Improvements in numeracy on a micro level:
A field study in the Philippines

Bachelor Thesis May 2013
Lund University
Department of Economics

Author:
Karin Lindell

Supervisors:
Andreas Bergh and Therese Nilsson

Acknowledgements

I would like to thank IKEA for their donation of pencils and Clas Ohlson for the discount on reflexes. I would especially like to thank Alega Skolmaterial AB who donated 100 solar powered calculators to the project. I also want to thank my supervisors Andreas Bergh and Therese Nilsson for excellent guidance all the way through the project.

A project like this would not have been possible without financial support from SIDA, for which I am very thankful. I am also grateful for the assistance in finding two high schools suitable for the project, which the Philippine Red Cross Palawan provided me with.

Finally, but most importantly, I would like to thank all the teachers, the principal and especially all the amazing students at Francisco Lagan Senior Memorial High School in Caramay and Tagumpay National High School. I appreciate your great hospitality, support and kindness.

Abstract

This project investigates if access to a solar powered calculator improves numeracy and who benefits the most from the use of a calculator. A randomized field study was carried out in two different high schools in Palawan, a province in the Philippines. All participating students took two identical mathematics tests based on mental arithmetic, the first at the initial stage and the second seven weeks later at the end of the project. Difference-in-differences estimation was used to find the difference between the change in test scores over time for control and treatment groups.

In one of the schools the calculator did have a significant positive effect on test scores among students in the treatment group. The difference-in-differences estimate indicates that the treatment group increased its test score by approximately one point more than the control group over the project's time period. The results also suggest that the improvements in mental arithmetic were highest in calculation problems based on division. Students living with neither parent and with access to fewer schoolbooks tend to have lower test scores at baseline. The change in test scores is reduced among students who have a higher number of siblings or high absenteeism. To increase numeracy overall focus has to be directed at low performers to improve basic knowledge in mathematics, as well as high performers who benefit the most from a calculator.

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Abbreviations

DepED MIMAROPA	Department of Education Mimaropa
FLSMHS	Francisco Lagan Senior Memorial High School
TNHS	Tagumpay National High School

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1. Introduction

The traditional Solow growth model states that an increased input of capital and labor into the economy will enhance economic growth, but to a limited extent due to diminishing returns to capital and labor. Instead, exogenous technological progress is considered to be the only source of long-run growth (Jones, 2002, p. 22-45). One consequence of the model is that an increase in inputs in less developed countries will result in more sizable economic growth than in countries where levels of capital and labor are already high. Thus an increase in capital can be very beneficial for less developed countries (Calmfors and Persson, 1999, p. 74-75). More recent models have put higher emphasis on economic growth as explained by factors inside the economic system itself. The concept of capital is extended to include not only monetary and physical capital, but also human capital. According to the models the assumption of diminishing returns to scale is not necessarily true. Improvements in human capital will enable labor to make use of both technology and also monetary and physical capital more efficiently, resulting in economic growth (Romer, 1986).

The models illustrate the importance of human capital in countries' economic growth; however, the actual increase in human capital takes place on a micro level among the individuals within a country. This project will focus on the individuals within the economy and how human capital can increase on the individual level.

Unlike numeracy, literacy is traditionally a common proxy for human capital. As a consequence, the literature on literacy is extensive while substantially less research has been made on numeracy (Hippe, 2012). Numeracy skills are nonetheless of great importance at individual level, both in individuals' professions as well as in everyday life. It is not only bankers and people working in financial services who are in need of numeracy skills; a shop owner in Manila or farmers in rural areas also need some numeracy skills to run their businesses. So an increase in numeracy, and hence an increase in human capital, would be beneficial for the overall economy as well as for the individual. The essential question is then; how can numeracy be improved?

To put a higher emphasis on how numeracy skills can be improved, I initiated a project among students in two high schools in Palawan, a province in the Philippines. I stayed in Palawan for seven weeks to perform the field study; during this time I organized a baseline survey and two mathematics tests, based on mental arithmetic, for the students. The aim of the project is to investigate if access to a solar powered calculator improves numeracy skills. There are two possible connections between having access to a calculator and improvements in numeracy, either a direct or an indirect connection. A direct improvement would be if the use of the calculator itself resulted in higher numeracy. An indirect improvement on the other hand would be if access to a calculator makes the student more enthusiastic about mathematics overall, resulting in more time spent on studying mathematics and thus improving numeracy skills. The main purpose of this project is not to study the direct or indirect connection, but to investigate the possible effect on numeracy that access to a calculator could have. Thus, the question of concern is as follows:

Does access to a calculator have a significantly positive effect on numeracy skills?

A calculator is likely to be more beneficial for some students than others, resulting in larger improvements in numeracy. In order to reach all students to enhance numeracy overall, the following question needs to be addressed:

Which students benefit the most from having access to a calculator?

To address the questions above, the following disposition has been used: chapter 2 provides background information on the province of Palawan, the Philippine education system, and the education in Palawan. Chapter 3 demonstrates the connection between human capital and economic growth. The importance of numeracy is described and illustrated with the example of Africa and Asia, and numeracy levels around the globe are presented. Chapter 4 presents the applied data and econometric model, and some limitations of the project are also discussed. The results in chapter 5 are followed by a discussion on the results in chapter 6 and a general conclusion in chapter 7.

2. Background

2.1. Palawan - a province in the Philippines

The province of Palawan is situated west of the main part of the Philippines. It is geographically one of the largest areas in the Philippines with the elongated Palawan Island as the main center of the province, and an additional 1780 islands surrounding it. The location as the most eastern province of the Philippines has been proven favorable since Palawan is protected from strong winds originating from the Pacific Ocean, and is rarely affected by typhoons (Palawan Chamber of Commerce and Industry, Inc., n.d.). The Philippines became a Spanish colony in 1521; the Christian church is one of the main heritages from the Spanish era. It remained Spanish until the outbreak of the Spanish-American war, and in 1898 a Peace treaty was signed, giving way to American rule over the Philippines (Dolan, 1991). During American rule Puerto Princesa was named the capital of Palawan, agricultural and educational reforms were being carried out, and new schools were built to make education more accessible to the public (Palawan Chamber of Commerce and Industry, Inc., n.d.). Palawan was occupied by Japan in 1942 and was liberated by the end of the Second World War in 1945. In 1946 the Philippines became independent from the US and the first president was elected (Dolan, 1991). In 2010 the total population of Palawan was 996,340, out of which 222,673 lived in Puerto Princesa (NSO, 2010). The official languages of the country are the Tagalog-based Filipino and English, but a wide variety of local languages are spoken throughout the Philippines (Belvez, n.d.). Agriculture is the backbone of Palawan's economy, with corn, rice and coconuts being some of the main products. Fishing, logging and mining are also of great importance, and in addition to this, oil-findings in the province have resulted in a growing oil industry (NE, 2013).

2.2. The Philippine education system

The education system consists of six compulsory years of elementary school, between the age of 6 and 11. This is followed by secondary school, which is comprised of four years of high school for children between 12 and 15 years old. Elementary and secondary school combined result in ten years of schooling (SEAMEO, n.d.). The Philippines is the only country in Asia with solely ten years of basic education, and only two other countries worldwide use the same educational system. The Philippine government has found that a high percentage of high school graduates lack sufficient skills needed in the labor market or for higher education. In order to increase the quality of education the Department of Education has recently introduced the K-12 policy program. The program is an attempt to adapt to the internationally accepted education system to make Filipinos more competitive in the global labor market (De Justo, Digal, and Lagura, 2012). The program will transform the education system into a twelve-year system in which two additional years will be added to the current high school, extending secondary school into four years of junior high school and two extra years of senior high school. The program will be implemented gradually; the first changes are to be made during the ongoing academic year of 2012/2013, and the current grade seven will be the first to graduate from senior high school in 2018 (The Official Gazette, 2012).

2.3. Education in Palawan

There are 114 public high schools and 19 private high schools in Palawan, with the majority of the children being enrolled in public education. Table 1 shows the number of students enrolled in high school compared to number of children in the corresponding age span living in the region. In rural settings of Palawan, approximately half of the children between 12 and 15 years old do not enroll in high school. Approximately six out of ten children study at a high school in the urban Puerto Princesa. The gender parity index of 1.27 and 1.19 indicates that a higher number of females than males enroll in high school. Approximately half of the enrolled students in the rural setting complete high school; the corresponding number is 44 % in Puerto Princesa. The drop out rate is relatively similar in both Palawan and Puerto Princesa, and it is higher among boys than girls (DepED MIMAROPA, 2008).

