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The Effect of Using XO Computers on Students' Mathematics and Reading Abilities: Evidences from Learning Achievement Tests Conducted in Primary Education Schools in Mongolia

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ABSTRACT

In 2008, Mongolia took part in One Laptop per Child (OLPC) project. Since that time, over 10,000 students in grades 2-5 in 43 primary education schools are using XO computers. This paper presents the findings of a study conducted in 2012 to evaluate the impact of the OLPC initiatives on students' literacy and math skills. This study covered 14 primary schools, of which 7 received XO computers and other 7 did not receive XOs. The schools were located in four provinces and two districts of Ulaanbaatar city of Mongolia. Over 2,000 5th grade students in these 14 schools were tested on Math and Reading skills, based on items from the 2008 National Primary Education Assessment. In addition to these tests, students were asked to respond to a questionnaire, which consisted of demographic and ICT-related questions and computer attitude measure for young student instrument. The findings of the study indicate that the use of XO may have enhanced students reading skills controlling for students gender, math scores, and hours spent for watching TV, doing homework and earning money.

Keywords: *OLPC; Primary Education; National Assessment Test; Math Skills; Reading Skills*

INTRODUCTION

The One Laptop per Child (OLPC) project is implemented by One Laptop per Child, a USA-based, non-profit organization created by faculty members from the MIT Media Lab. With the mission to empower the world's poorest children through education, this organization seeks to design, manufacture, and distribute sufficiently inexpensive laptops to every child in the world so that they can have access to knowledge and modern forms of education. The OLPC project allows children to use the laptops to access knowledge and to be engaged in their own capacity for learning, regardless of their physical location or financial limitations (OLPC, 2008). As of 2013, over 2.4 million children and teachers in 54 countries worldwide have received XO laptops (OLPC, 2013).

This article presents a brief description of the OLPC project in Mongolia, as well as a review of the OLPC literature. This is followed by our study methodology, and then followed by data analysis and findings. Within this study, over 2,000 5th grade students in 14 schools were tested

on Math and Reading skills tests, which were also used in 2008 National Primary Education Assessment. The study findings are discussed in light of relevant literature.

OLPC INITIATIVES IN MONGOLIA

OLPC project intended to improve the quality of education in Mongolia by achieving the following objectives: 1) providing access to computers and learning materials in order to improve teachers' skills; 2) creating a strong learning network that connects children and teachers at the national and international levels; 3) create community-based initiatives using laptop networks; 4) empowering teachers to foster student-centered methodology; 5) allowing students to apply their learning into their life and community; 6) enabling easy access to information; and 7) strengthening math and science (OLPC, 2008).

The President of Mongolia and the OLPC Foundation USA signed an Aide Memoire during the official visit of the former President Enkhbayar to the USA in 2007 (Embassy of Mongolia, 2007). With this initiative, Mongolia agreed to receive 20,000 XO computers for the school children. Specifically, it was agreed that 10,000 XO computers would be donated from the OLPC Foundation and the Government of Mongolia would purchase remaining 10,000 XO computers using state budget funding (nearly 1.2 billion tugriks or 1 million USD).

The Ministry of Education, Culture and Science (MECS) was in charge of managing the project nationwide. To follow up this initiative, the Government Cabinet resolution was approved in 2008 to establish the National OLPC Project Organizing Committee, to allocate state funding to finance OLPC activities, including OLPC Project Management Unit (PMU) staff salaries, customs tax, delivery cost of XOs to rural schools, additional equipment, basic teacher training, and development of Mongolian content (Government of Mongolia, 2008).

In early 2008, the OLPC Foundation donated the first 1,000 laptops to the Mongolian government, and two schools, one in Ulaanbaatar and another in rural area, were selected as pilot schools. OLPC Foundation funded all the activities needed for the start of the project. This initial support included provision of educational guidelines, installing the basic programs and infrastructure needed to run XO computers in schools such as setting up wires or VSAT, access points and local networking, development of criteria for school selection as well as OLPC technical assistance team visits.

