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ABSTRACT

This paper reports on a study investigating the relationship between available computer resources in schools and science achievement. Although the effects of computers on academic achievement has been extensively studied, the results are inconsistent. This study is a follow-up to Alspaugh (1999) and was conducted with the participation of (n=80) school districts from a Midwestern state. Results suggest that there is a positive relationship between the number of computers available in schools and students' science achievement. (Contains 28 references.) (YDS)

How Does Computer Availability Influence Science Achievement?

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How Does Computer Availability Influence Science Achievement?

Introduction

The effectiveness of computer technology in the science classroom has been studied extensively. However, the results are inconsistent. For example, Morrell (1992) investigated whether computer assisted instruction (CAI) would improve students' achievement scores in high school biology. She found no significant difference between the means of the achievement scores of the CAI group and the traditional instruction group. While Yalçinalp and colleagues (1995) examined the effectiveness of using CAI for teaching the mole concept in high school chemistry. They found that students who used the CAI accompanied with lectures scored significantly higher than those who attended recitation hours, in terms of school subject achievement in chemistry and attitudes toward chemistry subjects.

One way of observing the relationships of computer technology and students' achievement is by studying the number of computers available for students in the classroom. According to Anderson and Ronnkvist (1999), the most appropriate indicator of computer density is the student-computer ratio, which is the number of students enrolled divided by the total number of instructional computers available for students and teachers. The number of students per computer has been used as an indicator of computer availability to examine educational outcomes in Alspaugh (1999). Using this indicator provides researchers a clear notion of how many students are sharing one computer in the school and how many computers are available. Differentiated from this indicator, the number of students per Internet-connected computer is another indicator of computer availability and computer use in Internet-related tasks.

Using the number of students per computer as an indicator of computer availability, Alspaugh (1999) found no statistically significant differences among the mean reading/language arts, mathematics, science, and social studies achievement scores four the four levels of computer availability at school. In addition, no statistically significant difference was found among the mean attendance and high school dropout rates.

In response to the continuing growth of networked instructional technology in Missouri classrooms, the Missouri Census of Technology is designed to assess the investment in K-12 instructional technology and to help plan future efforts. The 2000 Missouri Census of Technology was conducted from March-July of 2000, by the University of Missouri, Office of Social and Economic Data Analysis, in cooperation with the Missouri Department of Elementary and Secondary Education (DESE) and the Missouri Research and Education Network. The Census surveyed the planning, training, hardware, and Internet connectivity of computer technology at the district level and building level.

The Missouri Census of Technology provides data about the number of computer resources and Internet-connected computer resources in the school districts. Internet-connected computers provide students opportunities to search for information outside of the school and communicate with each other. The previous study by Alspaugh (1999) investigated the effectiveness of computer technology in terms of the number of students per computer. This follow-up study tries to identify the differences between the number of students per computer and the number of students per Internet-connected computer in their effectiveness of science achievement.

Literature Review

Computer Use

Computers were not popular during the 1980s in school environments. Cuban (1986) investigated the history of technology use from 1920 to 1980s and concluded that computers in schools were rare (about 30,000) in 1980, but increased dramatically afterwards. Becker's study (1985) showed that, in 1983, only 250,000 computers were found in American schools for instructional purposes. Anderson and Ronnkvist (1999) combined other research findings from 1983 to 1998 (Anderson, 1993; Becker 1985, 1991) and showed tremendous increase in the number of instructional computers in school. During this time, the number of instructional computers in elementary and secondary schools in the U.S. has increased by about 15% per year. In 1998, the student-computer ratio decreased to about 6 students sharing one computer. Anderson and Ronnkvist (1999) predicted that the pattern of growth of computer at school is likely to increase in the future because of falling technology prices and the increased interest and funding of telecommunication.

