# Is the Social Network an Effective Factor When Using Tablet PCs for Learning? Evidence from a Field Experiment in Chinese Migrant Primary School

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**Abstract**

Education is an important factor related to a country's economic development, thus, there are a number of resources focused on how to improve educational outcomes. With the development of technology, scholars pay attention to technological learning methods such as computers, mobile phones and tablet PCs to increase students' learning abilities and academic scores. Some of previous studies have shown that technological tools may have a positive impact on students' learning, but there are various factors which may effect students' improvement rather than the technological tool itself, such as gender, grades, subjects and so on. This thesis is written to investigate if the social network factors between students who use tablet PCs for learning have any effect on their test scores using evidence from a migrant primary school in China.

**Biographical Sketch**

Yupeng Li graduated from School of Social Sciences and Behaviors at the University of Arizona with a Bachelor degree majoring in Economics and minoring in Mathematics and Business Administration in May 2012. Immediately after graduating from U of A, Ms. Li joined Charles H. Dyson School of Applied Economics and Management at Cornell University, and her research concentrations are development and experimental economics.

My thesis is dedicated to my parents, Xiaoyun Li and Aiqing Song. Without their support, I would not complete my graduate degree. Especially, during my last semester at this program, my father passed away suddenly without any forecasting, it is extremely pity for me that I am unable to have a look at him before he left us.

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Lastly, I want to specially acknowledge that Professor Ng provides me such a valuable opportunity to take part in the research project "*Bridging the Digital Divide: A Knowledge Enrichment Program for Migrant Children"* which is the basement of my degree thesis.

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# Chapter 1 Introduction and Background

Despite decades of investment in educational programs, nearly 18 percent of adults worldwide are illiterate and uneducated (UNESCO 2008). Especially in developing countries, the number can be over 20 percent. Therefore, for most developing countries, it is a priority for the government to improve their school enrollment and education quality. (Carrillo, Onofa, & Ponce, 2010) More and more policy makers tend to agree that the enhancement of these two fields could eventually contribute to the growth of productivity and promote long-term economic growth. Nevertheless, how to figure out efficient ways to solve these two problems is always a great challenge for the government (Carrillo, Onofa, & Ponce, 2010). Education has often been considered as a determining factor of economic well-being. In general, there are three academic frameworks to explain why education may affect the economic growth. First of all, education can reinforce the human capital inherent in the labor force, thus promoting the growth of productivity (Mankiw et al. 1992). Second, education can improve the innovation capacity for the society, which could be transformed into new technology and therefore promote economic development (Lucas 1988, Romer 1990, Aghion and Howitt 1998). Third, education can facilitate the diffusion and transmission of knowledge that is essential to understand how to process new information and successfully implement new technologies devised by others, which again promotes economic growth (Nelson and Phelps 1996, Benhabib and Spiegel 1994).

For politicians, educators, parents and researchers, most of them widely acknowledge that technology is an effective method to improve the quality of education (Angrist and Lavy, 2002). In fact, one of the earliest forecasted technologies applied into schools was Thomas Edison in 1922 and he stated “motion pictures” would revolutionize education (Israel, 1998, p.442). In the 1950s, psychologist B.F. Skinner estimated that “teaching machines” would improve learning quality in the schools remarkably in the future (Skinner, 1954, 1958). In the 1990s, the utilization of computers in education generally became more frequent. Even in those schools in developing countries, an increasing number of teachers and students are interested in the educational use of computers (Angrist and Lavy, 2002). With the rapid development of technology, traditional desktop computers became smaller, lighter and thinner, then laptops, smart mobile phones and tablet PCs appeared. Computers still play an active role in all educational aspects, however in the 1990s, the majority of people prefer to use laptops, smart mobile phones and tablet PCs which can be carried with everywhere, especially now that they can access to the Internet. In daily life, users can take advantage of laptops, smart mobile phones, and tablet PCs to access to the Internet for searching information and news, as well as for learning. In recent years, such technological methods as telecommunications, computers, mobile phones, tablet PCs and software are integrated into a whole as Information and Communications Technology (short as ICT).

Many countries were making their efforts to popularize the use of technology in education by investing in computers in schools (Organization for Economic Co-Operation and Development [OECD], 2001). For instance, the Australia government invested about 4.3 billion dollars on educational technology in 1999 and 2000 (Hall& Higgins, 2005). In the United States, schools spent more than 5 billion dollars per year on computers (MDR 2004) while in the United Kingdom, the expenditure on computers and technology in secondary schools almost doubled from about £40,100 to £75,300 per school between 1998 and 2002 (Machin, McNally & Silva, 2006).

With the prices of technological equipment declining, such as computers, smart phones and tablet PCs, the use of technological devices in the schools is increasingly popular, both in developed countries and developing countries. Even some public schools in developing countries with poor economic conditions pay attention to ICT methods so as to improve the quality of education.

For instance, in order to improve children's reading and mathematics abilities, the Thai Government launched the "One Tablet PC Per Child" (OTPC) program and distributed 800,000 tablet computers to grade-one students nationwide in 2012 (Pruet, Ang & Farzin, 2014). In addition, some scholars built a project named "ABC" to teach students who took an adult education program in Niger, to learn how to use simple mobile phones, so that the quality and persistence of educational gains could be promoted (Aker, Ksoll & Lybbert, 2012).

Moreover, there are a series of previous studies showing that ICT in the classroom could positively impact students' academic learning, while others have found that it could not. However, most of these studies mainly focus on mobiles and computers' influence on the academic teaching, while few pay attention to tablet PCs' impact. Among those studies that care about tablet PCs' influence on education, most of them only regard the tablet PC itself as a dominate factor causing individuals' changes, instead of taking into consideration any other interactive factors such as the influence of social networks on each participant.

This paper tries to explore whether the social network, which is composed of students who use tablet PCs for learning, can cause their academic test scores' to improve. In order to analyze this issue, we created a survey based on the research project called *Bridging the Digital Divide: A Knowledge Enrichment Program for Migrant Children* which is conducted by Professor Ng (my advisor) at Cornell University and The Youth Foundation of Hong Kong from a primary school in Beijing, China.

What distinguishes this study is, all of the students in this primary school are "migrant children" whose parents are "migrant workers (in Chinese 农民工)", which is one of the Chinese

Characteristics. Since the Chinese government adopted reform and opening-up policies, people have witnessed more and more rural migrant workers moving to the cities to improve their living standards. Migration workers usually come from all other parts around China especially regions with poor economic conditions. They move to a metropolis (etc. Beijing) to do manual work with low salaries, and gradually form a special group after great economic and social transformation happened in China, the special group has also led to a series of problems what the Chinese government has to deal with in the modernization process. Especially since the 1990s, the scale of floating population in China has continuously expanded, and the structure of floating population also changed obviously. One of the most remarkable changes is that a new characteristic in the migration process appeared then: a transition from individual-based to family-based. With the appearance of family-based floating population, the education of children in floating population has become a crucial problem and the focus of the whole society as well. For instance, they don't have time or capacity ability to take care of their children who become the so-called migrant children, so their children have to be left in migrant primary schools studying and living.

Due to the particularity of such kind of migrant primary schools, it is hard to find out qualified teachers, facilities or teaching appliances. Several current situations of migrant primary schools can be described as follows: 1) All of the students come from migrant family, whose parents cannot afford high tuition because of their corresponding low salary. The tuition of migrant primary schools is more affordable. Tuition is one of the most significant income for a school to update its facilities and attract qualified teachers. 2) The teaching faculty is not stable, and teachers' turnover is higher than for regular primary schools because migrant school cannot pay -abundant wages for them. Therefore, few or no qualified teachers are willing to work in these migrant schools. 3) Deficient funds formigrant school lead to lack of teaching appliances. They do not have enough money to purchase advanced high technology learning appliances for students, in fact, they are even unable to provide regular technology teaching appliances the same as other regular primary schools.