The MECS set basic rules and responsibilities related to the distribution of XO computers. First, at the initial stage, schools with electricity would have priority to receive XO computers. Second, Internet connection fees for schools would be covered from school operating cost. Third, schools receiving XO computers would do so through an agreement with parents of children in grades 2-5. Fourth, the PMU would be responsible for computer delivery, preparing teachers, developing lesson plans using XO computers, as well as maintenance. Fifth, teaching and learning contents were to be expected to be developed using free and open source software (Ministry of Education, Culture and Science, 2008a).

The strategic goals of OLPC expressed a three-part vision. By 2015, all the students in grades 2-5 would receive XO computers; and thus, teachers would receive necessary training and training manuals for creating lesson activities using XO computers. Further, the promotion of e-textbook was to be installed into school servers. From the infrastructure perspective, the project aimed at establishing high speed IT network covering all schools.

In total, 12,100 XOs were distributed to 43 schools in Mongolia. In those 43 schools, all primary education students (and teachers) of grades 2-5 received XO laptops (Ministry of Education,

Culture and Science, 2008b). By the end of 2010, the following activities were implemented by PMU: 1) basic teacher training covered all teachers who received XOs; 2) content framework for XO computer use was developed for each grade level; 3) competition for students using XO computers were organized; 4) professional assistance to teachers for the use of XO computers were organized based on request from the provinces; 5) monitoring visits to school was organized for 23 rural schools and 19 schools in UB in 2010; 6) survey of 4,780 students on the use of XO computers were organized; and 7) provision of technical maintenance support to schools was conducted (OLPC PMU report, 2010).

PREVIOUS STUDIES

The OLPC project vision is based on constructionist theories of Papert (1980, 1993), who advocates independent, playful learning assisted by a tool to think with. This theory emphasizes enhancement of children's learning by combining guided and continuous self-learning. The initial idea of Negroponte (1996) for providing more learning opportunities to underprivileged children and Papert's constructionism, were reflected in five core principles of OLPC project, namely, child ownership, low ages, saturation, connection and free and open source.

The term "One-to-One" refers to the ratio of digital devices per child so that each child is provided with a digital device, most often a laptop, to facilitate learning (Severin & Capota, 2011). Despite considerable body of research on one-to-one experience of students, few studies have examined the impact of using computers on students' academic achievements.

A recent study of OLPC program in Peru by Santiago, Severin, Cristia, Ibarrarán, Thompson, & Cueto (2010) employed a similar study experimental design. Treatment (OLPC) and control (non-OLPC) groups of schools were formed and assessment was done comparing the two groups. The study found better attitudes and expectations among teachers and parents in the treatment group. For example, students with OLPC experience were more critical of school work as well as their own performance and a greater development of technological skills was seen among them. However, no impact was observed in learning.

A synthesis of research on the implementation and effects of one-to-one initiatives allows us to conclude that the studies that did measure outcomes consistently reported positive effects on technology use, technology literacy, and writing skills (Penuel, 2006). As this synthesis showed, there is a scarcity of OLPC research with rigorous designs.

A recent attempt of synthesizing OLPC programs in Latin America and the Caribbean was conducted by Severin and Capota (2011). Describing and summarizing one-to-one programs in over 20 countries worldwide, the authors distinguished economic, social and educational progress rationales that justify the implementation of OLPC projects. Economic rationales emphasize the development of human capital for global competitiveness and new labor market demands and social rationale aims to reduce digital divide and promote equity. Educational rationale of one-to-one programs is based on their potential for improving the quality of education, including potential for addressing internal efficiency, academic achievement and new skills required for the 21st century (2011). However, as the authors conclude, the effect of one-to-one laptop programs on academic achievement measures is largely unknown.

Math and reading abilities are important characteristics of academic achievement especially in primary education level. Although there are numerous studies which investigate factors influencing math and reading abilities of students, very few have focused on detecting effect of using ICT on these important abilities. As one of such example, Geske and Ozola (2008) found

that reading literacy of students was affected by the factors such as gender, number of books, number of children, father's education and mother's education. Tian's study (2006) suggested that math achievements can also be influenced by family background factors such as number of parents, number of siblings, and father's socioeconomic status.

