves how to read and write SMS.

We estimate the impact of a mobile phone-based literacy and numeracy program for adult women and men in Niger, known as Project *Alphabétisation de Base par Cellulaire* (ABC). Similar to many of the poorest countries in the world, mobile phone coverage and adoption have spread throughout Niger since 2001; it is currently estimated that over 40 percent of the

[3] Adult literacy programs often include instruction on numeracy. Economists have often studied years of education as an outcome or focused on "literacy", measured by questions as to whether the respondent can read or write. Some research studies the impact of literacy and numeracy skills separately, but mostly in developed countries (Machin et al., 2001)

population has access to mobile phone coverage and that there are over one million subscribers in the country, representing 10 percent of the population. Niger is a compelling setting for testing the potential literacy and numeracy impacts of these growing mobile phone networks as Niger's education indicators are among the worst in the world, with over 71.3 percent of the population over 15 classified as illiterate (DHS 2006). Yet Niger is not unique in these indicators. Other countries in West Africa have similar educational indicators and mobile phone coverage rates, suggesting that the current results could be adapted to other contexts.

Project ABC was designed to provide a randomized evaluation of this potential impact by integrating mobile phone-based literacy and numeracy modules into conventional adult literacy training. The project was conducted in two districts of Niger, each with separate randomizations into treatment and control groups to enable separate analysis by district. Program villages were randomly selected from among a group of candidate villages, allowing differences in educational outcomes between the program and comparison villages to be attributed to the mobile phone-based literacy curriculum.

After one year of the program, and using half of our sample, we find evidence for positive program impacts on academic performance. Adults in ABC villages had higher math test scores than comparison villages immediately after the courses, a result that is statistically significant at the 10 percent level. In the somewhat more densely populated region (Dosso), test scores gains in math were large, but we cannot reject the hypothesis that there was no program effect in the Zinder region. Math results are stronger and statistically significant at the 10 percent level for women. Both literacy and numeracy tests scores are stronger for students younger than 45 years of age. Finally, test score gains acquired during two months of using mobile phones remained positive and statistically significant six months following the end of classes, suggesting that test score improvements reflect real learning. Students were not aware that there would be a

second test six months after the end of the program, and so these tests capture persistent active knowledge.

The remainder of the paper is organized as follows. In the next section, we situate our analysis relative to other work on literacy and technology. Section 3 provides the background on the setting of the research, as well the randomized intervention. Section 4 describes some key features of the data. Section 5 outlines our estimation strategy. Section 6 contains the preliminary results and discussion. In Section 7, we conclude by summarizing our results and offering a discussion of the relevance of these findings for policymakers and mobile service providers in the burgeoning cell phone sector of the world's poorest countries.

2. Information Technology and Education

Partly due to their rapid spread throughout the developing world, mobile phones have drawn substantial attention for their potential impacts on economic development and poverty (Bhavnani et al., 2008, Castells and et al., 2007, Corbett 2008, Donner 2008, Aker and Mbiti 2010). One of the demonstrated channels through which mobile phones improve the welfare of the poor is improved market efficiency and spatial integration (Aker 2010, Jensen 2007, Labonne and Chase 2009). Jensen (2007) speculated that "not only can [information] technologies increase earnings, but those increased earnings…can be expected to lead to improvements in health and education." While these kinds of wealth effects are certainly important, mobile phones may have an even more direct effect on education in settings with low educational outcomes.

Mobile phones – and in particular SMS – serve as a potential educational tool by allowing adults to practice their reading, writing or math skills via communications with family, friends

and commercial contacts. While such communication could occur by voice, the dominant pricing scheme makes SMS substantially cheaper than voice to mobile phone users in developing countries, particularly in sub-Saharan Africa. The sensitivity of consumer demand to the relative pricing of SMS and voice is key to the marketing of mobile services worldwide,[4] but this same price gap may have important unintended benefits among illiterate populations for whom cheap SMS rates provide a powerful financial incentive to learn to read and write text messages. Indeed, one of the authors observed anecdotally that relatively cheap SMS rates encouraged some previously illiterate grain traders in Niger to teach themselves how to read and write simple SMS.

This paper speaks to the large literature on the education production functions and the debate on the value of educational inputs (Hanushek 1995, Kremer 2003, Glewwe et al 2004, Kremer, Miguel and Thornton, 2009). More specifically, we show that skill acquisition can be facilitated and strengthened through modern information technology (Linden, et al., 2003). We explore three potential channels through which SMS-based training might produce functional literacy gains. First, when used effectively, technology can directly improve teaching efficacy. In this sense, mobile phones might provide a pedagogical platform for teaching literacy, and this analysis contributes to the broader discussion of educational inputs.

Second, technology and skills are often complementary. Thus, having access to mobile phones can increase the private returns to literacy by making it possible to communicate easily via (relatively cheap) SMS. Since the degree of complementarity between literacy and technology is heterogeneous, the value of SMS communication will differ based on individuals' livelihood and resource differences. This paper is therefore also related to the literature on heterogeneous returns to skills and on endogenous skill acquisition. Whereas a simple correlation between

[4] The cross-price elasticity of demand for SMS and voice is the subject of a recent structural econometric model (Kim, Telang, Vogt, and Krishnan 2010), which finds evidence that SMS and voice are (weak) substitutes.

owning a mobile phone and being literate cannot tell us whether the availability of mobile phones encourages people to learn to read and write or whether more literate people choose to buy mobile phones, the randomized design of Project ABC allows us to test the causal relationship between mobile phones and literacy.