Table 1. Education statistics on children in the age span 12-15 years old. (*Information retrieved from DepED MIMAROPA, 2008.)*

	Enrollment	Population	NER	GPI	Completion rate	Drop out rate
Palawan						
Total	32 170	67 164	47.9 %	1.27	51.9 %	7.6 %
Boys	14 366	33 950	42.3 %		48.5 %	9.8 %
Girls	17 804	33 214	53.6 %		55.2 %	5.6 %
Puerto Princesa						
Total	10 924	18 055	60.5 %	1.19	44.0 %	7.0 %
Boys	5 040	9 126	55.2 %		35.3 %	7.5 %
Girls	5 884	8 929	65.9 %		53.4 %	6.5 %

Notes:
Enrollment: number of children in the age span 12-15 enrolled in high school
Population: total population of children in the age span 12-15
NER: Net Enrollment Ratio is the percentage of children in the age span 12-15 years old who are enrolled in high school.
GPI: Gender Parity Index shows the ratio of female to male NER.

3. Theory

3.1. Human capital and economic growth

As Hanushek and Woessmann (2012) mention, investments in human capital, especially in education, have been regarded as highly instrumental in enhancing economic growth over the past few decades. They further point out that, such investments should result in improved economic progress, according to the well-established growth models (as presented in chapter 1), but the results have been disappointing. In their study they suggest that the effect of educational investments on growth is underestimated due to the use of less suitable measures of human capital. Numerous studies have used years of schooling as a proxy for human capital, but this measure has several deficiencies. The proxy is based on the assumption that the benefits for human capital of one additional year of schooling are the same worldwide. The assumption implies that one extra year in Bolivia should result in the same knowledge accumulation as in Germany. Furthermore, knowledge is assumed to be accumulated mainly through formal schooling, which means that alternative educational sources are ignored.

Instead of years of schooling, Hanushek and Woessmann (2012) use international tests in mathematics and science over the time period 1964 to 2003. The cognitive skills of students, measured by test scores, are thus used as a proxy for human capital. The study is based on the growth model from Hanushek and Woessmann's (2012, p. 271) study presented in equation 1 below in which g represent the growth rate of a country, GDP per capita. The independent variable H denotes skills of workers, which is approximated by using test scores of students in the particular country, and X signifies other aspects that have an impact on growth.

$$g = \gamma H + \beta X + \varepsilon \qquad 1)$$

Moreover, Hanushek and Woessmann (2012, p. 271) have decomposed the skills of workers, namely human capital, into four different parts according to equation 2 below. The variable F stands for educational inputs from the family, qS denotes the quantity and quality of schooling, A represents individual ability and Z signifies other aspects such as health and knowledge obtained in the labor market. Human capital is approximated by cognitive skills.

$$H = \lambda F + \phi(qS) + \eta A + \alpha Z + \nu \qquad 2)$$

The strength of this model compared to using years of schooling as a proxy for human capital is that it incorporates other parts than solely formal schooling. It takes into consideration the quality of schooling, not only the quantity, and it also incorporates other sources for human capital such as the family and the labor market. Performing a regression based on the growth model (1) above shows that test scores have a considerably stronger positive effect on economic growth than years of schooling. The average scores in all mathematics and science tests completed during the time period 1964 to 2003 in 50 different countries were used in the model. The result implies that test scores are a stronger proxy for human capital than years of schooling, which indicates that not only the quantity of formal schooling affect human capital. The quality of schooling, knowledge accumulated from other sources than school, individual ability and health also have an impact on test scores and, by extension, on human capital. According to the result, a one standard deviation improvement in test scores should on average lead to a 2 % increase in annual GDP growth rate over 40 years (Hanushek and Woessmann, 2012). Several other studies have found similar results; table 2 below presents a summary of different studies in the same field of interest.

Table 2. Summary of research on test scores and economic growth

Summary of research on test scores and economic growth			
Authors	**Year**	**Human capital proxy**	**Main results**
Lee and Lee	1995	International science test scores	Test scores have a higher association with economic growth than years of schooling or enrollment rates do. In addition, increased test scores reduce countries' fertility rates.
Hanushek and Kimko	2000	International mathematics and science test scores	A stronger significant effect of students' test scores, as an approximation of labor skills, on growth than for years of schooling. (Hanushek and Woessmann (2012) is based on this research, but the study has been extended).
Bosworth and Collins	2003	International mathematics and science test scores	A high association between test scores, which represent quality in education, and GDP per capita.
Altinok	2007	International mathematics, reading and science test scores	The study is similar to Hanushek and Kimko's (2000) research but includes a larger number of countries. The quality of education, in terms of test scores, has a significant positive effect on economic growth, unlike quantity of education.
Appleton, Atherton, and Bleaney	2013	International mathematics and science test scores	Lagged test scores have a positive association with subsequent economic growth, which emphasizes that not only quantity of education but also quality has an impact on future growth.

Altogether, the research presented above emphasizes the role of cognitive skills in economic growth, and highlights the significance of test scores as a measure of human capital. This implies that increased test scores indicate higher levels of human capital, which enhance economic growth. In other words, the development starts at a micro level with improved test scores among students, and higher skills among workers, and unfolds itself in macroeconomic growth. The main question is then how cognitive skills, and thus test scores, can be improved. Moreover, if efforts to enhance cognitive skills should focus on individuals with high or low test scores is an important question since it implies that policy on education may take two different directions, to educate a few specialists or to educate the masses. Research shows that both education initiatives result in increased economic growth, and interdependence can be found between labor with basic skills and highly educated labor. Individuals with high education are necessary to develop new innovations or to imitate other countries, while the practical implementation of such changes are dependent on a labor force with at least basic skills. To conclude, it is essential to improve test scores in order to achieve higher levels of human capital and economic growth, and it is also important to focus on improvements among all segments in society (Hanushek and Woessmann, 2012).

3.2. Definition of numeracy

The main focus in chapter 3.1 is on how human capital affects a country on the macro level, through economic growth. However, the last paragraph of the chapter emphasizes that the change in test scores, and human capital, takes place among individuals on the micro level. The remaining chapters of the theory focus on the importance of human capital, and more especially of numeracy, on the individual level. The term quantitative literacy, or mathematical literacy, is an alternative name for numeracy (Hippe, 2012). Numeracy can be interpreted according to the definition of mathematical literacy below, presented by OECD PISA (2012, p. 25).

> *"Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals to recognise the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens."*

The definition shows that school mathematics is a part of numeracy but that numeracy as a concept is wider (OECD PISA, 2012).

3.3. The importance of numeracy

Developments in the education system and an emerging capitalist society have historically enhanced numeracy skills as increased trade and entrepreneurship require the ability to perform basic calculations concerning key indicators such as profits, losses and interest. Several studies in Australia and the United Kingdom have found that higher numeracy skills have a significant positive effect on wages, full-time employment and labor force participation. Similar results were found in the United States, where higher numeracy skills were associated with a higher probability of full-time employment (A'Hearn, Crayen, and Baten, 2009). A study on 16-24 year olds in Canada found a strong positive association among women between numeracy on the one hand, and employment and number of weeks worked on the other. Basic numeracy skills had a significant positive effect on income, for both men and women (Finnie and Meng, 2000). Moreover, the importance of basic arithmetic obtained in school as a predictor of income in subsequent working life has grown over time. The results were found by comparing the predictive power of numeracy in United States over two decades, the 70s and 80s (Murnane, Willet, and Levy, 1995). Numeracy usually has a stronger explanatory power than literacy rates when it comes to wages and employment among those less educated and women (A'Hearn, Crayen, and Baten, 2009).

Christelis, Jappelli, and Padula (2007) and Lusardi and Mitchell (2007) have focused their research on financial decisions, in both Europe and North America, to map the level of numerical and financial literacy among the population. The importance of numeracy skills for people's ability to make sensible financial decisions has been the primary motivation for research. Lusardi and Mitchell's (2007) study on retirement saving plans among people over the age of 50 in the United States involved a series of questions, which required participants to perform calculations. The study found that participants with low numeracy skills and financial literacy had poor retirement saving plans compared to those with high numeracy skills. Poor numeracy was associated with low levels of savings and most of the existing wealth was in housing, making the household vulnerable to housing bubbles and the overall economy. Christelis, Jappelli, and Padula (2007) found similar results in a comparable study carried out in 11 different European countries.

The importance of numeracy skills in business has resulted in research focused on numeracy skills as a part of financial training. For a business to succeed, efficient financial decisions have to be made, and low financial literacy can have a critical impact on the quality of such decisions. Numeracy skills are an important part of financial management. In 2006-2008 a project in the Dominican Republic focused on the effects of financial training on microenterprises. Two groups of entrepreneurs received different types of training; one of the groups was taught basic rules of thumb on financial decisions and the other one more advanced financial accounting. There was no significant effect on the group receiving the more advanced training. However, the ones who received more basic financial training significantly improved their financial decision-making, which was illustrated by an increased likelihood of both bookkeeping and doing revenue calculations. There was no difference on average but sales did improve during bad periods, which suggests that higher financial literacy improves the entrepreneur's ability to deal with negative shocks, thus having a positive impact on enterprises' growth opportunities. The findings in this project indicate that basic and simple financial training can have a large influence in the success of a business (Drexler, Fischer, and Schoar, 2010). Positive impacts of financial training were also found in a project conducted in Bosnia-Herzegovina, where young entrepreneurs participated in a business-training program that covered subjects such as financial growth strategies and accounting. The entrepreneurs who received training did improve their enterprises' financial situation by for example developing more efficient production processes, higher investment rates and refinancing loans for better terms (Bruhn and Zia, 2011).