The migrant school where the research project conducted is relatively formal among migrant schools. There are almost seven hundred students in this school from grade one to grade six. However, there are only thirty-four teachers in this school, four of whom graduated from universities and the rest from colleges.

The paper describes detail in the participating students in this migrant primary school in Part 3 “Methodology and Participants”. The related data acquired and collected from this project at this migrant primary school will be explained in Part 4 “Data and Estimation Strategy”.  An OLS model was adopted to test whether the factors discussed have the effect on primary children’s academic scores or learning abilities.

# Chapter 2 Literature Review

There are a lot of studies showing that technological tools have an impact on students' learning and they are beneficial to the improvement of educational quality. For instance, Barrow et al. (2009) found that an instructional computer program for pre-algebra and algebra in the United States had a positive effect on test scores (about 0.17 of a standard deviation). Similarly, Banerjee et al. (2005) revealed that computer-assisted mathematics instruction improved mathematics scores of fourth-grade students in Vadodara, India (at least in the short run).

Other studies have found few or no correlations. For example, by using credible identification strategies, Leuven et al. (2007), Goolsbee and Guryan (2006), Angrist and Lavy (2002), and Rouse and Krueger (2004) found no evidence that the use of computers and software had a positive impact on student achievement. Additional researches investigated the circumstances under which the provision of ICT can be beneficial to student learning outcomes (Carrillo, Onofa, & Ponce, 2010).

As for those studies focus on using technology for learning, Ozdamli and Cavus (2011) mentioned that learner, teacher, environment, content and assessment are the basic factors of an effective mobile learning approach, but only if each of the factors could be prepared carefully then more efficient results and the best performances would appear. They described these basic factors as: 1) Learners at the center in all teaching and learning activities according to new education approaches; 2) Teachers convey books and other media elements which store information to student in traditional learning environments; 3) Content issues that expected to learn by students; 4) Environment must design properly to obtain positive learning experiences; 5) assessment is a critical component of the complete m-learning.

Aker, Ksoll and Lybbert (2012) used test score, demographics, assets, production and sales activities, migration and mobile phone ownership and usage as influence factors when they tested if mobile phones can improve adults' learning. They created a field experiment in Niger villages, and used the data to build an estimation equation:

(1) $test_{ivt} = \beta_0 + \beta_1 ABC_v + \beta_2 post_t + \beta_3 ABC_v * post_t + X'_{iv} + (e)cohort_v + (O-)_R + \varepsilon_{ivt}$

where ABCv*postt is the interaction between being assigned to the ABC treatment and a post indicator variable (the June test score rounds). The coefficient of interest is β3, which captures the average immediate impact of the mobile phone education program as compared with the basic adult education program, and is estimated by pooling across cohorts and years. The error term $\varepsilon_{ivt}$ captures unobserved student ability or idiosyncratic shocks.

In Motiwalla (2007)'s opinion, a useful mobile learning application is one of the most effective factors, to evaluate if an application will impact learning outputs, they observe the usage of this application in a classroom setting with students and obtain student feedback on their m-learning applications and determine the student opinions on the role and value m-learning applications, generally after participating in their study. Their study indicated that although the students acknowledged their application as useful and a good complimentary tool for the classroom interaction, when considered it into students' scores, there were not significant differences.

Fairlie and Robinson (2013) considered test score, gender, ethnicity, immigrant, parent's education, language, and household information as factors when they carried out an experiment at school to figure out the effects of home computers on school children's academic achievement. They present coefficients from the following regression:

$Y_i = \beta_{pc} * D_{ip} * C_i + \beta_{pt} * D_{ip} * T_i + \delta X_i + \varepsilon_i$

In the regression, $D_{ip}$ is an indicator for whether individual i is in the pth percentile of the pretreatment GPA distribution. Percentiles are calculated within each school and are restricted to 20 different percentile categories. $C_i$ is an indicator for the control group, and $T_i$ is an indicator for the treatment group. Thus, $\beta_{pc}$ and $\beta_{pt}$ are estimates of the relationship between pre- and post treatment performance in the control and treatment groups, respectively, and the difference, $\beta_{pt} - \beta_{pc}$ provides an estimate of the treatment effect at the pth percentile. $X_i$ is a minimal set of controls.

To investigate new evidence on classroom computer impact on pupils' learning, Angrist and Lavy (2002) collect test score, teacher's teaching information, and school's information as data. They assume that potential test scores are estimated by:

$Y_{is}=W'_s r+X'_i B+c_{js}x+g_s+e_{is}$

where $y_{is}$ is the test score for pupil i in school s, $W_s$ is a vector of school characteristics and $X_i$ is a vector of pupil characteristics. The regressor of interest, $c_{js}$, is either a dummy indicating whether the level of computer-use is greater than or equal to j (j=1, 2, 3), or the CAI intensity itself, which they denote $c_s$. The CAI intensity is coded from their teacher survey. Since all pupils tested in the same subject and grade have the same teacher, in practice $c_{js}$ and $c_s$ vary only with s. The other school characteristics, $W_s$, include the proportion of disadvantaged pupils in the school and the school's priority ranking in the Tomorrow-98 allocation process. The pupil characteristics, $X_i$, include sex and immigrant status. The error term $g_s$ is an identically and independently distributed (iid) random school effect that is introduced to parameterize within-school correlation in scores. The remaining error component, $e_{is}$, is specific to pupils. The coefficient, x, is the parameter of primary interest. The empirical analysis uses test scores in standard deviation units, so the estimates have an 'effect size' interpretation.

Ferrer, Belvis and Pamies (2011) adopted type of school, gender, place of birth, parent's level of education, and parent's work as factors to analyze the tablet PCs' influence on academic results at schools. Their results suggest: 1) to a greater or lesser extent, tablet PCs can contribute towards reducing the differences between the positions that boys and girls take in relation to ICTs at more advanced; 2) students who consider that their grades have improved the most with the use of tablet PCs are those that have a worse academic record on average; 3) tablet PCs have strong impact on learning processes for pupils born outside of Spain; and 4) here exists a stronger relationship between the mother's level of education and the impact of the tablet PC on the pupil's learning processes.

To understand tablet PC usage among primary school students in underdeveloped areas, Pruet, Ang and Farzin (2014) investigate the effects of the demographic profile of students, technology experience, students' learning styles, and attitudes towards tablet computer. Their findings are: 1) it is easier for boys to use technology tools for learning than girls; 2) students who preferred auditory, visual and high competitive learning style were more likely to have high anxiety on tablet computer learning; 3) tablet PCs' use seemed to have significant benefits for weak learners relative to average learners.

An additional study related to the use of tablet PCs in education is a focus on higher education in a university in Spain where Santamarta, Hernandez-Gutierrez, Tomas, Cano, Rodriguez-Martin and Arraiza (2014) state it is essential to use tablet PCs with a clear purpose in the classroom for learning. While there are several studies talk about “social networks” on learning process without mentioning ICT learning, none of them pay attention to “social network” factors when students use technological tools for learning nowadays.

After a survey created for college students, Bicen, Sadikoglu and Sadikoglu (2015) state that there is a positive effect of social network on learning foreign languages. However, their study does not focus on social networks between students but between students and teachers/instructors.

Another analysis is conducted by Molano and Polo (2015) to test social networks in a learning community, where they conclude the social network built on this research shows a low density, reflecting little cohesion between all the factors. The relationships formed in the social network are characterized by cooperation, trust, and solidarity. However, their study does not focus on social networks in school learning.

# Chapter 3 Methodology and Participants

## 3.1 Prerequisite Research Project

The research project, called *Bridging the Digital Divide: A Knowledge Enrichment Program for Migrant Children,* was conducted by professor David T. Ng (my advisor) at Cornell University and The Youth Foundation of Hong Kong, with the aim of improving migrant children's academic test scores and learning abilities by using tablet PCs as their learning tools.