Third, in the presence of communication technologies, complementarities exist not just between technology and the skills of an individual but also *between* individuals. Mobile phones may produce and sustain literacy gains via the potent network externalities that are inherent in information and communication technologies generally, and in mobile phones with SMS capabilities in particular. The value of SMS to a mobile phone owner (or one who has access to a mobile phone) is an increasing function of the number of others in her social or livelihood network who also have access to SMS. Furthermore, the profitability of SMS-based services – including relevant local information about weather forecasts and market prices and financial services such as banking or insurance – similarly increases as the network of SMS users growers. These network effects increase the returns to functional literacy and thereby magnify the incentive to obtain and retain these skills.[5]

3. Project ABC

3.1 Literacy in Niger

Niger is one of the poorest countries in the world, and the lowest-ranked country on the UN's Human Development Index (HDI). The country's education indicators are particularly low, with over 71.3 percent of the population over 15 classified as illiterate (DHS 2006). As is the case in

[5]Our paper also relates to the literature on skills depreciation, most of which is centered around skills lost during unemployment. Our paper highlights the fact that unused skills are lost more easily when they cannot be used on a regular basis (De Grip and Van Loo, 2002).

many other sub-Saharan African countries, women are disproportionately affected; the gender parity index (GPI) for literacy in Niger is below 0.50. The problem of illiteracy is even more pronounced in our study regions: Close to 90 percent of adults in the rural communities of the two regions are illiterate, and male and female literacy rates are estimated to be 15 and 7.5 percent, respectively.

3.2 Project Description and Timeline

Project ABC is implemented by Catholic Relief Services (CRS) in two rural regions of Niger, Dosso and Zinder. CRS is an international non-governmental organization (NGO) with a presence in over 80 countries, and has been operating in Niger since the 1990s. Dosso is primarily populated by the Zarma and Hausa ethnic groups, with income-generating activities focused on agricultural production and small ruminants. Zinder is primarily populated by the Hausa and Kanuri ethnic group, with agro-pastoral traditions. The main focus of CRS' program is agricultural marketing and adult literacy, the latter of which is implemented in two classes (men and women) in each village. In collaboration with CRS, the authors developed a curriculum to incorporate a mobile phone module into the adult literacy and numeracy curriculum.

There were 140 intervention villages across the two regions.[6] The randomization first stratified villages by region, and then by administrative divisions within each region. Randomization into program and comparison groups was then carried out within each stratum using a computer random number generator. Approximately half of the villages were selected to participate in the first year of classes (2009), and half of these were selected to participate in the ABC program. The same approach was followed for the 2010 villages. In line with the initial stratification, we often present tests for equality of means and the results separately by region.

[6] A number of CRS' intervention villages were not included in the randomized control trial, for two reasons: First, in a number of villages there existed already an ongoing adult literacy program administered by a different NGO or organization. Second, we excluded villages in which there was no mobile phone coverage as of the baseline (though these villages did receive the literacy program). The remaining villages are 111 villages, 60 of whom received the adult literacy project in the first year.

The Appendix Figure 1 shows the location of the intervention villages by year of intervention (2009 and 2010) and ABC and non-ABC status within both regions.

Starting in February 2009, CRS implemented an adult literacy program in 59 villages across the two regions, with two classes per village, separated by gender.[7] Within the village, 25 males and 25 females were randomly selected from among all eligible participants, using a public lottery. Eligible applicants had to be members of existing or newly formed producers' associations and unable to read or write in any language. Among the fifty slots in each village, approximately 10 percent were reserved for members of the village development committee (VDC) with whom CRS works. The remainder were randomly chosen among the eligible volunteers.

The adult literacy course implemented by CRS in our project regions covers 8 months of literacy and numeracy classes over a two-year period. Courses start in February of each year and continue until June, with a eight-month break between June and January due to the agricultural planting and harvesting season. Thus, classes that started in February 2009 finished in June 2010. All classes focus on basic literacy and numeracy in local languages (Zarma and Hausa) during the first year and functional literacy topics (agroenterprise and health) during the second year. Participants in ABC villages followed the same literacy and numeracy training as those in the comparison villages, but with two modifications: 1) participants are trained in how to use a simple mobile phone, learn where numbers and letters can be found on the mobile phone handset, and send and receive calls and SMS; and 2) the project provided subsidized mobile phones to groups of literacy participants (ie, one mobile phone per group of five people). The mobile phone module in the curriculum began three months after the literacy courses started,

[7] In comparison with other countries in West Africa, the number of indigenous languages in Niger is fairly limited, with less than 10 local languages (as compared to over 60 in Ghana and 100 in Nigeria). The primary languages spoken in Niger are Hausa, Zarma, Fulani, Kanuri and French. The primary local languages spoken in the Dosso and Zinder regions of Niger are Hausa, Zarma and Kanuri.

and neither students, teachers nor project staff were informed which villages were selected for ABC activities until two weeks prior to the start of mobile phone activities.[8]

4. Data

4.1 Household Survey and Test Score Data

In this section we provide information about the datasets used in this paper and compare characteristics of program and comparison group villages. We do not yet examine the implications of sample attrition across program and comparison villages, although attrition does not appear to have been a major problem.[9]

A baseline survey of test scores was conducted prior to the start of literacy classes in February 2009. Literacy and numeracy tests were administered to all class participants, providing a baseline sample of over 4,750 literacy participants for the 2009 and 2010 cohorts, of which approximately half participated in the classes starting in 2009. We conducted follow-up literacy tests in June 2009 (immediately after the end of the course) and again January 2010 (seven months later, prior to the start of the second year of courses). Prior to the June 2009 tests, participants in ABC villages had the opportunity to work with mobile phones for less than two months. Any literacy or numeracy gains based on such limited exposure to mobile phones would provide compelling evidence of potential mobile phone effects. The comparison of the

[8] In 2009, students in ABC villages had less than 6 weeks of practice using mobile phones. Mobile phones were therefore introduced at the same time in the 2010 villages. Students in ABC villages did not have any extra class time. Literacy courses are held for five days per week for 2-3 hours per day. One day per week is often allocated to revision of previous material.

