Using the U.S. PISA results to investigate the relationship between school computer use and student academic performance

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Abstract

This study examined the influence of school computer use frequency on the test scores of 15-year-old students in the United States using data from the 2003 Programme for International Student Assessment (PISA). A MANCOVA test found that students who use computers almost every day at school performed better than the students from the group who used computers between once a week and once a month, after controlling for students' SES backgrounds. Students who had never used a computer at school were found to be highest achievers among all comparison groups. These findings suggest that frequency of computer use might not be a good indicator of academic achievement. Results lead to the discussion of educational input. A further study should be conducted to investigate the characteristics of students who never use computer at school in order to interpret their high achievements in math, science and reading.

Keywords: computer use frequency, academic achievement, secondary school, PISA

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The use of technology in school learning and teaching has been a priority in the United States and most European countries during the last decade. The National Association for the Education of Young Children's (NAEYC) *Position Statement on Technology and Young Children* acknowledged that technology can enhance children's cognitive and social abilities if used appropriately (NAEYC, 1996). NAEYC also recommended that technology be integrated into the learning environment as one of several support options. The wide adoption of internet and computers in classrooms had changed learning and instruction in all subject areas (James & Lamb, 2000; Weaver, 2000).

As part of the No Child Left Behind Act of 2001, the Enhancing Education Through Technology program seeks to improve student academic achievement in elementary and secondary schools through the use of technology. In recent years, there has been an increasing interest in investigating the impact of home and school computer usage on student achievement outcomes. Evidence on this topic shows mixed results. Research on the influence of classroom computer use on student achievement has reported no influence or negative influence of using computers for instructional purpose on learning outcomes of math and reading (Angrist & Lavy, 2002; Rouse & Krueger, 2004). Other studies about the effectiveness of computer use for instruction had found positive relationships between computers use and students' academic achievements (Fuchs & Woessmann, 2004; Salerno, 1995). These results supported the argument that instructional activities that involve the use of technology capture the interest of students, which facilitates their understanding of the content and provides different way of expressing knowledge and therefore have a positive influence on performance.

The rapid growth of student's access to computers and internet in the U.S. schools is impressive, if not overwhelming. The 2007 U.S. Census Bureau statistics suggested that as of 2004, about 72 percent of students between age 5 and 7 use computers at school and about 89 percent of students between age 11 and 14 use computers at school. Even though this growth is considerable, the access and use of technology in U.S. schools is unbalanced, with schools mainly composite of black, Hispanic or low socioeconomic status (SES) students tending to have the lowest access to the usages of technology (Becker, 2000).

A great number of studies have established an empirical relationship between students' family SES and their academic performance, even though the strength of the relationship varies to a great extent. Family SES will largely determine the location of the child's neighborhood and school; it provides home resources as well as the "social capital," that is, supportive relationships among schools and individuals (i.e., parent-school collaborations) that promote the sharing of societal norms and values, which are necessary to success in school (Dika & Singh, 2002). Therefore, it is necessary to give considerable attention to the role of family SES in determining student academic performance in educational studies.

The mixed results from previous studies make it difficult to generalize about the overall influence of computer use on improving students' learning. Studies have suggested that research on this subject should focus more on what conditions (e.g., frequency of computer availability and comfort with computer use) would be necessary for computer use at school to become effective for learning (Gil-Flores, 2009; Papanastasiou, Zembylas, & Vrasidas, 2003). Based on above research scenario, the purpose of present study was to explore the influence of frequency of computer use at school on the test scores of 15-year-old students in the United States using data from the 2003 Programme for International Student Assessment (PISA). Specifically, it asks, if secondary school students who frequently use the computer at school perform better than those making a more limited use of it, after controlling for their SES background.

Method

Data Sources

Data for the present study were from the 2003 PISA American sample. PISA is an internationally standardized assessment that measures students' capabilities in mathematics, reading, and science literacy. According to OECD (2001), PISA focuses on young people's ability to use their knowledge and skills to meet real-life challenges, rather than merely on the extent to which they have mastered a specific school curriculum. Beginning from 2000, PISA is administrated every three years to randomly selected groups of 15-year-old students in principal industrialized countries. Missing data were listwise deleted prior to analysis. After deleting univariate ($|Z \text{ score}| > 3$) and multivariate outliers (Mahalanobis distance >16.26624) of test scores in math, science and reading, the final sample include 4,990 students at age of 15 (female = 2,547, male = 2,443) from 274 schools.