While students have more computers to use at schools, researchers and educators are concerning about the use and effectiveness of these instructional computers. Anderson and Ronnkvist (1999) examined the 1998 national survey, "Teaching, Learning and Computing", and reported about computer density, computer capability, computer renewal, peripherals, computer location, software, Internet access, and distributions and disparities. They concluded that the student-computer ratio is the best measurement for computer availability at school. They also reported that schools are shifting their computers from Macintosh to Windows as the grade level goes up. For middle schools, about 49% of computers were for Windows of DOS, 39% Macintosh and 8% Apple II. Middle school computers located mainly in the computer labs and classrooms (44% and 40%, respectively), and most computers had Internet access (94%). They feel that, although the rapid connection and computer renewal are impressive, but the "digital divide (p.17)" among schools remains and disparities still exist.

Coley, Cradler, and Engel (1997) explored school access to technology and student use of computer technology and found similar results as Anderson and Ronnkvist (1999). The number of students per computer ranged from 5.9 in Florida to 16 in Louisiana. Missouri had a student-computer ratio of 11, and the U.S. average was 10. Among eleventh graders, writing stories and papers was the most frequent computer use at home and school. Among fourth and eighth graders, playing games (presumably at home) was the prevalent computer use. Nine percent of fourth graders, 10% of eighth graders, and 19% of twelfth graders said they used a computer for schoolwork almost every day. On the other hand, 60% of fourth graders, 51% of eighth graders, and 37% of twelfth graders reported that they never used a computer for schoolwork.

Although computers are popular at school, a survey by Huinker (1996) revealed that these computers were not used properly. Elementary teachers in an urban school district participated in the survey about the status of mathematics and science teaching regarding instructional and assessment practices, adequacy of resources, and perceptions toward teaching mathematics and sciences. About half of the elementary teachers reported having access to computers in their classrooms. Computers were used frequently by 64% of the teachers for mathematics, but were rarely or even not used for science by about the same number of teachers.

Computer Use and Students' Achievement

The public seems to agree with the reform effort on placing computers in the classroom (American School Board Journal [ASBJ], 1997). About 81% of the public believes that a computer in every classroom would improve student achievement. Therefore by increasing the number of computers in the schools or classrooms, student achievement would be improved. However, is computer technology effective?

The amount of research on the effectiveness of computers has been accumulating while more computers are incorporated into the classrooms and schools. Results of these studies vary in different degrees. Kulik (1994) used a meta-analysis where he examined over 500 individual studies about the effectiveness of computer-based instruction. He reported that students usually learned more in classes in which they received computer-based instruction and they learned the same amount in less instructional time with computer aid. In addition, students had more positive attitudes toward computers and toward the classes. Kulik's study is criticized as emphasizing drill-and-practice type of instructions (Coley, Cradler, & Engel, 1997). Later, the Software Publishers Association commissioned an independent consulting firm to prepare another meta-analysis on the effectiveness of technology in schools (Sivin-Kachala & Bialo, 1994). This study concluded that educational technology could improve student achievement, attitudes, and interactions with teachers and other students.

Wenglinsky (1998) used data from the 1996 National Assessment of Educational Progress in mathematics to study the relationship between different uses of educational technology and various educational outcomes. The sample included 6,277 fourth graders and 7,146 eighth graders. For eighth graders, the frequency of home computer use was positively related to academic achievement and the social context/environment of the school; the frequency of school computer use was unrelated to the social context of the school and negatively related to academic achievement. For fourth graders, using computers for learning games was positively related to academic achievement and the social context of the school; the frequencies of home and school computer use were negatively related to academic achievement and the social context of the school. Wenglinsky concluded that computers are not cure-alls for the problems facing schools, but computers do have some impact on student learning.