The first pilot program took place from the end of April 2013 to the early July 2013, the second pilot program lasted from September 2013 to Jan 2014, and from Feb 2014 to July 2014 the third pilot program took place. During the research, I was working as a research assistant for all the three pilots. The participants in total are more than 500 migrant children from grade four to grade six in this primary school during all the three pilots.

In the first pilot program, both of the experiment group and control group were composed of only grade six migrant children, and there were three classes in grade six. Each class has about 32 to 42 students and 109 students in total. The research assistants distributed tablet PCs to certain students randomly which meant they were in the experiment group. Usually 2 or 3 students shared a tablet PC, but several students were selected at random who did not need to share tablet PCs (they can use tablet PCs individualy). Each student could use the tablet PC both at home and at school for 2 or 3 days per week. The research assistants installed some learning applications in the tablet PCs and imposed restriction on their use of the Internet in these tablet PCs to avoid them from playing games or searching websites unrelated to learning. It meant that they could only search websites about pupils' encyclopedia and watch videos about pupils' mathematics (other research assistants downloaded these videos from Khan Academy and I translated them into Chinese). The students who did not receive the tablet PCs were members of the control group. Tablet 1, 2 and 3 show the basic distribution of participants in Pilot 1.

Before the experiment group began to use tablet PCs, the researchers carried out a standardized mathematics test in April 2013 for both of the experiment group and control group, and these test scores were used as baseline scores in Pilot 1. In July 2013 (at the end of Spring 2013 semester), the researchers conducted another standardized mathematics exam as final scores in Pilot 1 on students in both experiment group and control group. Both the baseline and final standardized mathematics exam followed the same format with 33 questions (one point per question), and they had a similar level of difficulty. Figure.1 revealed the basic statistics results about Pilot 1 experiment program after calculation of differences between their baseline scores and final scores conducted.

In Pilot 1, the average score in the baseline Standardized Math Test of the experiment group is 20.1944 (std. 6.5239), 1.4339 higher than the control group which is 18.7606 (std. 7.0680). The average score in final Standardized Math Test of experiment group is 22.7778 (std. 6.6423), which is 1.8764 higher than control group with 20.9014 (std. 7.4453). As it can be seen from Figrue.1, , in Pilot 1 the average scores of whole experiment group are higher than control group both in baseline test and final test. It is also obvious that in Pilot 1, math performance /scores of students from experiment group are much better than control group at least according to our standardized math test results. Additionally, the average improvement of experimental group is 2.5834 (std. 6.1522), which is 0.4425 higher than control group with 2.1409 (std.7.2709). It indicates that experimental students who learn by using tablet PCs have more obvious improvements in their math scores than those students without tablet PCs for learning.

In the second experiment period from September 2013 to Jan 2014 (Fall 2013 Semester), the number of students who participated in the project increased from 109 to 212 with extension of scope, they came from grade four, grade five and grade six. Still the researchers randomly selected students as experiment group or control group, and 62 out of 212 were in experiment group while others were in control group. Tablet 4, 5 and 6 show the basic distribution of participants in Pilot 2.

The researchers repeated what they did during the first pilot program. Figure.2 indicates the basic statistics results about the second experiment program.

In Pilot 2, the average score in baseline Standardized Math Test of experiment group is 13.8136 (std.4.7723), which is 0.9837 lower than control group with 14.7973 (std. 5.5706). The average score in final Standardized Math Test of experiment group is 14.8644 (std. 5.9145), which is 0.4101 lower than control group with 15.2745 (std. 6.1272). It is reasonable to assume that, in Pilot 2 the average scores of whole experiment group both in baseline test and final test are lower than control group which is quite different from Pilot 1. Admittedly, experimental students' original math performance/scores are worse than control group at least based on our standardized math test results. However, the average improvement of experimental group is 1.0508 (std. 5.2471), which is 0.5736 higher than control group with 0.4772 (std. 4.2459). It indicates that even with relatively weaker abilities and scores in math experiment group students still show more obvious improvements in the standardized math test after using tablet PCs for learning, than those students who without tablet PCs for learning.

In the third pilot period from Feb 2014 to July 2014 (Spring 2014 semester), 221 students in total took part in the research program, among which 12 students missed some of their scores so we dropped these 12 observations. Tablet 7, 8 and 9 show the basic distribution of participants in Pilot 3.

The researchers carried out similarly as they did during the first and second pilot. Figure 3 shows the basic statistics results about the 3$^{rd}$ pilot program.

In Pilot 3, the average score in baseline Standardized Math Test of experiment group is 16.8358 (std. 6.5842), which is 1.3067 higher than control group with 15.5282 (std. 6.7485). The average score in final Standardized Math Test of experiment group is 17.2687 (std. 6.9687), which is 1.5098 higher compared with control group, the average of which is 15.7589 (std. 6.9805). It is evident that in Pilot 3 the average scores of the whole experiment group both in baseline test and final test are apparently higher than control group. Also, it can be concluded that in Pilot 3 there is no doubt that experimental students' math capability /scores are better than those of the control group resulted from the standardized math test results. Undoubtedly, the average enhancement of experimental group is 0.4328 (std. 5.3007), which is 0.3131 higher than control group with 0.1197 (std. 4.7736). From the different levels of improvement, it is easy to estimated that although both experimental group and control group have few obvious improvements, students who use tablet PCs for learning still have relatively larger improvements in the standardized math test than those students who don't take advantage of tablet PCs for learning.

Additionally, the researchers also did a case interview during Pilot 3 to learn students and teachers' attitudes towards experiences in this research project, which also contribute a lot for the whole reasonable outcome.

### 3.2 Following Survey and Data to Test "Social Network" Factors

According to the results discussed above, tablet PCs will promote children's academic scores as a learning tool at least in mathematics. The effective factor is the dummy variable "if a child receives a tablet PC for learning". To investigate if the factor "social network" will have an impact on the improvement of students' academic scores, the following survey was created to collect more information in Pilot 2. There are 57 out of 59 (the total experiment group number in Pilot 2) students participated in this survey. Table 10 shows the grade distribution of following survey in Pilot 2.

In this survey, students were asked four questions:

1) Which kind(s) of themes do you plan to search for or learn by using tablet?

2) How many minutes or hours do you plan to spend for tablet learning?

3) Do you know who is sharing the same tablet with you? If yes, what's his/her name?

4) Will you communicate with your group member(s) about his/her searching or learning information of tablet?

Among these four questions, question (3) and question (4) are most relevant to the social network factors which should be focused on. It is quite reasonable to assume that the students who shared with the same tablet would communicate with each other about their tablet learning information so that their tablet usage times and preferences would have some relationships.

The basic statistics of the following survey are listed as below:

For Question (3) 100% of the 57 participants knew who shared the same tablet with them, and 100% of them knew their partners' names.

Table 11 shows the answers distribution of Question (4). 52.63% of participated students sais they would communicate with their partners about what they searched and learned by using tablet PCs, and also they would search and learn what their partners did.

Additionally, during each pilot program period, the teachers at school cooperated with the researchers to withdraw students' tablet PCs, and to collect students' usage records, so that the researchers can recognize how much time a student spent on any learning materials via tablets (etc. encyclopedia readings, math videos, and fairy tales) and analyze the relationship between usage time/types and score changes.

It is also one of the most important sources to estimate if children's social networks on using tablets for learning will impact on each other's academic scores during the pilots. Since if two or three students share the same tablet, the usage of learning files name and times will be coded as the same number, so that it can be easily figured out if group members' usage of learning materials and times will effect each other in the same group. With such kind of method, it is effectively to get record of tablet usage with 38 out of 62 experiment group in total in Pilot 1 (11 out of 24 from Class 1, 14 out of 20 from Class 2, and 13 out of 18 from Class 3); 46 out of 59 experiment group in total in Pilot 2 (9 out of 17 from Grade 4, 11 out of 14 from Grade 5, 26 out of 28 from Grade 6); 56 out of 62 experiment group in total in Pilot 3 (14 out of 18 from Grade 4, 25 out of 25 from Grade 5, 19 out of 19 from grade 6).