3.4. Illustration of the importance of numeracy

To illustrate the importance of enhanced numeracy skills, Africa and Asia serve as examples. Youth unemployment is a severe problem in Africa; young adults have not yet accumulated as much human capital as older adults, which makes the youth less attractive on the labor market. The problem has escalated in South Africa; approximately half of the youth population is unemployed. Unemployment in early age comes with high costs, many young people fall deeper into poverty, and future employment opportunities diminish. The problem is particularly present in urban areas where youth unemployment is six times higher than in the countryside. Self-employment is one possible solution; street trading is becoming more common among young people living in the cities and the more prosperous African countries have a higher proportion of young business owners. Young women are especially vulnerable, with 35 % of all women between 15 and 24 years old classified as NEETs (Not in Employment, Education, or Training), while the rate for their male counterparts is 20 %. The early years of adulthood are critical; in a Kenyan study female NEET rates increased with age to a higher proportion than it did for males. Lack of qualifications and low levels of individual human capital, is one of the main obstacles preventing women from entering the labor market. In conjunction with gender segregation on the labor market resulting in a high proportion of women in more informal employment, these gender differences make women more vulnerable and at a higher risk of poverty (African Economic Outlook, 2012).

The average youth unemployment rate in South East Asia was 14.0 % in 2009 and the highest rates were found in Indonesia, 22.2 %, and the Philippines, 17.4 %. The rates were high already before the financial crisis in 2007-2008; in 2000 the rates were 19.9 % and 21.2 % in Indonesia and the Philippines respectively. There is a significant gap between the genders in the labor market in Asia and the Pacific; for every 100 male employees there are 65 female employees. Economic empowerment is an important step to decrease gender inequalities. One way to enter the labor market is through entrepreneurship. Discrimination in legal aspects and access to credit are two obstacles for women to enter the labor force through self-employment. Lack of human capital is another difficulty. Microloans have given the opportunity for women to start their own businesses, but increased human capital is important to be able to keep the business alive. Moreover, the overall employment on the South East Asian labor market has experienced a large shift since the early 90s from the agricultural sector to the rapidly growing service sector; such a shift requires accumulation of new kinds of human capital (UN-ESCAP, 2011).

The African and Asian experience illustrates why basic numeracy skills are important. As mentioned previously, higher numeracy skills have a positive association with full-time employment, and it also enhances entrepreneurial skills. Higher numeracy skills could thus ease the transition for young adults into the labor force, either into paid employment or self-employment. It could also enhance economic independence and empowerment of women in all ages.

3.4. Levels of numeracy around the globe

Extensive data can be found on literacy rates worldwide, while the data on numeracy is very limited. Hippe (2012) demonstrates a high correlation between literacy and numeracy, concluding that numeracy is as good as literacy as a proxy for human capital. These findings, combined with that basic arithmetic is often included in the definition of literacy rates, result in data on literacy being presented in this chapter as a substitute for numeracy (The World Bank, 2012).

There are 793 million illiterate adults around the globe, out of which 518 million live in Asia and the Pacific. This region is also the most populous area in the world, home to 61 % of the total world population. 89 % of the illiterate adults in the region are concentrated mainly in India, China, Pakistan, Bangladesh and Indonesia. The average literacy rate in South and South-West Asia is 64 %, compared to the worldwide average of 84 %. Illiteracy is also a question of gender, and 65 % out of the 518 million of illiterate adults are women. The Philippines is one of the countries with highest gender equality in literacy rates, with almost equal numbers of literate men and women (UN-ESCAP, 2011).

Literacy levels are usually lower in marginalized groups such as ethnic minorities or people living in informal settlements. For example, 94 % of the ethnic majority population in Vietnam is literate, while the corresponding number is 74 % for ethnic minorities. In Bangladesh 76 % of the richer families are literate, while the percentage rate is 28 % among the poorer families. A problem with statistics on literacy is that they often fail to incorporate marginalized groups, which results in an overestimation of the literacy rate in the country (UN-ESCAP, 2011). Indigenous people, used interchangeably with ethnic minorities, can be defined as a group separated from the mainstream society with their own economic, cultural and social establishments. In 2005-2009 the adult literacy rate in the Philippines was 95.4 %, but estimations indicate that the number of indigenous people exceeds 12 million. Another report from the National Statistics Office estimates the indigenous people to constitute 20 % of the total population in the Philippines (Asian Development Bank, 2002).

4. Method

4.1. Specifics of the project

To evaluate whether access to a calculator improves numeracy skills among high school students, I conducted a field study in Palawan during a time period of seven weeks. The project was set up as a randomized controlled trial with two unmatched groups, a control group and a treatment group. The purpose of the randomized design was to eliminate any systematic differences between the two groups; any differences between them should be solely random. At the initial stage, the students were given a survey on socioeconomic factors, access to school material and educational habits. The survey that was used is found in Appendix 1. As an example the students were asked questions about the living arrangements and occupation of people in the same household, number of siblings and access to different household accessories such as radio and TV. Other questions concerned how many textbooks the student owned, how often the student stayed at home from school to assist with chores in the household and how many hours per day were spent on chores at home. The purpose of the baseline survey was to compare the control and treatment group to assess if there was any statistically significant difference between the two groups. The aim was to assure that the randomization had been successful.

In addition to the survey, the students took a mathematics test based on mental arithmetic at the initial stage in order to map their numeracy skills prior to treatment. The mathematics test was marked with a letter, indicating if the student belonged to the control or treatment group. The papers had been mixed before the test was handed out, resulting in the students being randomly assigned either a reflex or a solar powered calculator, which they received when handing in the test. The reflexes did not have a specific role in the project; the purpose of handing them out to the control group was for equal treatment of the students. After grading the mathematics test, it was decided to add another test with an extra five, more difficult, calculations two days later. After the survey, the first mathematics test and the additional five calculation problems had been made, the students were left to use their calculator or reflex as they desired. Seven weeks later the students took a second, and final, mathematics test. Some calculations used in the baseline test were dropped since they were too basic, and the low variation would have created a problem in the final analysis. Apart from the calculations that were dropped, the same calculations were used as in the initial baseline test, and it was once again based on mental arithmetic. Students were thus not allowed to use the calculators during the mathematics tests. After the exclusion of the too basic calculation problems in the baseline test, the maximum total test score on both tests was 12 points. The duration of the final test was the same as for the baseline test. Mathematics is part of the normal curriculum, as it was during the seven weeks of the project. However, setting up control and treatment groups solves the problem of improved numeracy skills due to lectures in mathematics.

The Philippine Red Cross, the Palawan chapter, assisted in finding two suitable high schools. The two schools where the project was initiated are located in a rural setting in the municipality of Roxas, Palawan. To mitigate the risk of theft or students selling their calculator, a rural setting was preferred over an urban setting. Francisco Lagan Senior Memorial High School, FLSMHS, is situated along the ocean in the barangay of Caramay, approximately 100 kilometers north of Puerto Princesa. Tagumpay National High School, TNHS, belongs to the barangay of Tagumpay, which is located a little bit more inland and further north of Caramay. For administrative purposes the municipalities in the Philippines are the second smallest division, while barangays are the smallest and could be a village (Dolan, 1991). The local language in both barangays is Cuyonon, which is used interchangeably with the official languages of instruction, English and Filipino, during lectures.

Table 3. Number of students in the project and the total number of enrollees.

	Treatment	Control	Students in project	Enrolled in 7th grade/2nd year
Number of students				
FLSMHS	42	35	77	126
TNHS	27	24	51	104

TNHS has fewer enrollees, and is slightly smaller than FLSMHS. Since the high schools have a large catchment area, many students live in other surrounding barangays and walk a long distance to school every day. The project includes the 7th grade and 2nd year high school in both schools. Table 3 shows the number of students participating in the project and the total number of students enrolled in 7th grade and 2nd year in both schools. High absenteeism is the reason why there is a large number of enrolled students who are not a part of the project. Absenteeism was unusually high in TNHS on the day of the baseline test due to a local festival taking place in the barangay the evening before.