Variables

The dependent variables in the current study were literacy scores on math, science, and reading that were collected in 2003 PISA assessment. These variables assessed the students' academic achievement on math, science, and reading. To reduce the length of the test, PISA applied matrix sampling, which splits one long test booklet into several short test booklets. Therefore, each student works on one booklet only. Because students complete different tests, science achievement cannot be obtained using traditional test scores, but instead by using plausible values. Plausible values are multiple imputations of unobservable latent achievement for each student. Adams and Wu (2002) provided details about how plausible values are created and used. 2003 PISA used five plausible values to present each literacy achievement. Because the software program we used for analysis, *PASW Statistics 18* (formally *SPSS Statistics*) was not capable for us to use plausible values, the students' literacy scores on math, science, and reading were calculated by taking the average of five plausible values.

Type of school computer use frequency was used as the independent variable in this study, while student SES was used as a covariate. The student SES was an index variable in 2003 PISA data set that measures students' socio-economic and cultural status, higher values indicate a higher level of SES. Type of school computer use frequency was used as a grouping variable. There were five groups, denoted 1 to 5, in this variable referring to: almost every day, a few times each week, between once a week and once a month, less than once a month, and never.

Analysis

The original data set consisted of 5,456 student scores. To produce valid and accurate results, cases with missing data and outliers were removed before analyses. According to the purpose and research question of the study, a MANCOVA test was conducted to detect if school computer use frequency groups differ on the set of student academic achievement variables when controlling students' SES backgrounds. Based on research by Huberty and Morris (1989), "…a collection of conceptually interrelated variables that, at least potentially, determines one or more meaningful underlying variates or constructs", the dependent variables in this study constructed a system of variables: they were a collection of conceptually interrelated measures of student learning outcomes. However, they did not measure the same construct which suggested this system can be characterized as an emergent variable system. This study also determined the relative contribution of the three measures to the resultant group differences, contributing to the use of a multivariate analysis.

Results and Discussion

Descriptive statistics of five computer use frequency groups is summarized in Table 1.

Table 1

Description of Variables in School Computer Use Frequency

School computer use frequency groups		Dependent variable			Covariate
		Math	Science	Reading	SES
Almost every day	*M*	484.93	494.44	494.56	.27
	SD	85.95	89.22	86.11	.90
	n	1003	1003	1003	1003
A few times each week	*M*	490.70	499.06	501.91	.32
	SD	91.10	95.20	92.74	.90
	n	1109	1109	1109	1109
Between once a week and once a month	*M*	499.92	507.57	516.18	.40
	SD	85.08	88.26	85.59	.87
	n	1408	1408	1408	1408
Less than once a month	*M*	488.35	496.09	505.63	.28
	SD	83.27	87.69	86.16	.84
	n	1056	1056	1056	1056
Never	*M*	461.41	470.40	480.09	.25
	SD	84.60	88.61	88.19	.90
	n	414	414	414	414
Total	*M*	489.21	497.53	503.44	.32
	SD	86.76	90.43	88.25	.88
	n	4990	4990	4990	4990

Prior to inspecting the MANCOVA results, it was of interest to determine whether or not statistical assumptions were met for MANCOVA. A preliminary analysis was conducted to test if SES was related to the set of academic achievement variables. Wilks Λ of .80869 was statistically significant ($p < .001$), which indicated that the covariate of SES did account for statistically significant variance in the set of dependent variables. Another preliminary analysis was conducted to check if there was any interaction between the type of school computer use frequencies and SES. Wilks Λ of .99608 was not statistically significant (*p* = .076), indicating that the assumption of homogeneity of regression was tenable. Although multivariate normality was violated for all groups (see Table 2), the assumption of homogeneity of covariance was tenable. Box's test was conducted to test the tenability of equality of covariance matrices assumption, Box's M test = 59.863 and it was not statistically significant at .005 level, $F(40, 16881040) = 1.493$, $p = .023$. Although the sample sizes of the five groups were not equal (see Table 1), the log determinants of covariance matrix were approximately equal across groups (22.760, 22.706, 22.582, 22.522 and 22.728), with a pooled log determinate of 22.657, which further supported the tenability of this assumption. Given the results for above four tests, the MANCOVA assumptions were satisfactorily met.