Various meta-analytic comparisons of the effectiveness of computer technology on student achievement showed promising results of technology intervention. Glass, McGaw and Smith's definition (as cited in Christmann, Lucking and Badgett, 1997) of a meta-analysis is a secondary statistical re-analysis of prior research that provides answers to new questions through the manipulation of older data. Effect size is calculated through the meta-analysis procedure in standard deviation units, showing the degree of overlap between control and experimental groups. One common measure of effect size is the statistical difference in mean standard deviation units. According to Cohen (cited in Christmann, Lucking and Badgett, 1997), the effect size (ES) between 0.200 and 0.499 means small effect, ES = 0.500 to 0.799 is medium effect, and ES = 0.800 and above is large effect.

Earlier study (Kulik & Kulik, 1986) using meta-analysis to study the effectiveness of computer-based education showed that computer-based instruction had a positive impact on students in higher education. Conducted specifically for elementary school research, Ryan's (1991) meta-analytic study about the effect of microcomputer application on achievement analyzed data from 40 independent documents. The mean effect size was 0.309 with a small achievement effect of microcomputer. She explained this effect size meant that the effect of the treatment (computer instruction) is approximately one third greater than the effect of traditional instruction. Additionally, 0.309 can be interpreted as one third greater than the expected gain in a school year, or approximately 3 months additional gain in terms of grade-equivalent units—the grade-equivalent unit can be explained as, in each of the 10 school months, an average student is expected to gain 0.1 grade-equivalent units.

More recently, Christmann and his colleagues (1997) examined 27 studies regarding the effectiveness of computer-assisted instruction from grade six through twelve. They reported a mean ES of 0.209, which means that on average computer-assisted instructions (CAI) had a positive effect on students' achievement. The mean ES of CAI on science students' achievement was the largest ES (0.639) in their study; however, negative mean ES occurred with English (-0.420) students' academic achievement in comparisons between the effects of CAI and traditional instruction. Based on the results, they concluded that the average science student exposed to CAI attained achievement greater than that of 73.9% of those science students exposed to traditional instruction.

Christmann, Lucking and Badgett (1997) also investigate the effectiveness of CAI in urban, suburban, and rural settings. They found a mean effect size of 0.172. The ES for urban studies was 0.388, 0.137 for suburban studies, and 0.077 for rural studies. These mean effect sizes were fairly small, but indicated that CAI was most effective in urban areas, followed by suburban areas, and then by rural areas.

Using K-12 grade levels, Liao (1998) conducted a meta-analysis on the effect of hypermedia on students' achievement. Data from 35 studies published from 1986 to 1997 were transformed to ES and reported the mean ES was 0.48, which indicated that hypermedia has a moderate effect on students' achievement as compared to traditional instruction.

Christmann and Badgett (1999) conducted a meta-analysis from 11 studies concerning the effect of CAI in four science content areas: physics, general science, biology and chemistry, and three educational settings: urban, suburban, and rural. The overall effect size (ES) was 0.266, which has a small effect. The ES for science subjects were 0.280 for physics, ES = 0.707 for general science, ES = 0.042 for biology, and ES = 0.085 for chemistry. Similar to the result of Christmann, Lucking and Badgett (1997) reported a highest ES (0.685) in urban setting, 0.273 for suburban area, and 0.156 for rural area. Christmann and Badgett concluded that microcomputer simulations enable students to learn science through their actual experiences rather than through the transposed method of traditional lectures, and hence improved students' achievement in science.

Alspaugh (1999) investigated the effect of amount of computer resources at public school districts on students' academic achievement. The amount of computer resources was expressed as the number of students per computer, and it was found to have no effect on students' achievement in reading, mathematics, science, or social studies on a statewide test. However, because of the sampling procedure, the school districts selected in the Alspaugh's study were all small, rural districts. Christmann, Lucking and Badgett's findings (1997) regarding little effect of CAI on rural areas may be applied to explain the non-effectiveness of computer resources.

Other studies about the positive effect of computer-assisted instruction on achievement were reported (Dixon, 1997; Lu, Voss, & Kleinsmith, 1997; Yalçinalp, Geban, & Özkan, 1995). Although there are some contradicting findings in this topic (Liu, Macmillan, & Timmons, 1998; Morrell, 1992), which may be a function of rural school settings, most research shows a positive effect of computer technology on students' academic achievement.