[9] Attrition in literacy classes typically occurs within the first month of the course. As mobile phone activities did not begin until two months after the start of the course, and project staff, literacy teachers and students were not informed of the ABC program or their "treatment" status in advance, the decision to drop out of the literacy course could not have been based upon the ABC program. Similarly, once a student misses several weeks' of classes, the literacy teacher will typically not allow him or her to continue, as they have fallen behind in the curriculum.

June 2009 and January 2010 test results enables us to detect the persistence of any initial gains and further gains due to continued mobile phone use.

The literacy and numeracy tests were developed with the Ministry of Non-Formal Education and were identical in structure and difficulty for all survey rounds and between the two regions. For writing, each student was asked to participate in a dictation exercise, and the Ministry of Non-Formal Education staff then assigned scores into six categories : Level 0 (or "beginner"), which corresponds to not being able to write down any letters of the alphabet correctly; Level 1, which corresponds to correctly writing seven letters of the local language alphabet and syllables; Level 2, which means that the student can correctly write simple two-syllable words; Level 3, which means that a student can write more complicated two-syllable words; Level 4, which requires that the student write two complete short sentences; and Levels 5 and 6, which require that the student correctly write two complete sentences with more complex word patterns. The levels are similar for the numeracy test, ranging from Level 1 (simple number recognition) to Level 6 ((math word problems involving addition, subtraction, multiplication and division).[10] Examples of the literacy and numeracy tests are provided in Figure 1. The test-score dataset is our primary dataset for analyzing the impacts of mobile based literacy and numeracy training.

In addition, 11 respondents per village were sampled from among all literacy participants, with a balance between men and women. A total of 1,038 individuals were surveyed across 100 villages. The baseline survey covered information on household demographics, assets, production and sales activities, access to price information, migration and mobile phone ownership and usage. Average household size was 8.2, half of whom were children under 15.

[10] During the June 2009 literacy tests, the Ministry of Non-Formal education assigned grades based upon having a perfect score for a particular level. Therefore, a student could have correctly spelled all words in the two sentences of level 4 except for one, and been given a score of 3. The same is true with math. For this reason, the current estimates are lower bounds on the treatment effect.

Among adult survey respondents, only 4 percent have ever attended primary school, with approximately 20 percent ever having attended a Koranic school. Children's educational achievements were similarly low: only 60 percent of children aged 7-15 have ever attended primary school.

4.2 Pre-Program Characteristics of ABC and Non-ABC Literacy Centers

We utilize the 2009 household baseline survey data to compare socio-demographic characteristics of ABC and non-ABC students. Table 1 provides this comparison and suggests that the randomization was largely successful in creating groups comparable along observable dimensions. Controlling for stratified sampling, we find no significant differences in the age of respondents, their occupation, household size, assets owned (including mobile phone ownership) or whether the individual used a mobile phone prior to the program across ABC and non-ABC villages in the Dosso region (Table 1, Panel A). Household characteristics are also broadly similar across program and comparison villages in the Zinder sample (Table 1, Panel B). The one exception is the percentage of children under the age of 15 having ever attended primary school in the Dosso region; a higher percentage of children in non-ABC villages attended primary school, and this difference is statistically significant at the 5 percent level. To the extent that this is indicative of adults' attitudes towards education, and hence their performance in literacy classes, this could potentially bias our results. Nevertheless, as this percentage is higher in the comparison households, we would expect that this would put a downward bias on our literacy results.

Baseline test score distributions provide further evidence on the comparability of the program and comparison groups (Table 2). We cannot reject the equality of means for pre-program writing and math test scores in both regions. Literacy and numeracy scores for both

program and comparison villages were close to zero, suggesting that the project successfully selected participants who were illiterate prior to the start of the program.

5. Empirical Strategy and Results

We focus on reduced form estimates of the impact of mobile phones on both literacy and numeracy test scores. To better understand possible mechanisms underlying test score impacts, we also estimate program impacts on several channels, including measures of teacher quality and student effort. The main estimation equation is:

$$(1) \qquad test_{iv,t} = \alpha + \beta_1 ABC_v + \beta_2 year_t + \beta_3 ABC_v * year_t + X'_{iv}\gamma + \mu_{cv} + \varepsilon_{iv,t}$$

$test_{iv,t}$ is the literacy or numeracy test score attained by student i in class c in village v in the year of the literacy class (i.e., 2009 for cohort 1 villages, the current sample).[11] ABC_v is the program village indicator, $year_t$ is the time period (January 2009, June 2009 or January 2010) and $ABC*year$ is the interaction between the two. The coefficient β_3 captures the average program impact on the population targeted for program incentives. X'_{iv} is a vector of student-level baseline covariates. The error term consists of μ_{cv}, a common class-level error component perhaps capturing common local or teacher characteristics, and ε_{ivt}, which captures unobserved student ability or idiosyncratic shocks. We cluster the error term at the class level and include region- and randomization-level fixed effects in the regressions pooling Dosso and Zinder.[12] We also test for heterogeneity of the results by including indicator variables for gender, age and distance from a market.

[11] It is common practice in many education studies to normalize test scores (Glewwe et al 2004, Kremer, Miguel and Thornton 2009), one of the reasons being that test instruments are not comparable across rounds. Our test spans the range from illiterate/innumerate (not recognizing letters and numbers) to being able to write sentences and solve mathematical problems from verbal problems.

[12] Since the level of randomization was the subregional administrative unit, we account for this by including fixed effects which we call "randomization fixed effects."

5.1 Average Test Score Impacts in the Short-Term

Our sample includes all students who were in the program and comparison villages in 2009, and who had test scores in January and June 2009. Figure 2 summarizes the key results of this paper. The graph shows the difference in means in literacy (Panel A) and numeracy (Panel B) test scores prior to the program, immediately after the program and six months after the end of the first year classes. Literacy classes are associated with a positive and strongly statistically significant increase in participants' math and literacy scores immediately after the program. Literacy and math scores are higher in ABC villages immediately after the program, with a relatively stronger impact on math scores as compared with writing. Both groups experience depreciation in literacy and numeracy skills during the six months when classes are not held, but this depreciation is relatively less in the ABC villages. This suggests that the ABC program could not only improve skills acquisition in the short-term, but also mitigate skills depreciation after the end of the program.