STUDY GOAL AND OBJECTIVES

Based on prior studies and investigation, our goal of this study was to evaluate the impact of OLPC project on student learning in math and reading. According to education standards of Mongolia, all graduates of primary education must comply with the requirements of education standards. These standards specify the basic level of children's mathematics and literacy abilities that they should possess upon completion of primary education grades.

Based on the education standards requirements, two research questions for this study were formulated as follows:

1. Is there any difference in students' math and reading abilities between those who used XO and those who do not?

2. Are the children who used XOs in grades 2-5 better in their math and reading abilities as a consequence of using XOs compared to those who did not use XOs?

METHODOLOGY AND INSTRUMENTS

The data from 2008 National Assessment Test (NAT) was used as baseline data and the same test was administered in 2012 for the 5th grade students in the sample schools. This study was organized as a follow-up assessment of the National Assessment of Mongolian Language and Mathematics in 2008 administered by Education Evaluation Center (EEC) under the World bank-funded READ project. The assessment in 2008 was the first exercise to administer the large-scale student learning achievement in Mongolia with the goal of building the national capacity of education evaluation and education policy analysis. The two subjects assessment teams composed of experienced educators and curriculum developers were hired by EEC, and they developed and utilized detailed assessment blueprints that appear to be soundly based upon Mongolian curricula and draws upon relevant cognitive theories.

Specifically, the Math test covered four domains of mathematical competencies, namely, number and numeracy, algebra, geometry, and probability. About 70% of skills prescribed by primary education standards of mathematics were included for the assessment. As for the Reading test, three skills, including listening, reading and creative writing skills, were tested.

As for 2012 testing, two additional questionnaires for students were utilized. First, the questionnaire form was developed by the OLPC research team in order to reveal the level of using computers in everyday learning by students. For OLPC or treatment school students, extra questions about the use of XO laptops were included. The questionnaire forms were attached to the test booklets and were administered at the end of the test. Second, the international instrument, Computer Attitude Measure For Young Students (CAMY), designed to reveal the attitude of students towards ICT devices and their interests was used. This questionnaire was also attached to the test booklet and was administered for both treatment and control group students.

SAMPLING

In total, 4,750 students from 166 schools participated in the National Achievement Test (NAT) of Mathematics and Reading conducted during the school year of 2007-2008. These students who took part in the exam in each school were randomly sampled in 2008 from different student groups.

Of these 166 schools, only about 15 schools were introduced with the OLPC XO1 laptops in 2008-2009. Out of OLPC schools that participated in 2008 NAT, we selected schools that represent different regions of Mongolia. Thus, Khovd province from western region, Sukhbaatar province from eastern region, Dornogobi from the south and Darkhan-Uul from the north were selected. From nine districts of Ulaanbaatar, the capital city of Mongolia, three districts, Bayangol, Khan-Uul, and Songinokhairkhan were selected for the study. Once the province is selected, an OLPC school and a control school similar to OLPC school in the provincial center were selected in consultation with Education and Culture Department (ECD) of the province. Similarity included the aspects on school size, relatively similar level of student achievement, and distance from the province center. One of the criteria for OLPC school selection was that school policy allows students to take XO laptops home.

The final list of sample schools consisted of two groups, control (non-OLPC) and treatment (OLPC) each comprised of 7 schools. It was decided to conduct the same level of difficulty tests as NAT of 2008 for entire 5th grade students in both groups of schools. The following table presents a list of study schools.

***Table 1**: List of Sample Schools*

Province / District	School Name	Number of Grade 5 Students	OLPC Start Year	Taking XO Home Allowed?
Dornogobi	School # 3 (OLPC)	90	2008	Yes
	School # 2	156		
Khovd	Tsast Altai (OLPC)	125	2008	Yes
	School #2	155		
Sukhbaatar	Sukhbaatar School (OLPC)	215	2008	Yes
	Temuulel	227		
UB-Bayangol	School # 51 (OLPC)	94	2008	Yes
	School # 40	110		
UB-Khanuul	School # 52 (OLPC)	168	2008	Yes
	School #18	90		
UB-Songinokhairhan	School # 12 (OLPC)	177	2009	No
	School # 62	205		
Darkhan-Uul	School #4 (OLPC)	131	2009	Yes
	School #14	57		

Note. OLPC means treatment schools in which students in grades 2-5 use XO laptops.