4.2. Difference-in-differences estimation

The difference-in-differences model is applied to evaluate if access to a calculator improves numeracy skills. Difference-in-differences estimation is based on the concept of a comparison of two groups across two time periods, pre-treatment and post-treatment, in order to estimate the treatment effect. It is important to note that the comparison is based on the average of the groups (Imbens and Wooldridge, 2008, p. 64-65). In the current project, the model will imply taking the difference in the average baseline test score between the control and treatment groups, and comparing it to the difference in the average test scores at the end of the project. Table 4 provides an example to illustrate the concept of difference-in-differences by using data from TNHS. The difference-in-differences estimate of 0.982 found by using this method almost equals the difference-in-differences estimate given by OLS regression, which is presented in chapter 5.2. The difference between the two estimates, 0.001, is due to the rounding error of decimals in table 4.

Table 4. An illustration of difference-in-differences estimation

Average test scores			
	Post-treatment	Pre-treatment	Difference (post-pre)
Treatment group	8.259	6.444	1.815
Control group	7.708	6.875	0.833
Difference-in-differences estimation			0.982

Notes:
The difference between the average test score by the end of the project (8.259) and the average test score at the baseline (6.444) equals the first difference for the treatment group (1.815). The same calculation has been made to find the first difference for the control group (0.833). The difference-in-differences estimate (0.982) is obtained by subtracting the first difference for the control group (0.833) from the first difference for the treatment group (1.815).

Calculation problems with a rate of correct answers of 90 % or higher at baseline in both the control and treatment groups simultaneously have been excluded from the difference-in-differences estimations. The reason for excluding problems on which many students performed well was that a high initial test score provides limited room for further improvements.

The main assumption in difference-in-differences estimation is the common trend assumption; the meaning of this is that omitted variables are considered to be constant over time. The implication of the common trend assumption is that potential differences in average test scores between the two groups at the baseline are assumed to reflect a selection effect. By the end of the project, the difference in test scores will reflect the selection effect and the treatment effect. If the selection effect is constant, which the model assumes, the difference in average test score between the two time periods will eliminate the selection effect, and represent the treatment effect. The shorter the time period evaluated by difference-in-differences estimation, the more likely it is that the common trend assumption will hold. Comparisons of data over several time periods can be made to test the assumption of a common trend. However, in many studies such data is not available, which is the case in the current project. A discussion on the assumption is therefore necessary. (Angrist and Pischke, 2008, p. 185-190).

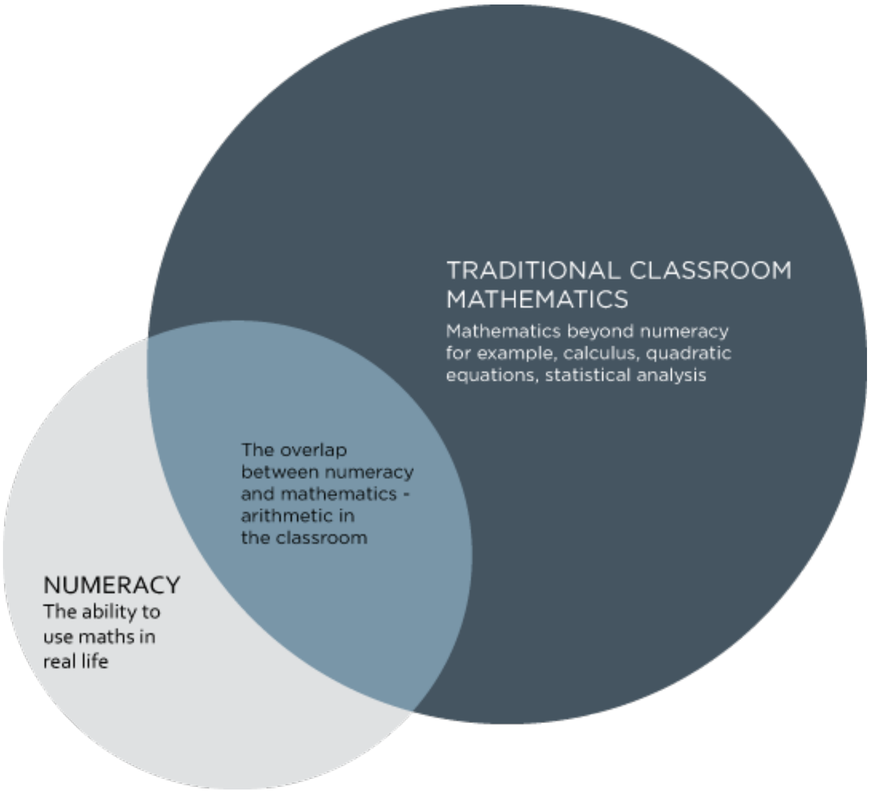
The baseline survey covered a large range of variables and the significance analysis showed that the control and treatment groups were similar for most of the variables. Still, it is possible that there is some unobserved variables for which the two groups are different. Nevertheless, if the controlled variables and the omitted variable bias stay constant during the time period, the common trend assumption is satisfied. The time scale of the project was seven weeks. It is possible that some student-specific shocks occurred during this time, but it can be assumed that the number of disruptive changes was relatively low during such a short time period. Moreover, the project took place in a rural setting where many households have similar living arrangements and livelihoods. If drastic changes were to happen, it is likely that they would affect both groups. One example could be if heavy rainfall was to destroy the harvest it would affect households in both control and treatment group, which means that the common trend assumptions would still be valid. In this project it is therefore assumed that the common trend assumption is satisfied due to the short time period and the rural setting in which the project took place.

4.3. Limitations of the project

Some limitations of the project are necessary to mention. The sample size is relatively small in the difference-in-differences estimation, when the control and treatment groups are compared in both schools. In the regressions performed in chapter 5.3, all students participating in the project have been merged together, which increases the sample size and makes the results more reliable. Moreover, the seven-week time frame of the project might be too short for any differences in improvements of test scores to be found. It is also worthwhile mentioning that a noisy classroom environment and a short distance between the student's school desks might result in biased test scores.

The theoretical framework presented in chapter 3 focuses on the broad concept of numeracy as defined in chapter 3.2. The field study was more limited, and focused on the area that numeracy and traditional classroom mathematics have in common: arithmetic. The figure retrieved from National Numeracy (n.d.) illustrates the role of arithmetic as in between numeracy and mathematics. Basic mental arithmetic including addition, subtraction, division and multiplication was used in the mathematics tests in the study. Due to language differences, testing the wider concept of numeracy would have been problematic.

Figure 1. Numeracy vs. mathematics (Figure retrieved from National Numeracy, n.d.)



5. Results

5.1. Significance analysis at baseline

The results of the baseline survey concerning socioeconomic factors, access to school material and educational habits are presented in appendices 2 and 3. The tables show mean and standard deviations for the different variables, and the p-value reflects the result from the significance analysis. The null hypothesis states that there is no difference in mean, or median, between the two groups while the alternative hypothesis suggests the opposite. A chi-square test was used for all qualitative variables. Quantitative variables that satisfied the assumptions of a normal distribution and equal variance in both groups were tested with a Student's t-test (Montgomery, 2012, p. 30-43). A Jarque-Bera test was used to test if the variable was normally distributed. Variables that had a normal distribution were examined with a F-test to establish if the variance was similar in control and treatment group. Four variables did not fulfill the assumptions; the age variable in FLSMHS, number of siblings living at home in TNHS and number of siblings living at home and working in both TNHS and FLSMHS. The mentioned variables were tested with the non-parametric Wilcoxon rank sum test/Mann-Whitney's test instead of a Student's t-test. A few statistically significant differences between control and treatment groups were found. In FLSMHS, 26 % of the students in the treatment group, compared to 3 % in the control group, stated that their household owns other kinds of livestock than the ones listed in the table. The difference was statistically significant at the 1 % level. Another significant difference, at the 5 % level, was that 7 % of the students in the treatment group in TNHS own more than eight textbooks, compared to 38 % in the control group. However, overall, the two groups are similar in both schools, and the significance analysis shows that the randomization was successful.

Tables 5 and 6 show the result of the mathematics test at baseline, before students in the treatment group received calculators. The result was similar in the control and treatment groups in both schools, with the exception of one calculation problem (523 / 2 = 261.5) in TNHS for which there was a statistically significant difference between the two groups at the 5 % level. 33 % of the students in the control group answered the question correctly while the corresponding number was 7 % in the treatment group. It is also noteworthy that many students already had a high test score on several of the calculation problems in the first mathematics test.