Table 3 shows the simple difference-in-differences (DD) estimates for the pooled sample without region-level or gender fixed effects. Overall, the literacy program strongly improved literacy in both the ABC (Panel A, Column 1) and non-ABC group (Panel A, Column 2) after 4.5 months of courses, and 1.5 months of mobile phone treatment. The literacy program was successful in teaching basic writing skills, as most students moved from a "beginner" level (i.e., not being able to recognize and write letters) to an average score of 1.94 and 1.73, suggesting that participants could recognize letters, syllables and two-syllable words. While literacy test scores were 0.22 points higher in ABC villages, this effect is not statistically significant at conventional levels.

Table 3 (Panel B) shows similar evidence for the participants' numeracy skills. On average, math test scores increased considerably in both ABC and non-ABC villages. Math scores were 0.30 points higher in ABC villages, and the effect is statistically significant at the 10 percent level.

This means that 1 of 4 students were able to attain a higher level of numeracy due to mobile phones. More concretely, they were able to transition from an inability to recognize any numbers to successfully completing simple addition and subtraction problems. The results for both sets of results are similar when including the pre-program literacy and numeracy levels.

Table 4 disaggregates these DD results by region, controlling for individual baseline characteristics. Consistent with the previous results, we do not find significant differences in literacy test scores across program and comparison villages in Dosso or Zinder. These results do not change after controlling for randomization fixed effects (Column 2), village-level fixed effects (Column 3) or gender (Column 4). Similar to the full sample results, the results are quite different for math scores. We find that participation in the ABC program leads to a 0.45-point higher test score in the Dosso region, and this difference is statistically significant at the 5 percent level. These results are robust to the inclusion of a variety of randomization, village and individual-level controls. In Zinder however, the difference in math and literacy scores between ABC and non-ABC villages is not statistically significant at conventional levels.

The short-term impact of the ABC program on math scores are aligned with the methodology of the mobile phone literacy program. First, the ABC curriculum in the 2009 villages only began 6 weeks prior to the end of classes, meaning that participants had limited opportunities with the mobile phone curriculum. For this reason, most ABC villages only had time to cover a limited number of topics in the mobile phone curriculum, namely, turning on and off the mobile phone, learning how to recognize numbers on the phone and making and receiving phone calls. Only certain villages were able to reach the level of identifying the letters on the mobile phone, and even fewer were able to teach the SMS component of the program. Second, writing SMS via mobile phones is based upon the numeric system, which means that literacy participants must convert numbers into letters – thereby strengthening their practice of using numbers.

5.2. Heterogeneous Program Effects

The short-term effects of the program suggest that mobile phones are more useful for math skills in one of the two regions. It is reasonable to assume that the program could also have heterogeneous effects based upon the respondent's gender and age. Table 5 presents these results by gender for the entire sample and by region, controlling for ABC villages, a time trend and randomization level fixed effects. Overall, the results are consistent with prior results in terms of literacy and numeracy; the ABC program does not have a statistically significant short-term effect on literacy scores for neither men nor women in the overall sample or in each region. However, the ABC program has a positive and statistically significant impact on math scores for women in the overall sample (Column 2) and in the Dosso region (Column 4), with a statistically significant difference between men and women. The magnitude of the effect is quantitatively larger; the ABC program increases math scores by .4-.5 points, suggesting a ½ level increase in math test scores for women.

Table 6 disentangles the same effects by age. Most empirical specifications of the education production function impose a quadratic age relationship based upon the assumption that educational achievement increases with age but at a decreasing marginal rate. The average age of literacy participants is 36 years, ranging from 13 to 70 years. While there is no statistically significant difference in the ages of participants across program and comparison villages, literacy participants are six years younger in Zinder as compared to Dosso, with a statistically significant difference at the 1 percent level. The results in Table 6 suggest that the ABC program is relatively more useful for younger participants, with the cutoff point at 45 years of age. Using the entire sample (Column 1, Panels A and B), younger participants have higher math and literacy scores, but there is not a statistically significant difference between the two. This effect also remains in Dosso for literacy scores (Column 3), but there is not a statistically significant difference of the impact of ABC on older and younger participants in terms of math scores.

Similar to previous results, there is no statistically significant impact of the ABC program by age in the Zinder region for either math or literacy.

5.3. Persistent Program Effects

One of the key assumptions of the ABC program is that information technology can not only reinforce skills acquisition in the short-term, but also mitigate skills depreciation when students are no longer in classes. Consequently, Table 7 contains slightly longer run effects for both regions, using literacy data from January 2010 (seven months' after the end of the first cycle of classes, about 11 months after the beginning of classes and prior to the second year). The tests conducted during this period were unannounced, so neither literacy students nor teachers were able to prepare for the tests in advance. For this reason, the sample size is considerably smaller than the June 2009 sample; the number of adult participants who took the test was 4,697, a bit more than 4/5 of the participants who started in 2009. If the people who took the test in January 2010 were the best-performing participants, then this could overestimate our results. If, however, those who were absent were the worst-performing students, then the results in Table 7 would underestimate our results.