# Chapter 4 Data and Estimation Strategy

### 4.1 Data Sources

There are three main sources of data. Firstly, standardized mathematics test scores in all three pilot periods and in total six standardized mathematics test scores (1 baseline in $1^{st}$ pilot program, 1 final in $1^{st}$ pilot program; 1 baseline in $2^{nd}$ pilot period and 1 final in $2^{nd}$ pilot period; and 1 baseline in $3^{rd}$ pilot period and 1 final in $3^{rd}$ pilot period). Secondly, the researchers collected students' usage records of tablets PCs for all three pilot programs but this data is incomplete due to some loss. Thirdly, the questionnaire created during the second pilot period to collect students' basic usage information on tablets and group members' information. Besides, I have the supplementary data where the researchers did a simple case interview with randomly selected students from experiment group and teachers in pilot 3 to learn more about their attitudes and experiences about the project.

### 4.2 Estimation Strategy

Before estimating the "social network" factors' impacts on students' academic outputs measured by test scores, it is assumed that some "social network" factors also may impact on students' learning time and habits. This assumption will be checked quickly by using two simple OLS models:

(1) $Mathhrs_i = \beta_0 + \beta_1 SocialMathhrs_i\ (+) + \beta_2 SocialMathhrs_i\ (-)$

(2) $Otherhrs_i = \beta_0 + \beta_1 SocialOtherhrs_i\ (+) + \beta_2 SocialOtherhrs_i\ (-)$

Where $Mathhrs_i$ is the hours student i spent on mathematics related learning material by tablet PC; $SocialMathhrs_i$ *(+)* is the hours student i's social partner(s) with improvement spent on math learning; similarly $SocialMathhrs_i$ *(-)* is the hours student i's social partner(s) with retrogress spent on math learning. $Otherhrs_i$ is the hours student i spent on other learning materials other than mathematics by tablet PC; $SocialOtherhrs_i$ *(+)* is the hours student i's social partner(s) with improvement spent on others learning; and $SocialOtherhrs_i$ *(-)* is the hours student i's social partner(s) with retrogress spent on others learning.

After regression, table 12 illustrates both variables "*SocialMathhrs*$_i$ *(+)*" and "*SocialMathhrs*$_i$ *(-)*" have a positive effect on student i's tablet PC usage time related to math learning, moreover these effects are close and extremely statistically significant (P-value is 0). Furthermore, both variables "*Socialotherhrs*$_i$*(+)*" and "*Socialotherhrs*$_i$*(-)*" have positive effects on student i's tablet PC usage time related to other study fields rather than math while these effects are also close and statistically significant (P-value is also 0). These results indicate that no matter a student's social partner has improvement or step backs, the tablet usage time and learning habit will influence a student's tablet learning time and habit. Table 12 shows the impact of social partner's tablet usage time and type on a student.

To estimate the impact of social network factors on primary children's academic outcomes when they use tablet Pcs for learning, we use a difference-in-differences specification.

Here, it is simply assumed *Difference*$_{igt}$ is the academic improvement/decrease between final standardized math test and baseline standardized math test measured by test scores for student *i* from grade *g* during pilot *t*. *Tablet*$_i$ is a dummy variable for whether student *i* is in experiment group and assigned to a tablet PC for learning (Tablet=1) or in control group (Tablet=0). *Baseline*$_i$, is a factor tested student i's previous academic performance measured by baseline standardized test scores. *Grade*$_i$ is the grade where the student i belongs to, if student i comes from Grade Four, then Grade 4 =1 (otherwise=0); if student i comes from Grade Five, then Grade 5 =1 (otherwise=0); if student i comes from Grade Six, then both Grade 4 and Grade 5 =0. *Irregularity*$_i$ is a dummy variable to check if there are any unexpected circumstances (etc. forgetting the next page of test papers or not answering questions seriously) happened during the standardized math tests which could possibly influence student i's test scores (Yes=1, No=0). *Gender*$_i$ is a dummy variable about student i's gender (Female=1, Male=0). *SocialPartner*$_i$ is an indicator variable to check whether there is any influence on student i's academic test scores contributed by "social network" factors, it equals to 1 if student i has a social partner to share the tablet for learning while equals to 0 if student i does not have a social partner to share the tablet. *SocialPartner*$_i$ (+) equals to 1 when student i has social partner(s) with positive *Difference* (improvement) in standardized math test scores;

otherwise=0. *SocialPartner*$_i$**SocialPartner(+)* is an interaction variable means student i has a social partner while his/her social partner has an improvement in test score. $SocialDifference_i$ (+) is the improvement in standardized math test scores of student i's social partner(s) and correspondingly $SocialDifference_i$ (-) is the decrease in standardized math test scores of student i's social partner(s).

Based on the information introduced above, education production equations are built as below:

(1) $Difference_{igt} = \beta_0 + \beta_1 Tablet$

(2) $Difference_{igt} = \beta_0 + \beta_1 SocialDifference_i\,(+) + \beta_2 SocialDifference_i\,(-)$

(3) $Difference_{igt} = \beta_0 + \beta_1 Baseline_i, + \beta_2 Irregularity_i + \beta_{31} Grade4_i + \beta_{32} Grade5_i + \beta_4 Gender_i + \beta_5 SocialDifference_i(+) + \beta_6 SocialDifference_i(-) + \beta_7 SocialPartner_i + \beta_8 Pilot2 + \beta_9 Pilot3 + \beta_{10} mathhrs_i + \beta_{11} otherhrs_i$

(4) $Difference_{igt} = \beta_0 + \beta_1 Baseline_i, + \beta_2 Irregularity_i + \beta_{31} Grade4_i + \beta_{32} Grade5_i + \beta_4 Gender_i + \beta_5 SocialDifference_i(+) + \beta_6 SocialDifference_i(-) + \beta_7 SocialPartner_i + \beta_8 SocialPartneri{*}Social\ Partner(+) + \beta_9 Pilot2 + \beta_{10} Pilot3 + \beta_{11} mathhrs_i + \beta_{12} otherhrs_i + \beta_{13} Tablet$

Where the error term $E_{igt}$ would capture unobserved influenced factors of students.

**4.3 Results**

Figure 4 depicts the average differences (improvements or decreases) on standardized math test scores for both the experiment group and control group. The experiment group is also divided into an experiment group with social partners (group members) to share a tablet PC for learning and an experiment group without social partners (group members) to share a tablet PC for learning (using a tablet PC for learning singly). Overall, the students in the experiment group with social partners (short for "sp" in figure 4) had a higher difference than the other two columns experiment group without social partners and control group on average.

Comparing the experiment group with social partners and the experiment group without social partners, the only different dummy variable between them is "social partner". The experimental group with social partners had an average improvement of 0.9474 (5.8985) between their final standardized math test scores and baseline standardized math scores; while the experimental group without social partners had a step back of 0.6 (3.4351) on average between their final standardized math test scores and baseline standardized math test scores. It indicates that if one only takes the average impacts of "social partner" on students' academic outcomes measured by standardized math test scores for experiment group into consideration, experiment students with social partners performed better than students that do not have social partners.

When comparing the experiment group without social partners and the control group (neither use tablets for learning nor have social partners), the only different dummy variable between them is "tablet". The control group (without social partners) have an average enhancement of 0.7187 (5.0543) between their final standardized math test scores and baseline standardized math test scores. It reveals that if one only considers the average impacts of "tablet" on students' academic outcomes measured by standardized math test scores for students without social partners, students do not use tablet PCs had a better performance than students who used tablet PCs.