Table 5. Mathematics test scores at baseline (FLSMHS)

Francisco Lagan Senior Memorial High School			
	Treatment group	**Control group**	
	Mean (s.d.)	**Mean (s.d.)**	**p-value**
7 x 6 = 42	0.81 (0.40)	0.71 (0.46)	0.91
11 x 5 = 55	0.90 (0.30)	0.86 (0.36)	0.91
117 + 24 + 36 = 177	0.90 (0.30)	0.94 (0.24)	0.91
140 / 7 = 20	0.74 (0.45)	0.80 (0.41)	0.91
18 x 12 = 216	0.67 (0.48)	0.77 (0.43)	0.91
220 x 7 = 1540	0.83 (0.38)	0.86 (0.35)	0.91
813 – 125 - 216 = 472	0.60 (0.50)	0.66 (0.48)	0.91
1034 + 767 – 933 = 868	0.86 (0.35)	0.89 (0.32)	0.91
237 x 23 = 5451	0.89 (0.33)	0.91 (0.28)	0.91
523 / 2 = 261.5	0.74 (0.45)	0.66 (0.48)	0.91
2112 – 675 + 389 = 1826	0.79 (0.46)	0.79 (0.42)	0.91
324 x 16 = 5184	0.86 (0.35)	0.74 (0.44)	0.91

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%

Table 6. Mathematics test scores at baseline (TNHS)

Tagumpay National High School			
	Treatment group	**Control group**	
	Mean (s.d.)	**Mean (s.d.)**	**p-value**
7 x 6 = 42	0.96 (0.19)	0.96 (0.20)	0.89
11 x 5 = 55	0.93 (0.27)	0.92 (0.28)	0.89
117 + 24 + 36 = 177	0.85 (0.36)	0.79 (0.41)	0.89
140 / 7 = 20	0.89 (0.32)	0.96 (0.20)	0.89
18 x 12 = 216	0.85 (0.36)	0.83 (0.38)	0.89
220 x 7 = 1540	0.93 (0.27)	0.96 (0.20)	0.89
813 – 125 - 216 = 472	0.67 (0.48)	0.67 (0.48)	0.89
1034 + 767 – 933 = 868	0.67 (0.48)	0.71 (0.46)	0.89
237 x 23 = 5451	0.93 (0.27)	0.88 (0.34)	0.89
523 / 2 = 261.5	0.07 (0.27)	0.33 (0.48)	0.05**
2112 – 675 + 389 = 1826	0.67 (0.48)	0.79 (0.41)	0.89
324 x 16 = 5184	0.85 (0.36)	0.92 (0.28)	0.89

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%

5.2. Difference-in-differences estimation

5.2.1. Regression model

To perform the difference-in-differences estimation an OLS regression has been used:

$$y_{it} = \beta_0 + \beta_1 G_i + \beta_2 T_t + \beta_3 G_i T_t + \varepsilon_{it}$$

The dependent variable Y represents the test scores. Index i refers to the individual student and t to time. The variables G and T are dummy variables, G refers to which group the student belongs to; 0 denotes control group and 1 treatment group. T indicates the time period; 0 denotes pre-project and 1 post-project time period. The treatment effect is estimated by the coefficient β_3, thus representing the difference-in-differences estimate. The performed difference-in-differences estimations have all been tested for the OLS regression assumptions; any corrections made are presented in the notes under the tables displaying the results.

Calculation problems with a rate of correct answers of 90 % or higher at baseline in both the control and treatment groups simultaneously have been excluded from the difference-in-differences estimations and the graphs. In FLSMHS, one calculation problem has been excluded (117 + 24 + 36 = 177), resulting in a maximum test score of 11 points. The following three problems have been excluded in TNHS: 7 x 6 = 42, 11 x 5 = 55 and 220 x 7 = 1540. The maximum test score in TNHS is thus 9 points.

5.2.2. Difference-in-differences estimation on total test score

The dependent variable Y in this difference-in-differences estimation represents the total test score. Table 7 below shows the difference-in-differences estimation for both schools. The high p-value for FLSMHS implies that no significant difference in change in test scores can be found. However, with a p-value of 0.091, the difference-in-differences estimate in TNHS is statistically significant at the 10 % level. The value of the coefficient (0.981) indicates that the treatment group increased its test score by approximately one point more than the control group over the project's time period.

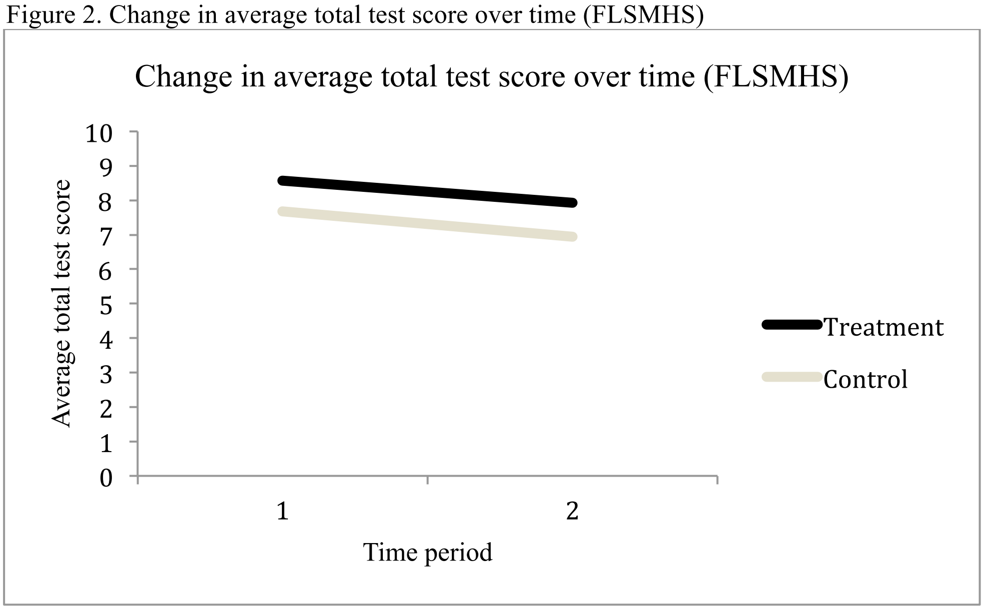
Table 7. Difference-in-differences estimation on total test scores in FLSMHS and TNHS

Difference-in-differences estimate total score			
School	**Dependent variable**	**Difference-in-differences estimate (s.d.)**	**p-value**
FLSMHS	Total test scores [1)]	0.100 (0.564)	0.860
TNHS	Total test scores [2)]	0.981 (0.576)	0.091*

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%
1) Regression corrected for autocorrelation with Newey-West standard errors.
2) Regression corrected for homoscedasticity with White's heteroscedasticity-consistent standard errors

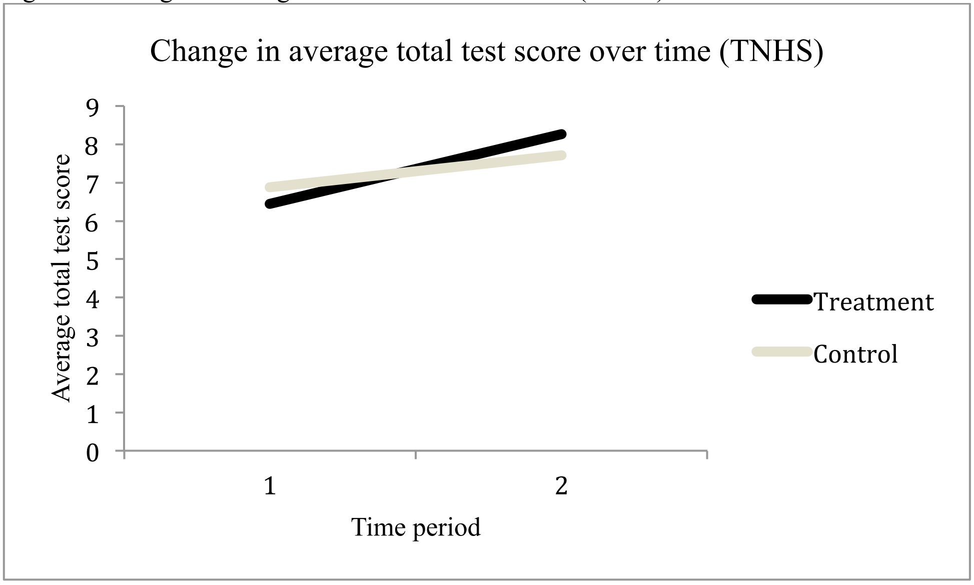
The following graphs illustrate the actual change in average total test score for control and treatment during the time period. In FLSMHS the treatment group scored higher than the control group on both tests. The average test score decreased over time in both control and treatment groups, and the change followed the same pattern in both groups. In TNHS, the treatment group had a lower average test score than the control group on the baseline test, and at the final test the results were the opposite. The average test score increased in both groups, but the treatment group had a slightly larger improvement in average test scores than the control group.

Figure 2. Change in average total test score over time (FLSMHS)



Notes:
Time period 1 = pre-treatment, 2 = post-treatment
Maximum total test score: 11 points

Figure 3. Change in average total test score over time (TNHS)



Notes:
Time period 1 = pre-treatment, 2 = post-treatment
Maximum total test score: 9 points

5.2.3. Difference-in-differences estimation on categories of calculation problems

To investigate if changes in test scores differ across different calculation problems, the calculations were divided into three different categories: mixed addition and subtraction, multiplication and division. Calculation problems in each category are presented in table 8. Three different regressions were made in both schools, with the dependent variable changing depending on the category.