As a majority of those absent in January 2010 were seasonal migrants – therefore younger men who showed stronger test scores gains in Table 6 – we posit that the results in Table 7 serve as a lower bound on the long-term effect. To econometrically deal with the attrition problem, we use the inverse Mills' ratio. Table 7 shows the results of the regression in equation (1) using the long-term data and a Heckman two-stage selection procedure to account for possible selection bias.[13] The results of the first stage are in the appendix Table 1. In the entire sample, the point estimates of the effect on literacy (Panel A) are not statistically significant at conventional levels. However, the effect of ABC on math scores is .11 and statistically

[13] In the first stage we regress a student's presence at the January 2010 literacy tests on a variety of determinants to calculate the inverse Mills' ratio. In the second stage, we include the inverse Mills' ratio as an additional regressor in the OLS regression.

significant at the 10 percent level. Consistent with the previous results, we find a strong heterogeneous effect by region: math scores in ABC villages are 0.21 points higher than non-ABC villages eight months after the end of classes and the effect is statistically significant at the 5 percent level. This suggests that the impact on numeracy skills is persistent, and that the mobile phone-based curriculum could mitigate skills depreciation after the end of classes. Nevertheless, there are no statistically significant effects in Zinder.

6. Alternative Explanations and Mechanisms

There are a variety of mechanisms through which the ABC program could affect learning in the short- and long-term. First, the presence of a mobile phone curriculum – including the additional two-day training that teachers received -- could potentially lead to increased teacher participation and motivation, thereby improving the effectiveness of the overall literacy curriculum. Second, the presence of mobile phones can increase students' motivation and incentives to learn, reflected by increased participation (attendance) in the classes. And finally, the mobile phone can be used as a tool for learning outside of the classroom – both during the course and after the end of courses --- thereby serving as a dynamic learning incentive. We will attempt to address each one of these in turn.

One principle concern with respect to the previous results is a difference in teacher quality. If the Ministry of Non-Formal Education or CRS chose better-quality teachers for ABC villages, or better-quality teacher self-selected into those villages, then any differences that we observe in test scores between villages might be due to observable differences in teachers' quality, rather than the presence of the ABC program. While this concern is highly unlikely due to the randomized nature of the intervention – and the fact that literacy teachers were chosen

prior to the ABC village selection process – we test for the equality of means in teacher characteristics across program and comparison villages in Table 8 and do not find a statistically significant difference in observable teacher characteristics.

Similarly, it is plausible that the presence of mobile phone or a new curriculum could increase teacher motivation and effort, either within or outside of the classroom. While we are unable to directly observe teacher effort either within or outside of the classroom, we are able to provide an observable measure of their effort through the number of classes taught. CRS and the Ministry of Non-Formal Education provided norms for the number of classes during teach month, the actual number of classes taught was at the discretion of each teacher. In 2009, teachers taught an average of 22 classes per month (Table 8), and there was not a statistically significant difference in the number of classes taught between ABC and non-ABC villages. This provides evidence that teachers in ABC classes were not teaching more and hence improving test scores.

Finally, the presence of the ABC program could also encourage greater student attendance during classes. Using daily attendance data in the literacy classes for 2009, we do not find a statistically significant difference in student attendance between ABC and non-ABC villages. The average attendance rate in 2009 was 73 percent, but there is not a statistically significant difference between ABC and non-ABC villages (Table 8). Student attendance is somewhat higher in ABC villages in Zinder, but the difference remains statistically insignificant.

Overall, these results – combined with the persistent effects of the ABC program on numeracy scores after the end of classes – suggest that the primary mechanism through which ABC affects learning outcomes is the opportunity to practice the newly acquired skills outside of the classroom. We will attempt to address this mechanism in future research.

7. Cost Benefit Analysis

A natural question related to the use of a new approach or technology is whether the expected benefits coincide with the additional costs. We explore the question as to whether a mobile-phone based adult education program should be a public policy priority for the poorest countries using a simple comparison of the benefits and costs of the program under the ABC and non-ABC curriculum.

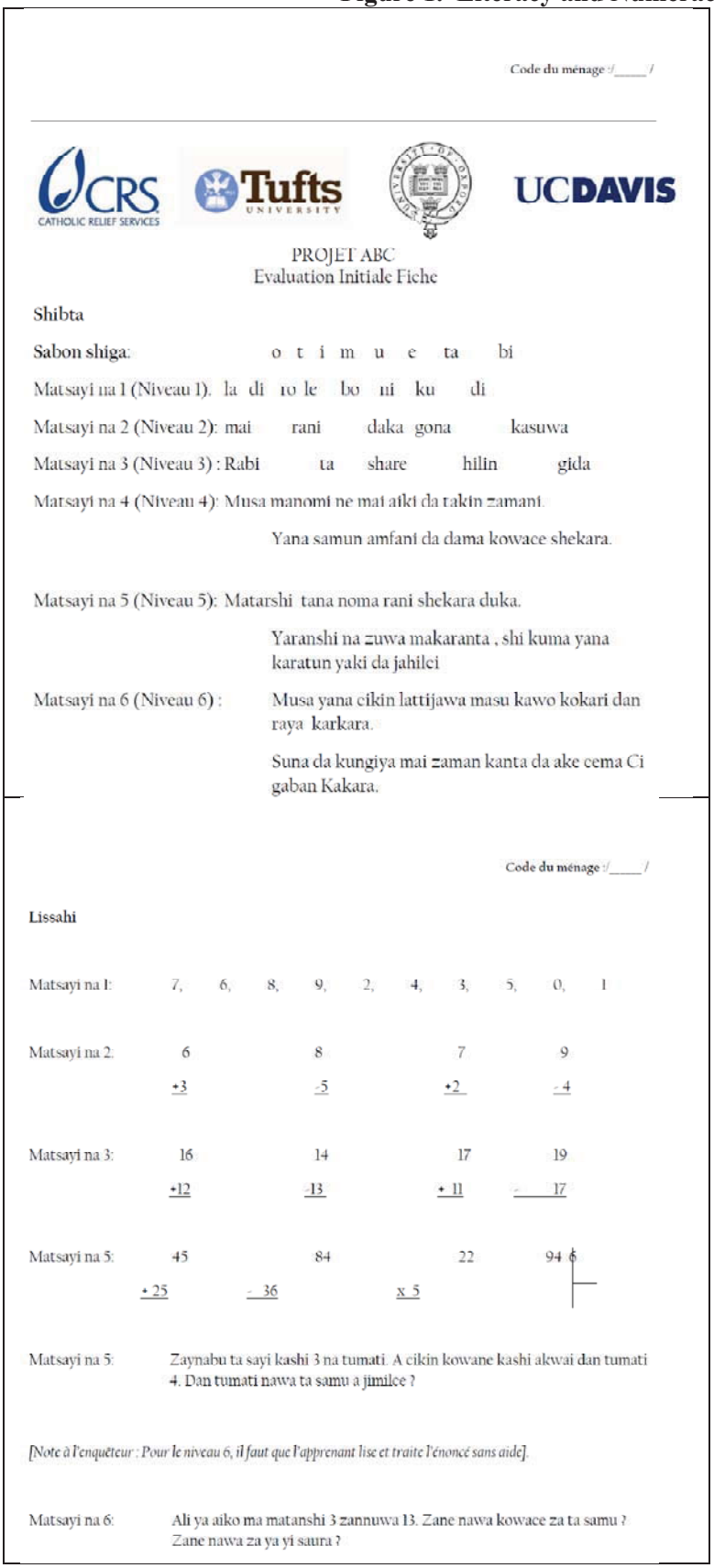
Annual government expenditure on education in Niger is one of the lowest in the world, approximately 3 percent of the annual budget is spent on education (World Bank (1999)). Consequently, using mobile phone technology for adult education programs is only one of many education interventions competing for scarce public resources. In order to perform the cost-benefit calculation, we define our benefits very narrowly to be the number of students who attain Level 1. 35 percent of students in non-ABC villages attained at least a Level 1 during the first year, and 39 percent of students in ABC villages. The per student the program cost is USD$21.50 in non-ABC villages and $USD28 in ABC villages. Thus, for an additional US$6.50 per student, 4 percent more students were able to reach Level 1. This suggest that the ABC program is approximately 10-15 percent more expensive per percent of students who attain a satisfactory level than the traditional literacy program. Since we do not include any other benefits the students might have due to having access to mobile phones (including the persistent effects on knowing and learning and access to prices information), this is a low additional cost.