STUDY DESIGN

The study uses quasi-experimental design with control and treatment groups of students. Math and Reading abilities of students are measured before and after the treatment, which in this case is the use of XO computers (see Figure 1). The study utilized difference in difference approach in measuring students' learning achievement: adjust difference between control and treatment groups by over-time progress and initial difference. In addition to comparison between XO and non-XO groups, a multivariate regression analysis method is used to determine net effect of using XO computers on Math and Reading abilities controlling for some other factors such as gender, family size, father's education level, mother's education level, family income, student's place for living, the way student comes to school, number of books in home, hours student spent for watching TV, doing homework, hanging round with friends, playing games and earning money.

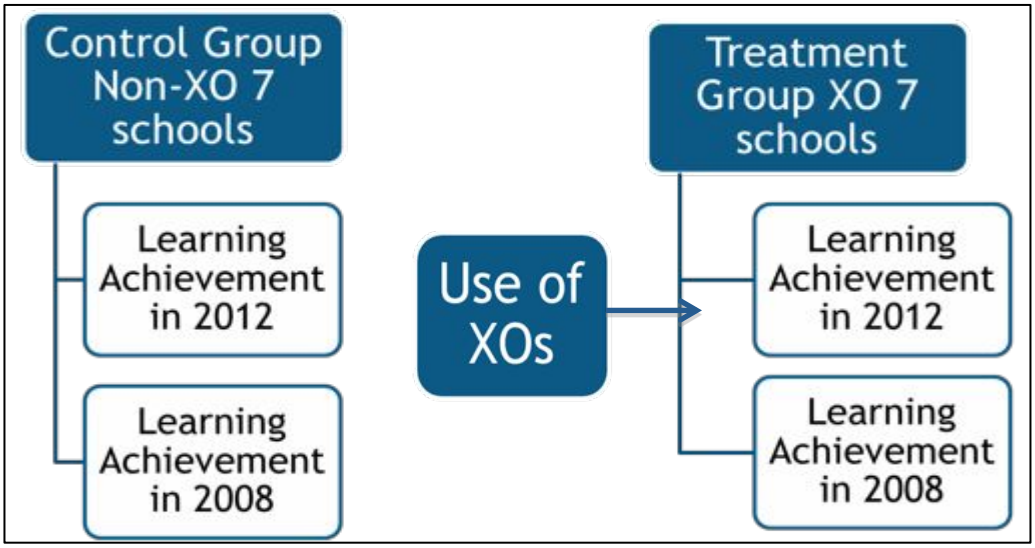

***Figure 1**: Study Design*

The study covered 14 primary schools (of which 7 received XO computers and other 7 did not receive XO computers) located in 4 provinces and two districts of Ulaanbaatar city of Mongolia. Over 2,000 5th grade students in these 14 schools were tested on Math and Reading skills tests, which were used also in 2008 NAT. In these tests, Math achievement was calculated as percent of right answers in total number of right answers and math score was the sum of right answers.

$$\text{Math achievement} = \frac{\text{Math score}}{44} \times 100$$

Reading (Mongolian Language) achievement was measured as combined score of students on reading, writing and listening test.

$$\text{Reading achievement} = \frac{\text{Listening} + \text{Rreading} + \text{Writing}}{49} \times 100$$

Reading score was the sum of right answers on the tasks 1-49. For the simplicity, in this article math and reading scores were used instead of their percentages as achievement indicators.

The data collection was conducted simultaneously in four provinces and three districts of Ulaanbaatar city between September and November in 2013. In order to conduct the study, the following main activities were implemented by the researchers: editing test booklets, layout design and preparing the final version for printing, contacting with all the schools and negotiating on conducting the study, developing OLPC questionnaire, developing manual for enumerators, hiring and training of enumerators for conducting Math and Reading tests, printing of booklets, preparing scoring guideline and database sheets, data collection at schools and quality control of data collection by research team members, developing variable coding, data entry and data analysis. In addition, the research team visited Khovd province, a site of research, in order to conduct interviews with teachers, school administrators and students.