Internet Use and Education Outcomes

There is a limited amount of research on the effect of Internet use on education outcomes, such as achievement and motivation. Becker and Ravitz (1999) pointed out that the use of e-mail and Internet-based collaborative tools has shifted learning from a private setting to a conversation-based experience by written communication. They found that teachers who used computers and Internet resources more regularly would have increased use of constructivist teaching practices and might change their pedagogical beliefs and practices related to computer technology.

Mistler-Jackson and Songer (2000) conducted a study to examine how Internet influenced student motivation and achievement. They found that Internet technology increased student motivation toward learning and student achievement in atmospheric science.

Coley, Cradler, and Engel (1997) reported on the status of computers in the classrooms and concluded that educational technology might improve students' achievement and attitude. However, they also warned:

> Technology is not the only component of an instructional activity. Assessments of the impact of technology are really assessments of instruction enabled by technology, and the outcomes are highly dependent on the quality of the implementation of the instructional design. ...There are also a host of methodological issues to confront. First, standardized achievement tests may not measure the types of changes in students that educational technology reformers are looking for. ...There is also a need to include outcome measures that go beyond student achievement, because student achievement may be affected by students' attitudes about themselves, school, and learning, and by the types of interactions that go on in schools. In addition, technological changes are likely to be nonlinear, and may show effects not only on student learning, but also on the curricula, the nature of instruction, the school culture, and the fundamental ways that teachers do their jobs. (p. 38)

Coley and colleagues' points should be taken seriously when conducting research about the effect of computer technology on academic outcomes, and researchers should be cautious when they interpret the data and discuss their findings.

Research Design

This study is a follow-up of Alspaugh (1999) to further investigate the relationship between computer resources in school and science achievement. In this study, 80 school districts have been previously selected from a Midwestern state as the sample of school districts (Alspaugh, 1999). These school districts were divided into four groups, with twenty school districts in one group, by either the number of students per computer or the number of students per Internet-connected computer. The number of students per computer and the number of students per Internet-connected computer were obtained from the 2000 Missouri Census of Technology. The number of students per computer to form the four groups were: 1) less than 2.74, 2) 2.75 to 3.36, 3) 3.37 to 4.51, and 4) more than 4.52. The number of students per Internet-connected computer to form the four comparison groups were: 1) less than 4.49, 2) 4.50 to 6.69, 3) 6.70 to 11.09, and 4) more than 11.10.

Schools within the comparison groups were carefully selected to form equivalent groups in terms of measures that are known from previous research to be related to educational outcomes (Alspaugh, 1995). Because the number and grade level of school-to-school transitions affect test scores, only school districts with one transition at seventh grade were included within the comparison groups. Hence, the sample of school districts were selected from the 200 districts with one elementary school containing grades kindergarten through grade six and one secondary school with grades seven through twelve. Small schools tend to have higher elementary achievement test scores than large schools. Therefore, the schools for the comparison groups were selected to have approximately the same enrollment. The means and standard deviations of the enrollments for the twenty schools in each of the four comparison groups are presented in Table 1. The socioeconomic background of the students within the schools as indicated by the percent of students receiving free or deduced lunch is related to educational outcomes (Alspaugh, 1995). The schools were selected to have approximately equal rates of free or reduced lunch.

The science achievement scores were obtained from the Missouri Assessment Program (MAP). MAP is a statewide standardized test and is handled by the Missouri Department of Elementary and Secondary Education and CTB/McGraw-Hill. MAP is administered every year in Missouri and has been developed for various content areas. The Science MAP is given for third, seventh, and tenth graders and includes multiple choice, short constructed-response, and performance-event items. To remove the socioeconomic background of the students within the schools, the percent of students receiving free or reduced lunch is used.