Table 2

Summary of Multivariate Normality within Groups

School computer use frequency groups	Mardia's multivariate skewness	*p*	Mardia's multivariate kurtosis	*p*
Almost every day	.748	< .001	15.614	.076
A few times each week	.701	< .001	15.765	.020
Between once a week and once a month	.582	< .001	15.697	.017
Less than once a month	.548	< .001	16.025	.002
Never	.787	< .001	16.384	.010

After all assumptions have been found tenable, the MANCOVA test of whether school computer use frequency groups differ on the set of dependent variables after removing/adjusting the influence of student SES was conducted. Wilks Λ = .976 was statistically significant, *F*(4,

4984) = 13.115, *MSE* = .987, $p < .001$, $\eta^2_p = .024$, indicated that after removing the variance due to SES, the school computer use frequency groups differ on the set of dependent variables. However, the effects size indicates a weak relationship between the type of school computer use frequencies and academic achievement according to Cohen's (1977) guidelines, with the school computer use frequency grouping factor accounting for 2.4% of the variance of student academic achievement, after removing the effects of student SES backgrounds. Structure coefficients and standardized coefficients for each dependent variable are shown in Table 3.

Table 3

Standardized Coefficient and Structure Coefficients for the Three Dependent Variables

Dependent Variable	Standardized Canonical Coefficient	Structure Coefficient
Math	-.34731	-.96328
Science	-.51160	-.98461
Reading	-.17047	-.94865

A follow up pairwise comparison was conducted to determine how the groups are differentiated by the adjusted centroids. Bonferroni adjustment of .017 (Mertler & Vannatta, 2004, p. 126) was performed in each procedure to protect against Type I error inflation. The academic achievement of the students who had never used computers at school was found to be statistically significant higher than all other groups, and the academic achievement of the students who use computer at school almost every day was statistically significant higher than the students from the group who used school computers between once a week and once a month (see Table 4).

Table 4

Summary of Pairwise Comparison Groups with Significant Adjusted Centroids Difference

Pairwise Group Comparison	Adjusted Centroid Difference	*SE*	*p*
Never vs. Almost every day	.276	.058	< .001
Never vs. A few times each week	.320	.057	< .001
Never vs. Between once a week and once a month	.398	.056	< .001
Never vs. Less than once a month	.318	.058	< .001
Almost every day vs. Between once a week and once a month	.122	.041	.003

The present study was designed to investigate if students with high computer use frequency at school perform better than those who have limited use of it after controlling for their SES background. The results suggested that students who use computer everyday at school have significantly higher achievement scores than those who use computers between once a week and once a month. This finding further supports the idea that student computer use at school has positive effect on academic performance. No significant difference on achievement was found between other moderate computer use frequency groups. Surprisingly, the students who have never used computers at school were found to have statistically significant higher scores than students in other groups, and students in this group had the lowest average SES scores in all the sample groups. These findings were unexpected and suggest that there are some unique characteristics exist in never use computer group students.

Conclusion

The present study adds supplementary information to the existing body of literature on the influence of computer use at school to students' academic performance. The weak correlation found in this study suggests the frequency of computer use might not be a good indicator to predict academic achievement. It was also found that students who use computers almost every day have significant higher achievement scores than those who use computers in moderate or low frequencies. These results suggest that simply increase the educational input on computers at school may not produce the desired effect; instead, the quality of integrating computer use into effective instructional activities plays a more important role in influencing student academic outcomes. Finally, the noticeable academic performance of students who had never used computers at school suggests future research on factors and characteristics that exist in this group of students.

This study provides important empirical findings by applying statistical methods with a proper treatment to a large scale database. However, this study was limited as it was based on a survey questionnaire. The students in each group were not randomly assigned, and the number of students within each group were not equal (maximum ration is 1408/414 = 3.4). An experimental balanced design was recommended for future studies. Despite the limitation, this study calls for the attention of incorporating effective instruction activities and the frequency of computer use at school to increase student academic achievements. Another advantage of this study was to use large national data for analyses. The national data set not only provided large random sample size which contributed to the representativeness of sample, but also provided more accurate latent variables, therefore strengthened the reliability and validity of this study.

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