DATA ANALYSIS

Demographic Information

In total, 2,011 5th grade students participated in the study. A half of the students studied in schools which did not receive XO computers, and the other half studied in OLPC schools and had access to XO computers at school (2-3 times in a week) and home. A little over 40% of students come from schools located in Ulaanbaatar city while the remaining students studied in schools located in the centers of 4 different provinces (see table). Gender composition of students was 51% girls and 49% boys. By ethnicity 96.4% was Khalkh-mongol, 2.3% -Khazakh and the remainder was distributed among Buriad, Durwud, Tuwa and others. The absolute majority of students (76.3%) come to the school by walking, 14% use public transportation and around 9% use private car or motorbike for coming to school. In terms of living, 89.3% live home, 9% of students stay together with relatives or family friends and 1.8% live in school dormitories.

***Table 2**: The Number of Students Participated in the Study by Provinces and UB Districts*

No.	Provinces and Districts of Ulaanbaatar	Number of Students	% in Total
1.	Darkhan-Uul	189	9.4
2.	Dornogobi	246	12.2
3.	Khovd	279	13.9
4.	Sukhbaatar	447	22.2
5.	Ulaanbaatar Bayangol district	206	10.1
6.	Ulaanbaatar Khan-Uul	263	13.1
7.	Ulaanbaatar Songinokhairkhan	383	19.0
	Total	2011	100.0

Difference in Difference

The quasi-experimental design employed in this study allowed comparisons of students' math and composite reading scores between OLPC and non-OLPC schools and between 2008 and 2012 studies. In this way, it was possible to detect net difference in students' math and reading scores between XO and non-XO schools adjusting for initial difference in 2008 and compare over-time progress in two groups.

In order to see if there was any initial difference in students' math and reading scores, national achievement test results of 2008 for the schools covered by this study were isolated from entire data set of 2008 NAT. Then, the average math and reading scores were calculated and T-test for independent samples was conducted between OLPC and non-OLPC schools.

There was a statistically significant (at 0.001) initial difference in math score between OLPC and non-OLPC schools. In 2008, OLPC school average math score was 17.03 compared to 15.22 of non-OLPC schools (see table 3). However, in terms of reading abilities both groups performed similarly in 2008 (21.99 vs. 22.02), the difference was not statistically significant (see table 3).

***Table 3**: Math and Reading Initial Differences*

	Group	N	Mean	Std. Deviation
Initial Difference in Math Score in 2008	Non-OLPC	208	15.22	5.53
	OLPC	215	17.03	5.82
Initial Difference in Reading Score in 2008	Non-OLPC	208	22.02	9.30
	OLPC	215	21.99	8.38

Table 4 compares math and reading scores of OLPC in 2012 and 2008. As we can see, the average math and reading scores in 2012 were much higher than in 2008: average math and reading scores increased by 6.69 and 6.39 points respectively. Similarly, average math and reading scores of non-OLPC group in 2012 also significantly exceed 2008 averages. Over the four years, average math and reading scores of non-OLPC schools increased by 6.95 and 2.64 points respectively (see table 5). This kind of improvement in students' math and reading abilities perhaps can be attributed to overtime improvements in quality of teaching and learning and other factors that have nothing to do with the computers. While increase in math scores in both OLPC and non-OLPC and the increase in OLPC reading scores were quite similar to each other, the progression of reading scores in non-OLPC schools was notably slow only 2.64 points over 4 year period.

***Table 4**: Math and Reading Scores in 2012 and 2008 in OLPC Group, Average Score (difference significant at 0.001)*

	Group	N	Mean	Std. Deviation
Math Scores in 2012 and 2008 in OLPC Group	2012	1006	23.72	8.30
	2008	215	17.03	5.82
Reading Scores in 2012 and 2008 in OLPC Group	2012	1006	28.38	9.49
	2008	215	21.99	8.38

***Table 5**: Math Scores in 2012 and 2008 in Non-OLPC Group, Average Score (difference significant at 0.001)*

	Group	N	Mean	Std. Deviation
Math Scores in 2012 and 2008 in Non-OLPC Group	2012	1005	22.17	9.28
	2008	208	15.22	5.53
Reading Scores in 2012 and 2008 in Non-OLPC Group	2012	1006	24.66	10.65
	2008	215	22.02	9.30

Table 6 compares average math and reading scores in 2012 between OLPC and non-OLPC schools. Independent sample t-tests were also conducted between OLPC and non-OLPC schools. As we can see from the table, average math scores of OLPC school students exceed average math score of non-OLPC school students by 1.55 points. This difference was statistically significant at 0.001 level. In terms of reading score, OLPC school students performed much better, 3.72 points higher than non-OLPC students.