8. Conclusion

Adult literacy and numeracy programs are an important part of the educational system in many countries, though their successes have been mixed, in part because reading materials in local languages are not available. We present evidence that cell phones can be used as cost-effective teaching tool, resulting in higher math scores for students overall and with quantitatively stronger results in one region, for women and for younger students. The effects on math are persistent,

even 8 months after the end of classes. Being able to read and write SMS, presumes that students have a higher level of knowledge that they could have acquired in such a short period of time. We posit that impacts on reading and writing will occur during the second year of literacy courses, which took place from February to June 2010. The larger (though not significant effect) on literacy skills 11 months after the beginning of the program points into that direction.

Figure 1. Literacy and Numeracy Tests



Code du ménage :/____/

PROJET ABC
Evaluation Initiale Fiche

Shibta

Sabon shiga: o t i m u e ta bi

Matsayi na 1 (Niveau 1). la di ro le bo ni ku di

Matsayi na 2 (Niveau 2): mai rani daka gona kasuwa

Matsayi na 3 (Niveau 3) : Rabi ta share hilin gida

Matsayi na 4 (Niveau 4): Musa manomi ne mai aiki da takin zamani.

Yana samun amfani da dama kowace shekara.

Matsayi na 5 (Niveau 5): Matarshi tana noma rani shekara duka.

Yaranshi na zuwa makaranta , shi kuma yana karatun yaki da jahilci

Matsayi na 6 (Niveau 6) : Musa yana cikin lattijawa masu kawo kokari dan raya karkara.

Suna da kungiya mai zaman kanta da ake cema Ci gaban Kakara.

Code du ménage :/____/

Lissahi

Matsayi na 1: 7, 6, 8, 9, 2, 4, 3, 5, 0, 1

Matsayi na 2:

6	8	7	9
+3	-5	+2	-4

Matsayi na 3:

16	14	17	19
+12	-13	+ 11	- 17

Matsayi na 5:

45	84	22	94 ÷ 6
+ 25	- 36	x 5	

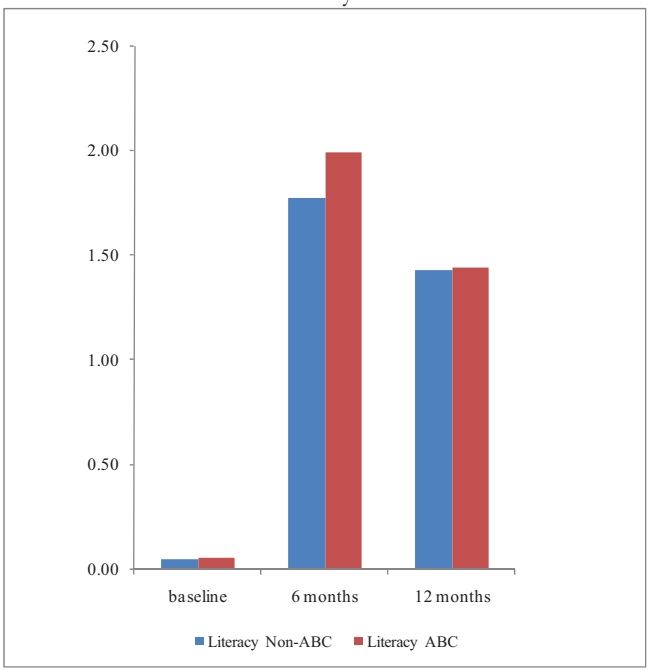
Matsayi na 5: Zaynabu ta sayi kashi 3 na tumati. A cikin kowane kashi akwai dan tumati 4. Dan tumati nawa ta samu a jimilce ?

[Note à l'enquêteur : Pour le niveau 6, il faut que l'apprenant lise et traite l'énoncé sans aide].