Table 8. Categories of calculation problems

Categories of calculation problems		
Category	**Calculation problems**	
	FLSMHS	**TNHS**
Mixed addition and subtraction		117 + 24 + 36 = 177
	813 – 125 - 216 = 472	813 – 125 - 216 = 472
	1034 + 767 – 933 = 868	1034 + 767 – 933 = 868
	2112 – 675 + 389 = 1826	2112 – 675 + 389 = 1826
Multiplication	7 x 6 = 42	
	11 x 5 = 55	
	18 x 12 = 216	
	220 x 7 = 1540	220 x 7 = 1540
	237 x 23 = 5451	237 x 23 = 5451
	324 x 16 = 5184	324 x 16 = 5184
Division	140 / 7 = 20	140 / 7 = 20
	523 / 2 = 261.5	523 / 2 = 261.5

Table 9 presents the results of the regressions made on test scores in FLSMHS, while the result for TNHS is displayed in table 10. None of the difference-in-differences estimates in FLSMHS are statistically significant. The p-value (0.128) for the division category in TNHS is almost significant at the 10 % level, which would suggest that the treatment group increased its test score on calculation problems based on division by approximately 0.3 points more than the control group.

Table 9. Difference-in-differences estimation on categories of calculation problems (FLSMHS)

Francisco Lagan Senior Memorial High School difference-in-differences estimate categories		
Dependent variable	**Difference-in-differences estimate (s.d.)**	**p-value**
Test scores mixed addition and subtraction [1)]	0.095 (0.258)	0.713
Test scores multiplication [1)]	0.067 (0.352)	0.850
Test scores division [1)]	- 0.157 (0.162)	0.334

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%
1) Regressions corrected for autocorrelation with Newey-West standard errors.

Table 10. Difference-in-differences estimation on categories of calculation problems (TNHS)

Tagumpay National High School difference-in-differences estimate categories		
Dependent variable	**Difference-in-differences estimate (s.d.)**	**p-value**
Test scores mixed addition and subtraction	0.468 (0.360)	0.198
Test scores multiplication	0.208 (0.217)	0.340
Test scores division	0.306 (0.199)	0.128

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%

5.3. Regressions based on test scores and baseline characteristics

5.3.1. Regression models

In addition to the difference-in-differences estimations, regressions were performed to investigate if different socioeconomic factors affect the test score at baseline, and the change in test score over time. All calculation problems have been included, and the total test score is therefore 12 points on both tests. The regressions investigate which students who benefit the most from having access to a calculator, in other words, which students who improve their numeracy the most. In the regressions all students participating in the project in both schools were merged together, thus the division into control and treatment groups does not apply to the regressions in this chapter. The regressions performed are presented below and the result is displayed in table 11 and 12 in chapter 5.3.2. In models 1) to 8), two different regressions are made. The dependent variable, Y, is the test score at baseline in the first regression and the difference in test scores (post-treatment – pre-treatment) in the second.

1) $$y_i = \beta_0 + \beta_1 GENDER_i + \epsilon_i$$

2) $$y_i = \beta_0 + \beta_1 SIBLINGS_i + \epsilon_i$$

3) $$y_i = \beta_0 + \beta_1 CELL_i + \epsilon_i$$

4) $$y_i = \beta_0 + \beta_1 TIME_i + \epsilon_i$$

5) $$y_i = \beta_0 + \beta_1 LIVE\_1_i + \beta_2 LIVE\_2_i + \epsilon_i$$

6) $$y_i = \beta_0 + \beta_1 BOOK\_1_i + \beta_2 BOOK\_2_i + \epsilon_i$$

7) $$y_i = \beta_0 + \beta_1 HOME_i + \epsilon_i$$

8) $$y_i = \beta_0 + \beta_1 CHORES_i + \epsilon_i$$

The variable GENDER is coded as a dummy variable where 1 is boy and 0 is girl. SIBLINGS represents the number of siblings living in the student's household. The dummy variable

CELL is 1 if the student owns a cell phone, otherwise it is 0. TIME takes the value 1 if it takes the student more than 30 minutes to get to school, and 0 if it takes less than 30 minutes. The dummy variable LIVE_1 indicates if the student lives with one of the parents, while LIVE_2 means that the student lives with neither parent. The student lives with both parents when the variables are zero, and living with both parents is thus the reference category.

BOOK_1 and BOOK_2 are dummy variables denoting the number of schoolbooks the student owns; they represent categories of between zero and three, or four and seven schoolbooks. The variables are in relation to the reference category; if the student owns eight or more schoolbooks. The dummy variable HOME indicates if the student stays at home two days, or more, per month to assist with household chores. The effect of HOME on the result is in comparison with the alternative; if the student never, or once per month, stays at home from school. CHORES is a dummy variable that signifies if the students spend three or more hours per day doing chores at home. The effect on the test score is relative to the alternative of spending less than three hours per day on chores.

It can be seen in appendices 1 and 2 that there are fewer categories of response options in regression 4) to 8) than in the baseline survey. The explanation for this is that some response options have been merged together in the regressions in order to limit the loss of degrees of freedom. The performed difference-in-differences estimations have all been tested for the different OLS regression assumptions; any corrections made are presented in the notes under the tables with the results.

5.3.2. Regression results

The results of the regressions are presented in tables 11 and 12 on the following pages. The dependent variable in table 11 is test scores at baseline. Students who live with neither parent have approximately two points (- 2.05) lower test scores at baseline compared to students who live with both parents. The negative effect of such differing living arrangements is statistically significant at the 5 % level. There is a statistically significant negative effect of owning fewer schoolbooks at the 10 % level. Students who owns zero to three schoolbooks have a 0.84 points lower score at the baseline test than students who owns eight or more books.

Table 11. Regressions results with test score at baseline as dependent variable

Regression results **Dependent variable:** Test score at baseline		
Independent variable	**Coefficient (s.d.)**	**p-value**
Gender	- 0.46 (0.42)	0.28
Number of siblings living at home	- 0.08 (0.14)	0.56
Ownership of cell phone	0.39 (0.43)	0.37
Time to get to school		
More than 30 minutes	0.05 (0.50)	0.93
Living arrangements		
Live with one parent	- 0.18 (0.72)	0.80
Live with neither parent	- 2.05 (0.91)	0.03**
Number of schoolbooks student owns		
0-3	- 0.84 (0.49)	0.09*
4-7	- 0.74 (0.53)	0.16
How often student stays at home from school to assist with household chores		
Two days or more per month	0.65 (0.42)	0.13
Hours per days doing chores at home		
3 or more	- 0.09 (0.41)	0.82

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%

Difference in test scores is the dependent variable in the regressions in table 12. A statistically significant negative effect of number of siblings on the difference in test scores is found at the 10 % level. One additional sibling results in a 0.3 points lower change in test scores over time. The coefficient for if the student lives with one parent is almost significant at the 10 % level. The value of the coefficient implies that the change in test score over time would be 1.14 points lower for students living with one parent compared to students living with both parents. The change in test score over time is almost one point (- 0.98) lower among students who stay at home two days or more per month in comparison with students who never, or one day per month, stay at home. This effect is significant at the 5 % level.

Table 12. Regression results with difference in test scores as dependent variable

Regression results **Dependent variable:** Difference in test scores (post-treatment – pre-treatment)		
Independent variable	**Coefficient (s.d.)**	**p-value**
Gender [1)]	0.11 (0.46)	0.82
Number of siblings living at home [1)]	- 0.30 (0.17)	0.07*
Ownership of cell phone [1)]	- 0.18 (0.46)	0.69
Time to get to school [1)]		
More than 30 minutes	- 0.02 (0.48)	0.97
Living arrangements		
Live with one parent	- 1.14 (0.72)	0.11
Live with neither parent	0.45 (0.82)	0.58
Number of schoolbooks student owns [1)]		
0-3	0.54 (0.42)	0.20
4-7	0.66 (0.66)	0.32
How often student stays at home from [1)] school to assist with household chores		
Two days or more per month	- 0.98 (0.44)	0.03**
Hours per days doing chores at home [1)]		
3 or more	- 0.62 (0.44)	0.17

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%
1) Regressions corrected for autocorrelation with Newey-West standard errors.

6. Discussion

The two graphs of changes in average total test score over time in chapter 5.2.2 illustrate that the initial test score at baseline was relatively high in both schools. As mentioned previously, the adult literacy rate, which includes basic arithmetic, is quite high in the Philippines. However, statistics on literacy often fail to incorporate indigenous people, resulting in an overestimation of the literacy rate (UN-ESCAP, 2011). The number of indigenous people is estimated to exceed 12 million in the Philippines (Asian Development Bank, 2002). Education statistics on children between 12-15 years old in rural Palawan (table 1) show that less than half of the children are enrolled in high school. One possible explanation is that children of indigenous people living in the inland rainforest are not enrolled in school. Another explanation for the low enrollment rates could be long distances to school, in combination with poor infrastructure and a lack of vehicles. In addition to this, the alternative cost of children's schooling might be too high in less fortunate families. Time spent in school implies less time spent on household chores, and fewer hours spent on working to bring income to the family.