Figure 5 shows the average differences (improvements or decreasing) on standardized math test scores for the experiment group which is divided into two categories: experiment group with social partners who have improvements in test scores and experiment group with social partners who have decreasing in test scores. Generally speaking, the students in the experiment group with social partners who had improvements (short for sp+ in figure 5) in math test scores have a higher average enhancement as 1.0455 (6.4735) than the experiment group with social partners who had decreasing (short for sp- in figure 5) in math test scores. It illustrates that an experimental student who had a social partner with improvement in test scores is more likely to behave better during math standardized tests than one who had a social partner with decreases in test scores.

Table 13 pools the data across all three rounds (Pilot 1, Pilot 2 and Pilot 3) and presents the results of equation (1), (2), (3) and (4). Using the simplest specification, the OLS regression shows several core results:

1) The regression outcome of Equation (1) shows the dummy variable "*tablet*" has a positive effect with 0.9186 on students' differences between final math standardized test scores and baseline math standardized test scores, which means, if student i receives a tablet for learning, his/her final math standardized test score will be increased by 0.9186, and this improvement is statistically significant at the 10 percent level of significance.

2) The regression result of Equation (2) indicates the variable "*SocialDifference(+)*" also has a positive effect with 0.0144 on students' differences between final math standardized test scores and baseline math standardized test scores. To be more specific, if student i's social partner has one point in improvement, student i's final math standardized test score will be increased by 0.0144, but this effect is not statistically significant. The variable "*SocialDifference(-)*" has a negative effect with 0.1782 on students' differences between final standardized test scores and baseline math standardized test scores, which shows if student i's social partner has a one point decrease, student i's final math standardized test score will be decreased by 0.1782, and this effect is almost statistically significant at the 10 percent level of significance.

3) The regression result of Equation (3) reveals the dummy variable "*SocialPartner*" has a positive effect with 0.747 on students' differences between final math standardized test scores and baseline math standardized test scores. So we could conclude that if student i has a social partner to share a tablet for learning, student i's final math standardized test score will be increased by 0.747, however this effect is not statistically significant.

4) The regression result of Equation (4) shows the interaction variable "Social Partner ***SocialPartner(+)*" has a positive influence with 1.8461 on students' differences between final math standardized test scores and baseline math standardized test scores. To make it more clear, if student i has a social partner and his/her social partner has an improvement in test score, student i's final math standardized test score will be increased by 1.8461, and this impact is statistically significant at the10 percent level of significance.

# Chapter 5 Conclusion

How to improve children's education quality and academic outcomes is a crucial issue for the educational system in many countries, especially in developing countries. Many studies have already analyzed the impact of information technology on education, but in addition to technological tools (etc. tablet PCs, computers, mobile phones and so on) themselves, whether there exist any other social factors related to technological tools usage. This paper assesses the impact of "social network" factors when students use technological tools for learning. Our study shows there are some slight social network effects.

Based on the above results, if a student has a social partner (etc. group member who shares the same tablet PC for learning), it will improve a student's test score, however it is not statistically significant. Therefore, it is necessary to divide students' social partners into two groups: social partners with improvements in tests and social partners with retrogresses in tests. The former has a **positive** effect on a student's test score and is statistically significant at 10 percent level of significance; while the latter has a **negative** effect on a student's test score but is not statistically significant.

Additionally, the greater the improvement in test scores a student's social partner has, the greater the improvement a student will have; conversely, the greater the decreasing in test scores a student's social partner has, the greater retrogress a student will have. However, neither of these two impacts are statistically significant at 10 percent level of significance, while they are statistically significant at the 20 percent level of significance.

Finally, the tablet usage time and category of a student's social partner will impact the student's tablet learning usage time (both in mathematics and others areas) and category significantly. The learning habit of a student's social partner could easily influence on a student's learning habit itself. However, there is no statistically significant evidence to prove that a student's tablet learning usage time does impact the student's academic outcomes measured by test scores.

In our daily life, not only children but also adults maybe influenced by the people surrounding us. In China, there is a proverb that says "one takes a color of one's company (近朱者赤，近墨者黑)", which means if a person always stays with a good people, s/he will get better and if a person always stays with a bad people, s/he will get worse. In this migrant school where our research project occurs, a student and his/her social partner communicate frequently since they share the same tablet PC for learning, therefore they will talk about the learning materials and learning time together. Inevitably, if a student feels some learning materials in the tablet PC is useful and interesting, s/he would possibly tell his/her social partner; and the same thing happens for the student's social partner. In this case, they affect each other's tablet learning usage time and habit and improve each other's scores. Otherwise, if a student does not use the tablet for learning (sometimes it happens since a few students unlock the tablets for playing games), it is possible that s/he shares a not academic experience by using the ablet for entertainment. Then both of the student and his/her social partner are more likely to decrease in their test scores.

In general, "social network" factors between students who applying technological tools to education may impact a student's academic outputs, but the effects are neither extremely clear nor strongly significant. To investigate this kind of "social network" factors further, it is essential to do more corresponding experiments and assess larger samples. However, one thing we can guarantee in this paper is, partner's learning habit does impact on a student's learning habit, and this impact is significant.

# Tables

**Table 1. Group Distribution in Pilot 1**

| Group | f | % |
|---|---|---|
| Experiment | 62 | 56.88 |
| Control | 47 | 43.12 |
| Total | 109 | 100 |

Note: f represents number of observations.

**Table 2. Class Distribution in Pilot 1**

| Class | f | % |
|---|---|---|
| Class 1 | 32 | 29.36 |
| Class 2 | 35 | 32.11 |
| Class 3 | 42 | 38.53 |
| Total | 109 | 100 |

**Table 3. Gender Distribution in Pilot 1**

| Gender | f | % |
|---|---|---|
| Female | 40 | 36.70 |
| Male | 69 | 73.30 |
| Total | 109 | 100 |

**Table 4. Group Distribution in Pilot 2**

| Group | f | % |
|---|---|---|
| Experiment | 62 | 29.25 |
| Control | 150 | 70.75 |
| Total | 212 | 100 |

**Table 5. Grade Distribution in Pilot 2**

| Grade | f | % |
|---|---|---|
| Grade 4 | 68 | 32.08 |
| Grade 5 | 62 | 29.24 |
| Grade 6 | 82 | 38.68 |
| Total | 212 | 100 |

**Tablet 6. Gender Distribution in Pilot 2**

| Gender | f | % |
|---|---|---|
| Female | 92 | 43.40 |
| Male | 120 | 56.60 |
| Total | 212 | 100 |

**Table 7. Group Distribution in Pilot 3**

| Group | f | % |
|---|---|---|
| Experiment | 62 | 28.05 |
| Control | 159 | 71.95 |
| Total | 221 | 100 |

**Table 8. Grade Distribution in Pilot 3**

| Grade | f | % |
|---|---|---|
| Grade 4 | 64 | 28.96 |
| Grade 5 | 62 | 28.05 |
| Grade 6 | 95 | 42.99 |
| Total | 221 | 100 |

**Tablet 9. Gender Distribution in Pilot 3**

| Gender | f | % |
|---|---|---|
| Female | 96 | 43.44 |
| Male | 115 | 52.04 |
| Total | 221 | 100 |

**Table 10. Grade Distribution of Following Survey in Pilot 2**

| Grade | f | % |
|---|---|---|
| Grade 4 | 16 | 28.07 |
| Grade 5 | 12 | 21.05 |
| Grade 6 | 29 | 50.88 |
| Total | 57 | 100 |

**Table 11. Q(4) Distribution of Following Survey in Pilot 2**

| | | A | B | C |
|---|---|---|---|---|
| Grade 4 | f | 1 | 9 | 6 |
| | of Grade 4 | 6.25% | 56.25% | 37.50% |
| Grade 5 | f | 1 | 9 | 2 |
| | of Grade 5 | 8.33% | 75.00% | 16.67% |
| Grade 6 | f | 2 | 12 | 15 |
| | of Grade 6 | 6.90% | 41.38% | 51.72% |
| Total | f | 4 | 30 | 23 |
| | of Total | 7.02% | 52.63% | 40.35% |

Note: A represents "Yes, I will communicate with my partner, but I will not search for what s/he searches by tablet"; B represents "Yes, I will communicate with my partner, and I will search for what s/he searches or what is similar to s/he searches by tablet"; C represents "No, I will not communicate with my partner".