Matsayi na 6: Ali ya aiko ma matanshi 3 zannuwa 13. Zane nawa kowace za ta samu ? Zane nawa za ya yi saura ?

Figure 2: Year 1 (2009) Test Score Impacts of ABC and non-ABC Literacy Centers for Cohort 1

Panel A: Literacy Test Scores



Panel B: Numeracy Test Scores

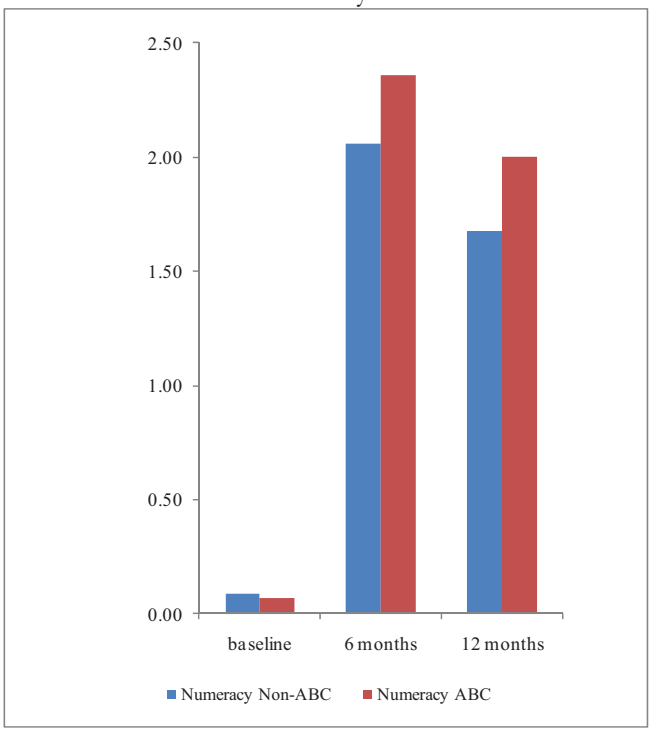


Table 1: Baseline Household Descriptive Statistics (by Treatment Status)

	ABC	Non-ABC	Difference	
Panel A: Dosso				
Age	41.13	41.84	-0.71	
Head of Household	0.49	0.54	-0.05	
Farming is respondent's main occupation	0.78	0.75	0.03	
Household chores are respondent's main occupation	0.21	0.23	-0.01	
Number of household members	8.92	9.17	-0.25	
Percentage of Children <15 with at least some primary education	0.60	0.71	-0.12	**
Number of assets owned	9.67	10.07	-0.39	
Number of houses owned	3.03	3.36	-0.33	
Respondent has used mobile phone since harvest	0.63	0.65	-0.01	
Access to a market in the village	0.32	0.23	0.09	
Panel B: Zinder				
Age	34.18	34.53	-0.35	
Head of Household	0.50	0.47	0.03	
Farming is respondent's main occupation	0.85	0.83	0.02	
Household chores are respondent's main occupation	0.14	0.15	-0.01	
Number of household members	7.23	7.68	-0.45	
Percentage of Children <15 with at least some primary education	0.54	0.55	-0.02	
Number of assets owned	8.40	9.24	-0.84	
Number of houses owned	2.92	3.10	-0.19	
Respondent has used mobile phone since harvest	0.44	0.50	-0.05	
Access to a market in the village	0.22	0.40	-0.18	

Notes: Table displays summary statistics for treatment (Column 1) and control group (Column 2). Column 3 reports the difference. ***, **, * denote statistically significance at 1, 5, 10 percent, respectively. Summary statistics are for respondents with non-missing information

Table 2: Baseline Literacy Test Outcomes (by Treatment Status)

	ABC	Non-ABC	Diff(s.e)
Panel A: Dosso			
Baseline literacy test scores	0.06	0.05	.02(.03)
Baseline math test scores	0.09	0.11	-.02(.04)
Panel B: Zinder			
Baseline literacy test scores	0.04	0.06	-.01(.02)
Baseline math test scores	0.04	0.07	-.02(.02)

Notes: Table displays summary statistics for ABC (Column 1) and non-ABC (Column 2). Column 3 reports the difference. Standard errors in parenthesis, adjusted for stratified sampling. ***, **, * denote statistically significance at 1, 5, 10 percent, respectively. Summary statistics are for respondents with non-missing information

Table 3: Effects of Mobile Phone Literacy Program: DD Results

Panel A: Literacy

		(1) ABC	(2) Non-ABC	(3) ABC-Control
1	4-month results	2.00	1.78	0.22 (0.20)
2	Baseline	0.05	0.05	0.00 (0.02)
3	4-month results - baseline	1.94 (0.14)***	1.73 (0.15)***	0.22 (0.20)

Table 3: Effects of Cell Phone Literacy Program: DD Results

Panel B: Numeracy

		(1) ABC	(2) Non-ABC	(3) ABC-Control
1	4-month results	2.44	2.17	0.27 (0.18)
2	Baseline	0.07	0.09	-0.02 (0.02)
3	4-month results - baseline	2.37 (0.13)***	2.07 (0.12)***	0.29 (0.18)*

Notes: ABC villages are the villages in which traditional literacy training was complemented by cell phone based literacy training. 4-month results are the results after 4 months of training. Panel A: contains results for literacy. Panel B: contains results for numeracy. ***, **, * denote statistically significance at 1, 5, 10 percent, respectively. Robust standard errors clustered at the class