***Table 6**: Comparison of Math Scores between OLPC and Non-OLPC Groups, Average Score (difference significant at 0.001)*

	Group	N	Mean	Std. Deviation
Comparison of Math Scores between OLPC and Non-OLPC Groups	Non-OLPC	1005	22.17	9.28
	OLPC	1006	23.72	8.29
Comparison of Reading Scores between OLPC and Non-OLPC Groups	Non-OLPC	1006	24.66	10.65
	OLPC	215	28.38	9.49

Figure 2 and Figure 3 illustrate math and reading scores in 2012 for OLPC and Non-OLPC groups.

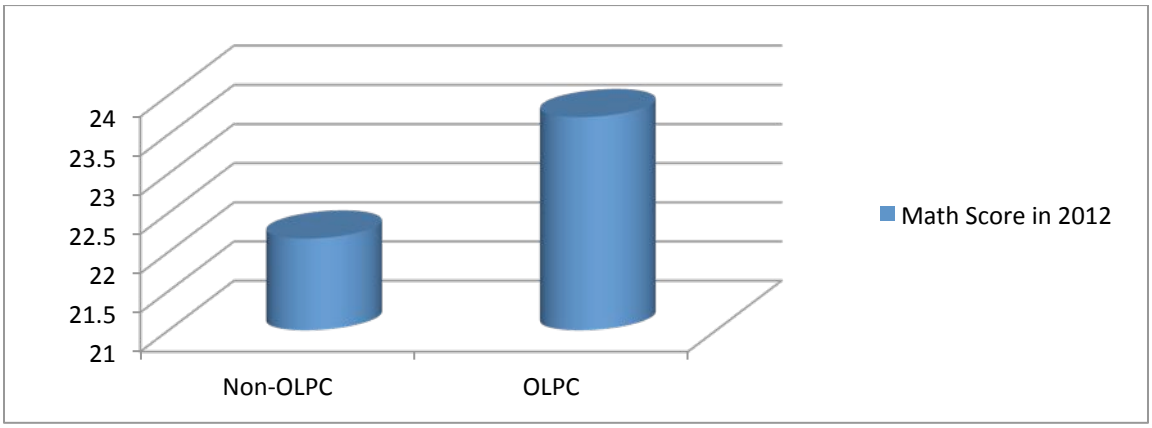

***Figure 2**: Math Scores in 2012*

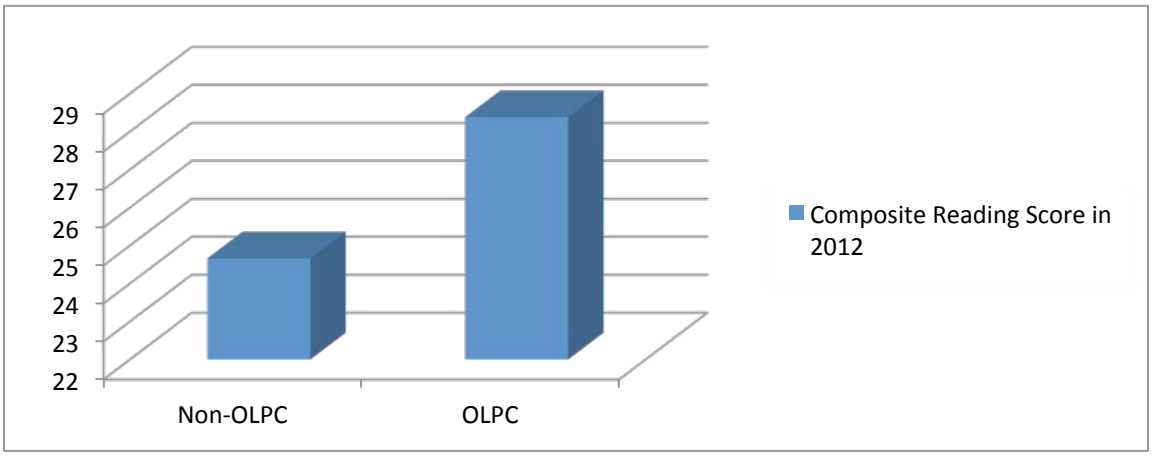

Figure 3: *Composite Reading Score in 2012*

Higher performance of 5th grade students using XO computers in math and reading tests compared to those who do not use XO computers can, of course, be attributed to the very fact of using XO laptops, in the absence of any other plausible factors. However, because we have data for 2008, before introducing XO computers, we should adjust these differences in math and reading scores in 2012 by the initial differences in 2008, before making any assumptions (See the following calculations).

Calculation of Net Differences (Difference in Difference)

Math

2012 difference between OLPC and Non-OLPC: 23.72-22.17 = 1.55
2008 difference between OLPC and Non-OLPC: 17.03-15.22 =1.81
Net difference = 1.55 – 1.81 = -0.26

Reading

2012 difference between OLPC and Non-OLPC: 28.38-24.66 = 3.72
2008 difference between OLPC and Non-OLPC: 21.99-22.02 = -0.03
Net difference = 3.72-(-0.03) = 3.75

These calculations show that

(a) In terms of Math scores there was virtually no difference between OLPC and non-OLPC schools: after adjusting by initial difference statistically significant difference in 2012 disappears.

(b) In terms of Reading scores, there was a statistically significant difference between OLPC and non-OLPC groups. This difference exists even after adjusting by initial difference forming a net advantage of OLPC students over non-OLPC students in reading score equal to 3.75 points.

Net Effect of Using XO Computers