Furthermore, there is a large difference between enrollment and number of students participating in the project, due to high absenteeism. In FLSMHS, 77 students participated, out of 126 enrollees. The corresponding numbers in TNHS were 51 participants and 104 enrollees. High absenteeism is usually due to reasons similar to those for low enrollment rates: long distances and high alternative costs. Taken together, low enrollment rates and high absenteeism result in test scores not reflecting an accurate picture of children's numeracy skills in rural Palawan. The average total test scores is thus based on those children who have low school absenteeism, and who are likely to already spend more time on school work than those students not participating in the project.

The high initial test scores provide little room for extensive improvements in test scores. As mentioned previously, a direct improvement would be if the use of the calculator itself resulted in higher numeracy. On the other hand, an indirect improvement would be if access to a calculator makes the student more enthusiastic about mathematics overall, resulting in more time spent on studying mathematics and thus improving numeracy skills. If the students participating in the project already spend a large amount of time on schoolwork, it would result in a lower possible increase in study hours than for less active students. If this is the case, the exclusion of students with high absenteeism means that the difference-in-differences estimation would be biased downwards. The consequence of the bias would be that the true potential of having access to a calculator would be underestimated. To allow for improvements in test scores, some calculation problems in which the rate of correct answers at baseline was high were excluded from the estimations. Nevertheless, the possibility of an underestimation is still an important factor to consider since the project did not reach children who are not enrolled in high school or have high absenteeism.

The result of the difference-in-differences estimation on total test score was not statistically significant in FLSMHS. In fact, the average total test score decreased over time. The explanation for this is that the classroom environment in the second mathematics test was considerably noisier than in the baseline test, which resulted in less time for the students to fully focus on the calculations. In addition to this, some students were late for the second test, but still handed it in at the same time as their classmates. In TNHS, the difference-in-differences estimate was significant at a 10 % level, and the treatment group increased its test score by approximately one point more than the control group over the project's time period. This result indicates that the calculator did have a positive effect on test scores among students in the treatment group.

When the calculation problems were divided into different categories, none of the difference-in-differences estimates were significant. However, in TNHS the category with division was almost statistically significant. The category contained two calculation problems, and one of them required knowledge of decimals. The result implies that the highest positive impact of a calculator is found on the performance in mental arithmetic in which division and decimal numbers are used. Access to a calculator provides students with the opportunity to experiment with different calculations on the calculator, which may increase students' understanding of division and decimals. If the calculator evokes enthusiasm about mathematics, students may spend more time on complicated calculation problems, which facilitates increased knowledge of division and decimals. Moreover, improved performance in more complicated problems with division and decimals suggests that students who already have some basic knowledge in mathematics might benefit the most from access to a calculator.

As mentioned previously, the regressions in chapter 5.3 were performed to examine if different socioeconomic factors affect test scores at baseline, but also the change in test score over time. The regressions in which test scores at baseline is the dependent variable show what factors that negatively affect the numeracy skills among students. In relation to the fact that the maximum test score is 12 points, a two points lower score in the baseline test among students living with neither parent compared to those living with both parents is a rather large drop in test scores. Possible explanations might be that students who live with neither parent might have a larger responsibility for household chores, and hence less time to focus on mathematic studies. Moreover, parents may regard education of their children as an investment for future security since the Philippine society has a high emphasis on the family, which includes taking care of the elderly in the family. If the student does not live with his parents, such expectations of future security might not be present in the student's household and studying time might be less prioritized. That ownership of fewer schoolbooks negatively affects the test score at baseline is not surprising. Lower access to such important school supplies as schoolbooks reduces the possibility for students to study mathematics at home.

The regressions with the change in test score over time as the dependent variable show which students who benefit the most from having access to a calculator. As the number of siblings living at home increases, the change over time is reduced by 0.3 points. It is reasonable to assume that a higher number of siblings result in less time spent on studying mathematics and using the calculator, which leads to a lower change in test score. The coefficient for students living with one parent was almost significant. Students living with one parent might have less time over to use the calculator for schoolwork than students living with both parents; a reason for this might be that they have to spend more time on helping the single parent at home. Finally, students who stay at home more often to assist with household chores had a lower change in test scores than other students. Students who have high absenteeism miss out on some of the mathematics education; if they are lacking basic knowledge in mathematics, a calculator might be less useful. Moreover, enthusiasm about school overall and especially mathematics, might be lower among students with high absenteeism if they fall behind in the education. Finally, one explanation for high absenteeism could be that the student has to stay at home to work, assist with chores and to keep the family economy running. If this is the case, the student might have less time to spend on studying mathematics and using the calculator, than more fortunate students.

7. Conclusion

The significant difference-in-differences estimate in TNHS shows that access to a calculator does have a positive effect on numeracy. Moreover, the greatest improvements are made on more complicated problems based on division and decimals. This result implies that students who already have some basic knowledge in mathematics can use the calculator to extend their comprehension to more challenging problems. The implication of this result is that students who actively take part in the mathematical education in school benefit the most from having access to a calculator.

There are also other essential areas that need to be addressed in order to improve numeracy overall. A critical issue is that many children are not enrolled in school at all, and absenteeism among enrollees is high. The students who benefit the greatest from having access to a calculator are those who live with both parents, have a low number of siblings, and spend a significant amount of time in school. Hanushek and Woessmann (2012) discussed whether focus should be directed at low or high performers, concluding that both segments are mutually important. The same conclusion is applicable in this field study. To increase numeracy overall, efforts need to be focused on the students with lower performance in the initial test. In order to benefit from having access to a calculator, basic knowledge in mathematics is necessary. To increase numeracy among low achievers, higher enrollment rates and decreased absenteeism are critical. Among those students who did well in the baseline test, a calculator encourages the students to extend the knowledge in mathematics that they already possess, resulting in improved numeracy. Thus, efforts need to be focused on both low and high performers in order to increase numeracy overall.

To further evaluate the improvements a calculator could contribute to, additional research on the area is needed. In addition, the design of the research needs to cover a longer time-period. The current project lasted for seven weeks, but a more extensive time frame would give the students more time to use the calculators and yield larger improvements in numeracy. It is also important to reach all students, and not only those with already low absenteeism, to avoid underestimated difference-in-differences estimates. More extensive research on additional ways to improve numeracy through the education system, such as different kinds of schoolbooks or extended educational training for the teachers, is also of interest.

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Appendix 1

First name: ……………………………………………… Last name:………………………………………………

Age: ……………. Current school year: ………………

Put a cross in the box with the right answer. ☒

Boy ☐ Girl ☐

Catholic ☐ Protestant ☐ Muslim ☐ Other ☐

How long does it take for you to get to school?

Less than 15 minutes ☐ Less than 30 minutes ☐ Less than 60 minutes ☐ More than 60 minutes ☐

How do you live?

Live with both parents ☐ Live with mother only ☐ Live with father only ☐ Live with neither parent ☐

What do the ones you live with do for their living? (You can choose more than one)

Farming ☐ Fishing ☐ Meat production ☐ Logging ☐ Working in a store ☐ Tourism ☐ Other ☐

If you have any siblings, what are their names?

……………………………………………… ……………………………………………… ………………………………………………

……………………………………………… ……………………………………………… ………………………………………………

……………………………………………… ……………………………………………… ………………………………………………

……………………………………………… ……………………………………………… ………………………………………………

If you have siblings still living in <u>your</u> home, what are their names?

……………………………………………… ……………………………………………… ………………………………………………

……………………………………………… ……………………………………………… ………………………………………………

……………………………………………… ……………………………………………… ………………………………………………

……………………………………………… ……………………………………………… ………………………………………………

If you have siblings still living in <u>your</u> home, name the ones who work (not in school):

……………………………………………… ……………………………………………… ………………………………………………

……………………………………………… ……………………………………………… ………………………………………………

……………………………………………… ……………………………………………… ………………………………………………

Which, if any, of the following do you have?

Cell phone	Bicycle	Motorbike/tricycle
☐	☐	☐

Which, if any, of the following do you have at your home?

Radio	TV	Refrigerator	Electricity	Water pump	Latrine in the house	More than one room in the house
☐	☐	☐	☐	☐	☐	☐

Do you have any livestock? (You can choose more than one)

None	Sheep/goats	Cows	Pigs	Poultry/chickens	Other
☐	☐	☐	☐	☐	☐

***If you have livestock*, how many animals do you have?**

0	1	2	3	4	5	6	7	8	More than 8
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

How many textbooks do you have at home?