**Table 12. The Impact of Social Partner's Tablet PC Usage Time on a Student**

| Panel A: Mathhrs Effects | |
|---|---|
| Social Mathhrs+ | 0.4<br>(8.4261) |
| Social Mathhrs- | 0.3872<br>(4.3834) |

| Panel B: Otherhrs Effects | |
|---|---|
| Social Otherhrs+ | 0.4268<br>(8.8223) |
| Social Otherhrs- | 0.4121<br>(6.8519) |

Note: The numbers inside "( )" are t-stats.

**Table 13 The OLS Regression Results of Equation (1), (2), (3) and (4).**

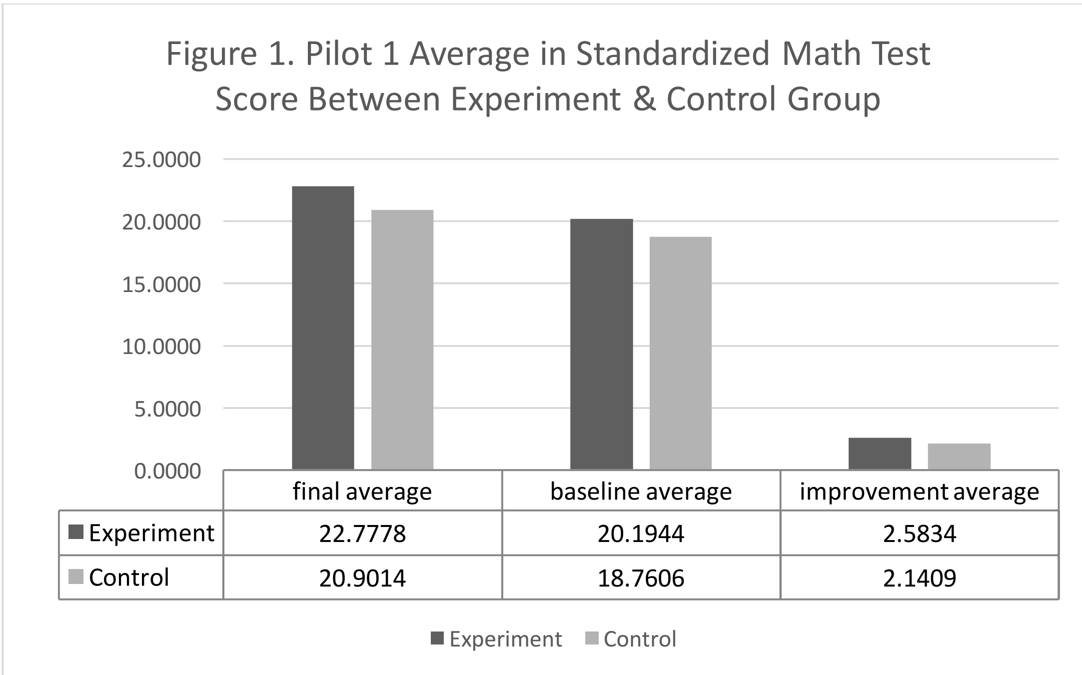
| Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| baseline | | | -0.4427 | -0.4458 |
| | | | (0.0358) | (0.0358) |
| irregularity | | | -6.7774 | -6.7468 |
| | | | (1.2086) | (1.2046) |
| grade 4 | | | 2.8448 | 2.7834 |
| | | | (0.5560) | (0.5554) |
| grade 5 | | | -2.8119 | -2.8899 |
| | | | (0.5534) | (0.5525) |
| gender | | | -0.1242 | -0.1026 |
| | | | (0.4055) | (0.4044) |
| tablet | **0.9186** | | | **1.2274** |
| | **(04740)** | | | **(0.6727)** |
| social partner | | | 0.747 | -1.3392 |
| | | | (0.7427) | (1.1390) |
| social partner*social partner+ | | | | **1.8461** |
| | | | | **(1.0874)** |
| social difference+ | | 0.0144 | -0.0688 | -0.1392 |
| | | (0.0890) | (0.0992) | (0.1104) |
| social difference- | | -0.1782 | -0.1074 | -0.2013 |
| | | (0.1156) | (0.1164) | (0.1280) |
| pilot2 | | | -3.8244 | -3.3909 |
| | | | (0.6429) | (0.6683) |
| pilot3 | | | -3.4994 | -3.0214 |
| | | | (0.6352) | (0.6666) |
| mathhrs | | | -0.1612 | -0.2067 |
| | | | (0.2562) | (0.2560) |
| otherhrs | | | -0.0347 | -0.0531 |
| | | | (0.0915) | (0.0917) |
| # of Observations | 529 | 529 | 529 | 529 |
| $R^2$ | 0.0071 | 0.0046 | 0.2788 | 0.2870 |

Note: The numbers inside "(    )" are standard errors.

# Figures

## Figure.1

**The Average Scores and Differences of Experiment Group and Control Group in Pilot 1**

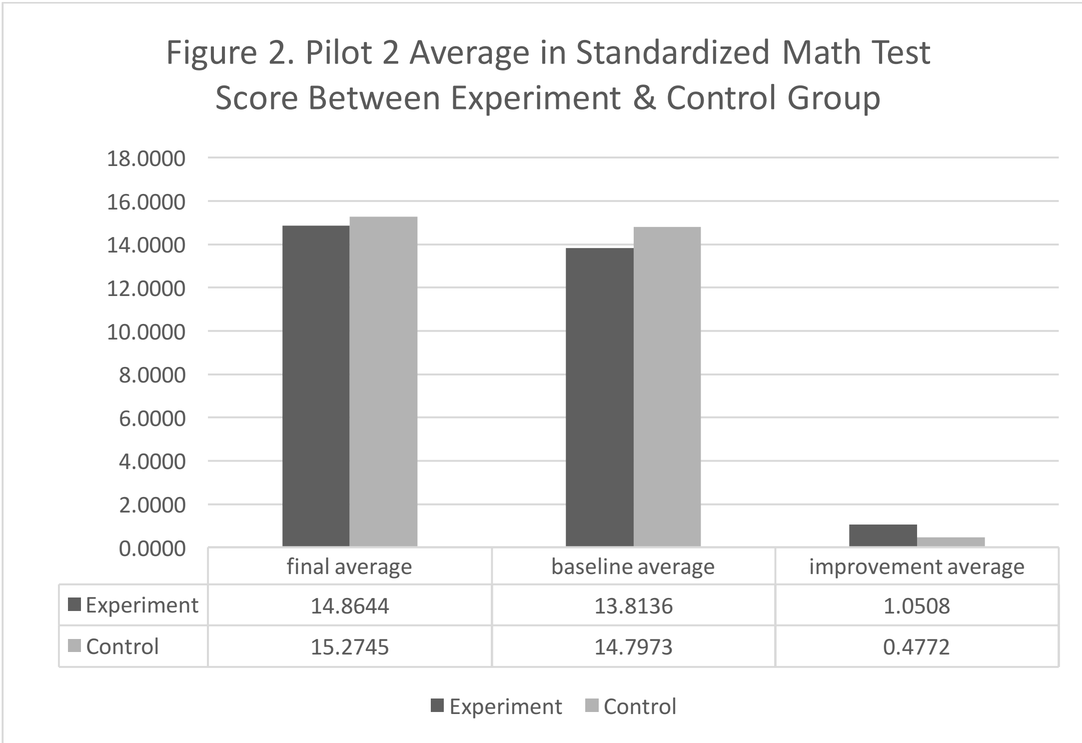



The two-tailed P value for average improvement equals 0.7317;