Once we determined a difference in students' reading scores which was attributable to the use of XO laptops, we attempted to discern net effect of using XO computers controlling for some other factors. For this purpose a multivariate regression analysis was conducted with a dependent variable of reading score and independent variables such as math score, gender, use of XO computer, family size, father's education level, mother's education level, family income, student's place for living, the way student comes to school, number of books in home, hours student spent for watching TV, doing homework, hanging round with friends, playing games and earning money. Since our intention was not to determine the relationships between specific, pre-determined independent variables, we used stepwise procedure for entering independent variables, which allows gradual exclusion of variables that has insignificant effect on the dependent variable.

The most parsimonious model that SPSS multivariate regression analysis comes up with was as follows:

$$\mathrm{RS} = 7.11 + 0.56\mathrm{X1} + 2.48\mathrm{X2} + 2.48\mathrm{X3} + 0.68\mathrm{X4} - 0.38\mathrm{X5} + 0.37\mathrm{X6}$$

Where: RS was the dependent variable, Reading Score.
X1 – math score;
X2 – use of XO computer;
X3 – student's gender;
X4 – hours spent watching TV;
X5 – hours spent for earning money; and
X6 – hours spent for homework.

Model was significant at 0.05 and explained 30.6% of variations in reading score. This model suggests that the use of XO computers had a significant net effect on student's reading score controlling for students gender, math score, and hours spent for watching TV, doing homework and earning money.

Model also indicates that (a) Student's math skills can positively influence their reading score; (b) girls average reading score is significantly higher than that of boys; (c) those who spent more hours watching TV have better reading scores; (d) those who spent more time doing their homework have better reading scores; and (e) those who spent more hours for earning money have less average reading scores.

DISCUSSION

The main findings of the study can be summarized as the following six points.

First, there was a statistically significant initial difference in math score between OLPC and non-OLPC schools. However, there was no initial difference in students' reading scores. No initial difference in math and reading scores would be expected to exist if the schools were quite similar, especially in the quality of teaching and learning. However, small but significant difference in math score can be attributed to better math teaching in OLPC schools, because teacher factor has strongest correlation to student mathematics and reading performance (Linda, 1999).