Table 4: Program Effects by Region

Panel A: Effects on Literacy	Dosso				Zinder			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ABC*4-months	0.162	0.158	0.151	0.136	0.293	0.297	0.277	0.271
	(0.206)	(0.205)	(0.207)	(0.207)	(0.285)	(0.286)	(0.287)	(0.286)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Randomization fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Village fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Gender	No	No	No	Yes	No	No	No	Yes
N	2,962	2,962	2,962	2,962	2,421	2,421	2,421	2,421
R-squared	0.262	0.289	0.309	0.340	0.479	0.499	0.535	0.543
Panel B: Effects on Numeracy	Dosso				Zinder			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ABC*4-months	0.457**	0.433**	0.431**	0.421*	0.112	0.119	0.105	0.102
	(0.209)	(0.208)	(0.209)	(0.211)	(0.286)	(0.288)	(0.290)	(0.289)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Randomization fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Village fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Gender	No	No	No	Yes	No	No	No	Yes
N	2,974	2,974	2,974	2,974	2,424	2,424	2,424	2,424
R-squared	0.528	0.549	0.577	0.594	0.519	0.538	0.584	0.585

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Notes: ABC villages are the villages in which traditional literacy training was complemented by mobile-phone based literacy training. 4-month results are the results after 4 months of training. Panel A: contains results for literacy. Panel B: contains results for numeracy. ***, **, * denote statistically significance at 1, 5, 10 percent, respectively. Robust standard errors clustered at the class.

Table 5: Program Effects by Gender

Panel A: Effects on Literacy	Whole Sample		Dosso		Zinder	
	Men	Women	Men	Women	Men	Women
	(1)	(2)	(3)	(4)	(5)	(6)
ABC*4 months	0.0417	0.340	-0.125	0.341	0.258	0.318
	(0.252)	(0.270)	(0.257)	(0.238)	(0.372)	(0.397)
N	2,644	2,739	1,439	1,523	1,205	1,216
R-squared	0.436	0.303	0.367	0.199	0.517	0.454
Panel B: Effects on Numeracy	(1)	(2)	(3)	(4)	(5)	(6)
ABC*4 months	0.134	0.417*	0.345	0.511*	-0.095	0.311
	(0.241)	(0.244)	(0.245)	(0.305)	(0.422)	(0.388)
N	2,652	2,746	1,446	1,528	1,206	1,218
R-squared	0.556	0.504	0.591	0.497	0.524	0.520

Notes: ABC villages are the villages in which traditional literacy training was complemented by mobile-phone based literacy training. 4-month results are the results after 4 months of training. Panel A: contains results for literacy. Panel B: contains results for numeracy. ***, **, * denote statistically significance at 1, 5, 10 percent, respectively. Robust standard errors clustered at the class.

Table 6: Program Effects by Age

Panel A: Effects on Literacy	Whole Sample		Dosso		Zinder	
	Younger than 45	Older than 45	Younger than 45	Older than 45	Younger than 45	Older than 45
	(1)	(2)	(3)	(4)	(5)	(6)
ABC*4 months	0.338	0.242	0.404	0.322	0.006	0.238
	(0.215)	(0.219)	(0.251)	(0.319)	(0.262)	(0.351)
N	2,750	2,648	1,153	1,592	1,809	829
R-squared	0.516	0.529	0.257	0.471	0.272	0.498
Panel B: Effects on Numeracy	(1)	(2)	(3)	(4)	(5)	(6)
ABC*4 months	0.434*	-0.016	0.433*	0.271	0.481*	-0.157
	(0.240)	(0.235)	(0.230)	(0.328)	(0.266)	(0.307)
N	2,745	2,638	1,156	1,594	1,818	830
R-squared	0.379	0.342	0.558	0.493	0.512	0.574

Notes: ABC villages are the villages in which traditional literacy training was complemented by mobile-phone based literacy training. 4-month results are the results after 4 months of training. Panel A: contains results for literacy. Panel B: contains results for numeracy. ***, **, * denote statistically significance at 1, 5, 10 percent, respectively. Robust standard errors clustered at the class.

Table 7: Persistent Effects of ABC on Literacy and Numeracy

Panel A: Effects on Literacy	Whole Sample (1)	Dosso (2)	Zinder (3)
ABC village * 11 months	0.028	0.077	0.025
	(0.09)	(0.128)	(0.125)
N	4485	2355	2129
R-squared	0.3214	.2732	.3690
Panel B: Effects on Numeracy	Whole Sample (1)	Dosso (2)	Zinder (3)
ABC village * 11 months	.11*	.215**	0.014
	(0.065)	(.080)	(.104)
N	4697	2568	2129
R-squared	0.5459	.5982	.5213

Notes: ABC villages are the villages in which traditional literacy training was complemented by cell phone based literacy training. 11-month results are results 11 months after the beginning of classes and 7 months after the end of the first year of classes. OLS regressions that control for ABC village, time, region (except columns (4) and (5)) , sex (except columns (2) and (3)), and columns (1) and (6) also for sex*region. Panel A: contains results for literacy. Panel B: contains results for numeracy. ***, **, * denote statistically significance at 1, 5, 10 percent, respectively. Robust standard errors clustered at the class.

Table 8: Teacher and Student Characteristics and Attendance

	ABC	Non-ABC	Diff(s.e)
Teacher Characteristics			
Level of Education	8.90	8.25	.657(.435)
Age	32.01	32.64	-.624(1.72)
Sex (1=Woman, 0=Men)	.25	.32	.066(.089)
Teacher Attendance (Number of Classes Taught)			
Overall	56.74	57.13	-.388(3.36)
Doutchi	58.66	59.95	-1.29(4.01)
Zinder	54.11	53.49	.621(5.65)
Student Attendance Rate			
Overall	0.739	0.727	.012(.034)
Doutchi	.705	.743	-.038(.041)
Zinder	.786	.704	.082(.056)

Notes: Table displays summary statistics for ABC (Column 1) and non-ABC (Column 2). Column 3 reports the difference. Standard errors in parenthesis. ***, **, * denote statistically significance at 1, 5, 10 percent, respectively.

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Appendix Figure 1. Map of Intervention Villages by Cohort (2009 and 2010) and ABC and Non-ABC Status