95% confidence interval of this difference: From -2.1095 to 2.9945

**Figure 2.**

**The Average Scores and Differences of Experiment Group and Control Group in Pilot 2**

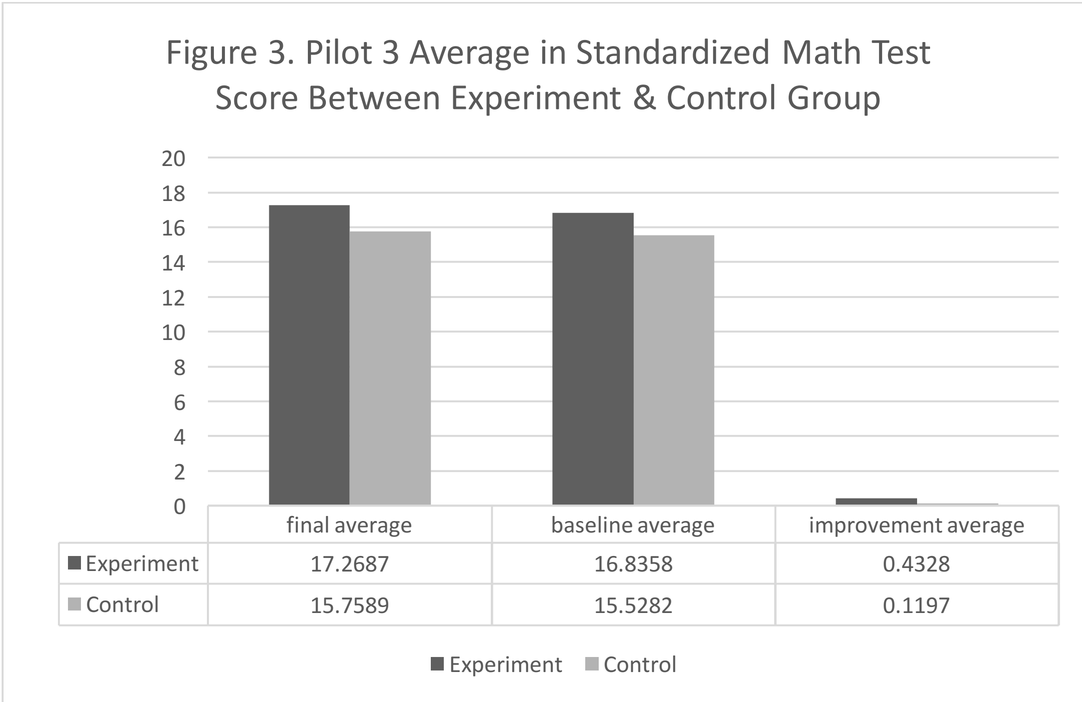



The two-tailed P value for average improvement equals 0.4057;

95% confidence interval of this difference: From -0.7835 to 1.9307

**Figure 3.**

**The Average Scores and Differences of Experiment Group and Control Group in Pilot 3**




| | final average | baseline average | improvement average |
|---|---|---|---|
| Experiment | 17.2687 | 16.8358 | 0.4328 |
| Control | 15.7589 | 15.5282 | 0.1197 |

The two-tailed P value for average improvement equals 0.6716;

95% confidence interval of this difference: From -1.1406 to 1.7668

**Figure 4. The Average Differences of Experiment Group with Social Partners, Experiment Group without Social Partners and Control Group in all three pilots.**

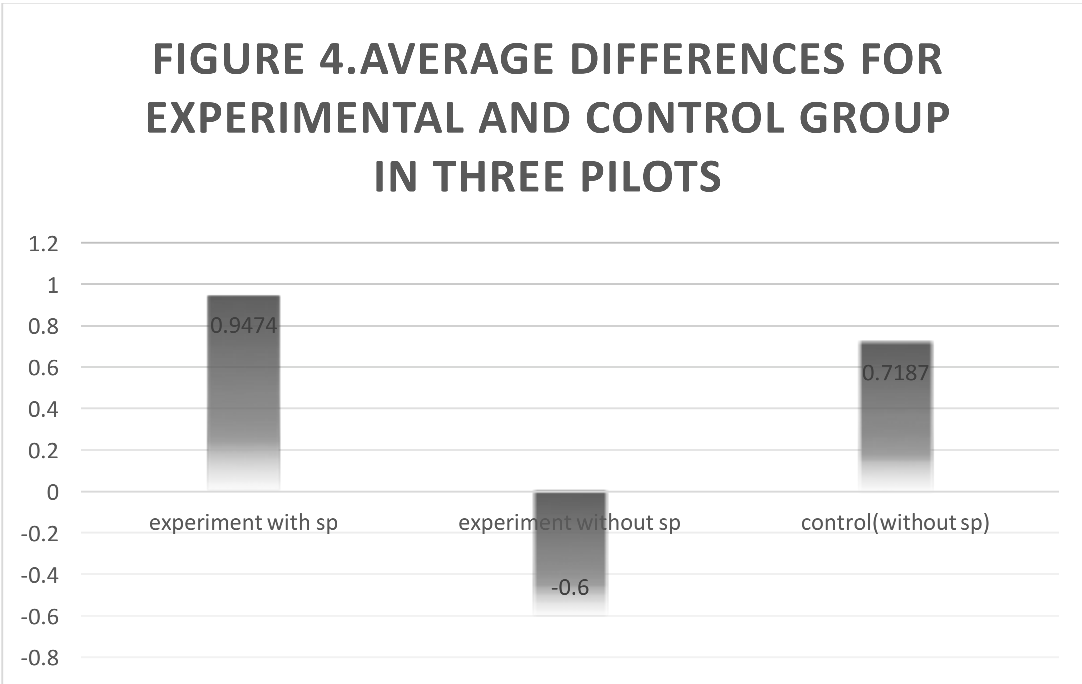
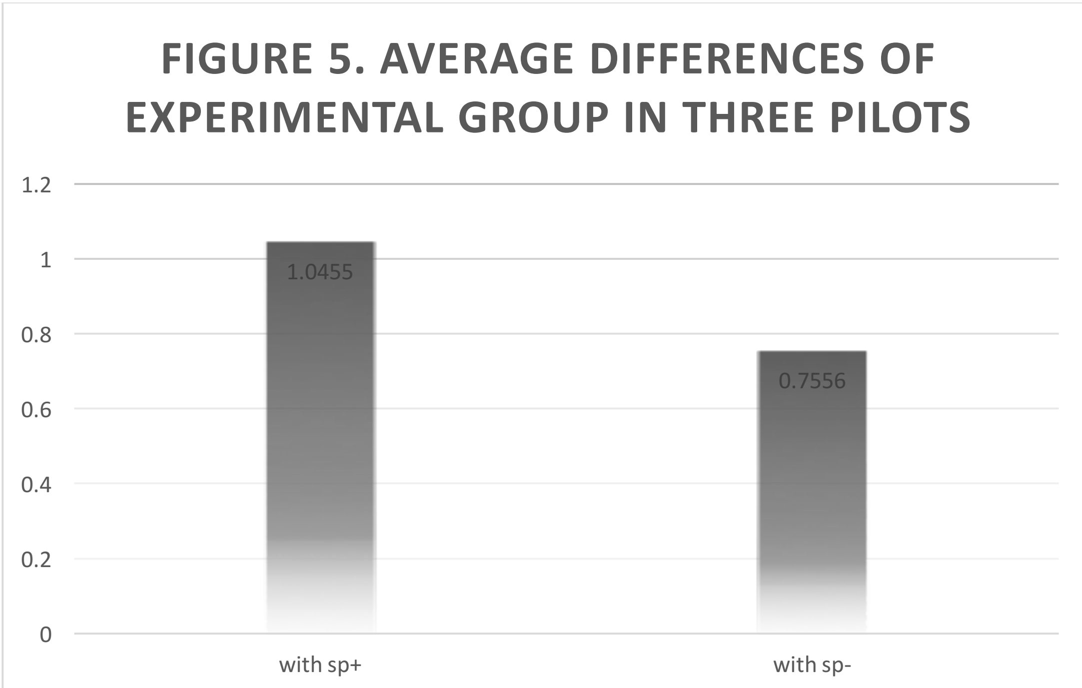


**Figure 5. The Average Differences of Experiment Group with Social Partner (+) and Experiment Group without Social Partner (-) in all three pilots.**



# Appendix. Case Study (Interview)

To learn more about students and teachers' views about the research project, the researchers random interviewed with six students from experiment group and three teachers who charge of experimental classes (Grade4Class2, Grade5Class2, and Grade6Class2).