Second, in terms of the comparison of test scores between 2008 and 2012, both math and reading scores increased significantly in 2012 compared to 2008 in both OLPC and non-

OLPC groups. However, for OLPC group reading scores increased at much higher rate than non-OLPC group. This finding can be better understood in view of Gulek and Demirtas (2005) study which suggests that the use of laptops may enhance students' grades for writing, English-language arts, mathematics and overall GPAs. In our case, the use of XO computers can be a factor that positively affected reading, writing and listening abilities of students.

Third, there was a statistically significant difference in reading score in 2012 between OLPC and non-OLPC groups. Reading scores of OLPC group exceeded non-OLPC by 3.72 points. Santiago, et al. (2010) study found that the students with a higher score in the reading comprehension test obtained 0.204 points more in the ICT test than those who obtained a lower score in the reading comprehension test. Similarly positive, but reverse relationship was found in our study: reading scores can be improved with the use of XO computers.

Fourth, after adjustment of the scores by initial difference between OLPC and non-OLPC groups, there was no difference in students' math scores between OLPC and non-OLPC groups. Although one of the objectives of OLPC in Mongolia was to strengthening math and science, this finding indicates that the initiatives did not meet this objective. It can be assumed that introducing one-to-one laptop does not automatically result in strengthening ability of math and science. Existing studies did not really detect big progress in math achievement as result of technology use, instead, a positive but modest effect on mathematical achievement can be produced by the application of educational technologies (Cheung and Slavin, 2013).

Fifth, net advantage of OLPC group over non-OLPC group in reading score was 3.75 points. This means that those who used XO computers gained 17% advantage over the average reading score of 2008. Underlying mechanism of such advantage may be related to the fact that XO computers provided more reading opportunities for the students. Students provided with XO laptops obviously spent more time using the computers i.e. exploring different applications and reading contents that were translated into Mongolian.

Sixth, multivariate regression analysis suggests that the use of XO computers may enhance students reading ability controlling for students gender, math scores, and hours spent for watching TV, doing homework and earning money.

This finding is also consistent with previous studies which found that the use of laptops can influence writing skills because reading score in our case is actually a composite of reading, listening and writing scores (Penuel, 2006; Gulek & Demirtas, 2005).

It was found that some family background variables had net effect on reading scores in addition to the use of XO laptops. Similar findings have also been demonstrated by several studies. For example, Aksoy and Link (1999) and Trautwein (2007) found that homework and time spent on homework can positively affect the achievement. Geske and Ozola (2008) found that reading literacy of students was affected by the factors such as gender, number of books, number of children, father's education and mother's education. Watching TV usually has a negative effect on the achievement (Geske & Ozola, 2008; Aksoy & Link, 1999). However, in our study, hours spent watching TV had a net positive effect on reading score. This finding can be understood in the rural school context of Mongolia, in which, TVs often serve as a main source of information and educational content.

CONCLUSION

In conclusion, the findings of our study contribute to the body of research that shows positive effect of using XO computers on students' academic achievement. This study for the first time points out that the use of XO computers may enhance students reading ability controlling for students gender, math scores, and hours spent for watching TV, doing homework and earning money. Further research in this direction is needed to provide more evidence on the effects of using XO computers.

There are two aspects that the readers should bear in mind when using findings of this study.

First, the schools, training managers and teachers were cooperative in administering the study. Some training managers helped to organize the classes ready for test administration. However, teachers feel quite sensitive when their students need to take tests that measure their knowledge related to education standards. Because teachers thought that the results of the study can be used to judge teachers work performance which often affect their wages and salary, we should be aware that some teachers may have tried to help students to answer the questions. This would affect test results. However, research team provided necessary explanations and tried to persuade teachers on proper administration of the tests.

Second, a clear limitation of the study is the relatively small number of students who participated in 2008 national assessment test from two groups of schools selected for test administration in 2012. Out of 4,750 students covered by 2008 assessments only about 200 (one class of 30 students per school) come from either from OLPC or non-OLPC schools selected under our study. Therefore, readers should bear in mind that the comparison of 2012 and 2008 math and reading scores are based on the means for entire 5th grade students in 2012 and the means of one class in 2008.

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