0	1	2	3	4	5	6	7	8	More than 8
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

How many new books did you get last semester?

0	1	2	3	4	5	6	More than 6
☐	☐	☐	☐	☐	☐	☐	☐

Have you during the last week used a textbook at home?

Yes	No
☐	☐

Have you done any homework in last week?

Yes	No
☐	☐

How often do you stay at home from school to help out with chores?

Never	A couple of days per year	One day per month	Two days per month	More than two days per month
☐	☐	☐	☐	☐

How many hours per day do you spend doing chores at home?

0	1	2	3	4	5	More than 5
☐	☐	☐	☐	☐	☐	☐

Do you like going to school?

Yes	No
☐	☐

Do you think mathematics is fun?

Yes	No
☐	☐

Appendix 2

Table 13. Significance analysis on baseline data (FLSMHS)

Francisco Lagan Senior Memorial High School			
	Treatment group	**Control group**	
Variable	**Mean (s.d.)**	**Mean (s.d.)**	**p-value**
Age	13.7 (0.97)	13.7 (1.08)	0.54
Gender	0.38 (0.49)	0.49 (0.51)	0.49
Religion			
Catholic	0.90 (0.30)	0.74 (0.44)	0.91
Protestant	0.05 (0.22)	0.06 (0.24)	0.74
Other	0.05 (0.22)	0.20 (0.41)	0.09*
Time to get to school			
< 15 minutes	0.29 (0.46)	0.30 (0.47)	0.93
< 30 minutes	0.45 (0.50)	0.52 (0.51)	0.76
< 60 minutes	0.14 (0.35)	0.15 (0.36)	0.82
> 60 minutes	0.12 (0.33)	0.03 (0.17)	0.33
Living arrangements			
Live with both parents	0.68 (0.47)	0.79 (0.42)	0.91
Live with mother only	0.15 (0.36)	0.09 (0.29)	0.71
Live with father only	0.07 (0.26)	0.06 (0.24)	0.80
Live with neither parent	0.10 (0.30)	0.06 (0.24)	0.88
Occupation of people in the household			
Farming	0.35 (0.48)	0.58 (0.50)	0.09*
Fishing	0.35 (0.48)	0.27 (0.45)	0.65
Meat production	0.00 (0.00)	0.00 (0.00)	0.91
Working in a store	0.03 (0.16)	0.00 (0.00)	0.92
Other	0.38 (0.49)	0.21 (0.42)	0.21
Siblings			
Number of siblings	3.00 (2.02)	2.94 (1.89)	0.90
Number living at home	1.71 (1.22)	1.57 (1.36)	0.94
Number living at home and working	0.24 (0.66)	0.17 (0.45)	0.94
Ownership of			
Cell phone	0.67 (0.48)	0.74 (0.44)	0.91
Bicycle	0.19 (0.40)	0.29 (0.46)	0.48
Available household accessories			
Radio	0.74 (0.45)	0.66 (0.48)	0.91
TV	0.52 (0.51)	0.49 (0.51)	0.91
Electricity	0.00 (0.00)	0.00 (0.00)	0.91
Latrine in the house	0.12 (0.33)	0.11 (0.32)	0.77
More than one room in the house	0.36 (0.48)	0.14 (0.36)	0.06*
Livestock			
None	0.00 (0.00)	0.09 (0.28)	0.18
Sheep/goats	0.10 (0.30)	0.06 (0.24)	0.85
Cows	0.14 (0.35)	0.29 (0.46)	0.21
Pigs	0.60 (0.50)	0.63 (0.49)	0.91
Poultry/chickens	0.40 (0.50)	0.37 (0.49)	0.95
Other	0.26 (0.45)	0.03 (0.17)	0.01***
Number of schoolbooks student owns			
0-2	0.26 (0.45)	0.29 (0.46)	0.98
3-5	0.38 (0.49)	0.34 (0.48)	0.91
6-8	0.07 (0.26)	0.06 (0.28)	0.85
> 8	0.29 (0.46)	0.26 (0.44)	0.98

How often student stays at home from school to assist with household chores			
Never	0.00 (0.00)	0.06 (0.24)	0.42
A couple of days per year	0.10 (0.30)	0.09 (0.28)	0.85
1-2 days per month	0.15 (0.36)	0.14 (0.36)	0.81
> 2 days per month	0.75 (0.44)	0.71 (0.46)	0.91
Hours per day doing chores at home			
0-2	0.37 (0.49)	0.48 (0.51)	0.45
3-5	0.29 (0.46)	0.21 (0.42)	0.64
> 5	0.34 (0.48)	0.30 (0.47)	0.92

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%
1. Gender is coded as a dummy variable where 1 is boy and 0 is girl.
2. Multiple choices were available for “Occupation of people in the household” and “Livestock”.

Appendix 3

Table 14. Significance analysis on baseline data (TNHS)

Tagumpay National High School			
	Treatment group	**Control group**	
Variable	**Mean (s.d.)**	**Mean (s.d.)**	**p-value**
Age	13.5 (0.99)	13.8 (1.14)	0.34
Gender	0.26 (0.45)	0.33 (0.48)	0.79
Religion			
Catholic	0.89 (0.32)	0.88 (0.34)	0.89
Protestant	0.07 (0.27)	0.04 (0.20)	0.92
Other	0.04 (0.19)	0.08 (0.28)	0.92
Time to get to school			
< 15 minutes	0.26 (0.45)	0.48 (0.51)	0.19
< 30 minutes	0.52 (0.51)	0.35 (0.49)	0.35
< 60 minutes	0.15 (0.36)	0.09 (0.29)	0.82
> 60 minutes	0.07 (0.27)	0.09 (0.29)	0.72
Living arrangements			
Live with both parents	0.96 (0.19)	0.79 (0.41)	0.89
Live with mother only	0.00 (0.00)	0.04 (0.20)	0.95
Live with father only	0.00 (0.00)	0.00 (0.00)	0.89
Live with neither parent	0.04 (0.19)	0.17 (0.38)	0.28
Occupation of people in the household			
Farming	0.92 (0.27)	0.91 (0.29)	0.89
Fishing	0.12 (0.33)	0.09 (0.29)	0.88
Meat production	0.00 (0.00)	0.04 (0.21)	0.95
Working in a store	0.00 (0.00)	0.09 (0.29)	0.42
Other	0.08 (0.27)	0.13 (0.34)	0.88
Siblings			
Number of siblings	1.70 (1.92)	2.50 (2.89)	0.25
Number living at home	1.07 (1.49)	1.21 (1.86)	0.92
Number living at home and working	0.22 (0.51)	0.25 (0.61)	0.94
Ownership of			
Cell phone	0.63 (0.49)	0.58 (0.50)	0.89
Bicycle	0.07 (0.27)	0.25 (0.44)	0.18
Available household accessories			
Radio	0.44 (0.51)	0.71 (0.46)	0.89
TV	0.44 (0.51)	0.46 (0.51)	0.86
Electricity	0.30 (0.47)	0.29 (0.47)	0.79
Latrine in the house	0.11 (0.32)	0.21 (0.41)	0.57
More than one room in the house	0.19 (0.40)	0.33 (0.48)	0.37
Livestock			
None	0.07 (0.27)	0.08 (0.28)	0.67
Sheep/goats	0.00 (0.00)	0.08 (0.28)	0.42
Cows	0.04 (0.19)	0.13 (0.34)	0.52
Pigs	0.63 (0.47)	0.75 (0.44)	0.89
Poultry/chickens	0.41 (0.50)	0.54 (0.51)	0.50
Other	0.26 (0.42)	0.17 (0.38)	0.65
Number of schoolbooks student owns			
0-2	0.41 (0.50)	0.21 (0.42)	0.22
3-5	0.44 (0.51)	0.38 (0.50)	0.83
6-8	0.07 (0.27)	0.04 (0.20)	0.92
> 8	0.07 (0.27)	0.38 (0.49)	0.02**

How often student stays at home from school to assist with household chores			
Never	0.07 (0.27)	0.04 (0.21)	0.89
A couple of days per year	0.11 (0.32)	0.17 (0.39)	0.82
1-2 days per month	0.41 (0.50)	0.39 (0.50)	0.86
> 2 days per month	0.41 (0.50)	0.39 (0.50)	0.86
Hours per day doing chores at home			
0-2	0.54 (0.51)	0.41 (0.51)	0.55
3-5	0.23 (0.43)	0.36 (0.49)	0.50
> 5	0.23 (0.43)	0.23 (0.43)	0.75

Notes:
*** Significantly different from zero at 1 %
** Significantly different from zero at 5 %
* Significantly different from zero at 10%
1. Gender is coded as a dummy variable where 1 is boy and 0 is girl.
2. Multiple choices were available for "Occupation of people in the household" and "Livestock".