Three of research assistants ask some questions and talk with these participated students/teachers during the interviews, and here are the related records below.

1) Basic Backgrounds of interviewee:

Student A, female, Grade 4 Class 2, transferred to Hua Ao School in the second semester of Grade 2, has a younger brother, Top 5 students in academic scores at class; Student B, male, Grade 4 Class 2, transferred to Hua Ao School in the first semester of Grade 2, does well in Mathematics, sometimes help parents selling products, Top 1 student in academic scores at class, likes playing cards; Student C, male, Grade 5 Class 2, studied at Hua Ao School from the first semester of Grade 1, Top 2 students in academic scores at class; Student D, female, Grade 5 Class 2, studied at Hua Ao School from the second semester of Grade 1, Top 2 students in academic scores at class; Student E, female, Grade 6 Class 2, comes from Henan Province, facing junior high school entrance exam, hopes to come back hometown for high school; Student F, male, Grade 6 Class, comes from Hebei Province, facing junior high school entrance exam, also hopes to come back hometown for high school. Teacher X, takes charge of Grade 4 Class 2; Teacher Y, takes charge of Grade 5 Class 2, young and nice, cares about her students and pay much attention to our project; Teacher Z, takes charge of Grade 6 Class 2, strict and autocratic, make students silent and numb when she is at class.

2) Interviewee's feedback to tablets learning and our research project:

Student A thinks the compositions in tablets are pretty good, and the pronunciation of English is standard which is helpful to English learning. She reads and watches more than half of the whole learning materials installed in the tablets. Sometimes she uses tablet for preview.

Student B thinks tablet is just so-so. He only uses it for one or two days and he almost doesn't use tablet after he finishes his homework, instead, he prefers to play outside. He thinks tablet is not as helpful to him, but he likes tablets more than books. His parents sometimes urge him to learn by using tablet.

Student C thinks tablet learning method is interesting and helpful, especially for English learning. His English ability is used to be weak but tablet helps him improve his English ability. He says "I feel English learning videos like a real person who is pretty friendly." He usually uses tablet every two days and he believes learning from tablets improves his composition ability especially narration essays. He never used tablets before our research project, and he thinks this research project provides a pretty good opportunity for him to use tablets. He promises to use tablets more to improve his academic grades and study ability.

Student D also likes using tablets for learning and she thinks tablet stimulates her interests in study. During her using of tablets, she watches mathematics videos mostly. She tells us there are many calculation methods shown in the mathematics videos which make her math knowledge improved. Every time when she has some knowledge that she doesn't understand, she prefers to refer to tablet's learning video. Usually, her group mates who share the same tablet as her will suggest some useful learning materials for her.

Student E thinks tablet helps her learning greatly, and she tells us "my composition was not good before, but I think it is improved obviously after I use tablet for learning." Also, she thinks tablet learning teaches her many learning methods. For example, for composition aspect, she learns that she must examine the topic carefully, follow the main point and keep a correct writing procedure. Additionally, she thinks tablet improves her English annunciation. She thinks our project's tablets are easy to use and pretty good.

Student F tells us he usually watches composition and mathematics material using tablets, while sometimes watch English videos. He thinks tablet's learning materials broadens his knowledge and increases his interest in learning. He is keeping using tablets after he joined our research project and has already watched and read most of learning materials in tablets.

Teacher X thinks tablet learning is pretty good and useful in English and composition writing, but she doesn't pay more attention to mathematics. Overall, tablet learning matches children's characteristics and teaching plan. She supports our research project.

Teacher Y thinks tablet learning is pretty good and useful in Chinese and Mathematics, but for English, tablet learning is not such helpful. Since for student's general level, English materials in tablet are related too difficult. Therefore, students don't learn those carefully.

Teacher Z thinks tablet learning helps children a lot in their study generally. For example, English composition materials improve student's writing ability, encyclopedia enriches children's leisure time. Also, the schedules of learning materials in tablets are associated tightly with teaching plans at school. Additionally, students always have their own preferences when choose learning materials. They can choose what they are interested in to read and watch.

3) Interviewee's advice/suggestion to tablets learning and our research project:

Student E suggests us to add some more mathematics formula and entrance exam to junior high school related learning materials since she is a sixth grade student who is facing entrance exam to junior high school.

Student F suggests us to increase the difficulty of learning materials in tablets while add more learning materials related to their school classes.

Teacher X hopes to add new learning materials in the tablets and she thinks tablets are easy to use.

Teacher Y hopes our tablets can be updated timely and added more abundant learning materials. Also she suggests us to add more learning videos. Additionally, she hopes our research assistant are able to do research and interactions with students per half a month or per month while encourage them to learn better by using tablets.

Teacher Z says our learning materials in tablets are becoming out of date with time passing, so she hopes we can add more new learning materials in tablets especially for grade 6 students.

4) Differences between students who use tablets and who don't use tablets:

Student C states one's academic ability and score seriously can be improved by using tablets for learning. For instance, his own English grade and Chinese composition grade have been improved obviously after using tablets for learning.

Student D tells us, if some students take part in our project and have a tablet for learning, they will surely use the tablets which benefit to their academic grades.

Student E states using tablets for learning surely improve students' academic grades. For instance, her Chinese composition ability has been improved obviously after using tablets for learning. However, the students who don't join this project may not use tablets for study these learning methods in tablets.

Student F tells us, at least for himself, using tablets for learning helps a lot for his mathematics grade.

Teacher X tells us in her class there are eighteen students take part in this project while fifteen students don't take part in the project. The students who take part in this project are satisfied with this project, and their interest in learning have been improved. For those who don't take part in the project, most of them hope to join next time.

Teacher Y tells us the students who have tablets usually pay more attention to study so that their academic grades have been improved. For instance, a student's Chinese grade is improved obviously after using tablets, so that some parents support this project very much and hope every student could have a tablet for learning. For those students who don't join this project, they don't have opportunity to learn that knowledge from tablets.

Teacher Z says about twenty students join this project while more than twenty students don't join this project. During the period of pilot, new gaps between students' academic grades surely appear. At first, some students who have tablets fully apply this kind of learning resource so that they have great improvement; however, some children have no interests in anything so that they don't apply tablets to learning properly, therefore their academic ability and grades have not been improved obviously. What's more, those students who don't have tablets cannot enjoy these benefits, so that the gap between them and students have tablets is wider.

5) Ideas about group members

Student A doesn't know the specific usage information about her group member who shares the same tablet PC as her.

Student B doesn't know the specific usage information about his group member who shares the same tablet PC as him.

Student D says she always communicates with her group member about the usage information on tablet learning, and her group member will recommend some useful learning materials to her.

In general, both students and teachers who join the research project have a positive attitude on tablet learning. They believe tablet learning can provide benefit and improvement for students' academic ability and in reality it does. Some of participated students will communicate with and impact by their group members when using tablets for learning while others not.

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