Data Analysis

Statistical analyses were conducted to assess the differences of science achievement among the four comparison groups of the number of students per computer using SPSS 10.0. The science achievement scores were obtained from the Missouri Assessment Program (MAP) test conducted at 3rd, 7th, and 10th grades. The original Science MAP scores were standardized z-scores, and were transformed to a state mean of 50 and standard deviation of 10.

The analysis of covariance (ANCOVA) was conducted using the number of students per computer as a between subject factor, and the grade levels as a within subject factor. The percentage of free/reduced lunch was served as the covariate to remove the effect of the socioeconomic background of students. The four groups of number of students per computer are 1) less than 2.74, 2) 2.75-3.36, 3) 3.37-4.51, and 4) more than 4.52. Mean MAP scores and adjusted means for students per computer at three grade levels were calculated for comparison.

The number of students per computer was the between subject factor as the indicator of the access that students have to computers at school. However, Internet connected computers have the capacity for students to research information on the Internet and interact with each other rather than computers without Internet access. Therefore, the number of students per Internet-connected computer was calculated for each of the 80 school districts, and the 80 districts were further divided into 4 comparison groups based on the number of students per Internet-connected computer. The number of students per Internet-connected computer were 1) less than 4.49, 2) 4.50 to 6.69, 3) 6.70 to 11.09, and 4) more than 11.10. Another similar ANCOVA was conducted using the number of students per Internet connected computer as a between subject factor.

Results

The means and standard deviations of K-12 enrollment and percent of free/reduced lunch of the 80 schools are presented at Table 1. The average enrollment size was 383.60 (SD = 147.48). The mean of percentage of free/reduced lunch was 42.36 (SD = 15.10).

Computer Availability

The mean MAP scores and adjusted means for students per computer at three grade levels are presented in Table 2. The group with 2.75 to 3.36 students per computer has higher achievement scores than the other three groups, and students tend to perform better in grade 3 Science MAP than in older grades.

The result of the ANCOVA is presented in Table 3. The correlation between the free/reduced lunch and the Science MAP score is -0.59. There was a statistically significant difference in students' mean Science MAP scores for the four groups of number of students per computer. In addition, there was a statistically significant difference in mean Science MAP scores for the three grade levels. No statistically significant differences of Science MAP scores were found among the four comparison groups.

The adjusted mean of Science MAP scores for each of the four comparison groups from Table 2 were graphed (Figure 1). Students in the two groups with fewer students per computer have higher achievement scores than in the other two groups.

The mean MAP science achievement scores in the three grade levels are 51.3, 49.95, and 50.03 as shown in Figure 2.Grade 3 students performed better than 7th and 10 graders on Science MAP.

Internet-Connected Computer Availability

The mean MAP scores and adjusted means for students per Internet connected computer at three grade levels are found in Table 4. The group with lowest number of students sharing one computer (less than 4.49) had the highest mean Science MAP score than the other three groups.

A second ANCOVA was conducted similar to the previous one. The ANCOVA used the number of students per Internet connected computer as a between subjects factor, grade levels as a within subjects factor, MAP scores as the dependent variable, and the percentage of free/reduced lunch as the covariate to remove the effect of students' socioeconomic background. As shown in Table 5, there is a statistically significant difference of Science MAP scores between the four comparison groups ($p<0.01$). Significant differences of Science MAP scores among the three grade levels were found ($p<0.01$), but the interaction between number of students per Internet-connected computer and grade levels was not significant.

The adjusted mean MAP science achievement scores in the four groups are graphed in

Figure 3. The group with fewer than 4.49 students per Internet-connected computer has highest Science MAP scores than the other three groups, and it is higher than the sample mean (50.43).

Discussion and Conclusion

The two independent ANCOVAs found that the more students sharing a computer, the less the students' Science MAP scores. While the group with less than 4.49 students per Internet-connected computer had the highest adjusted mean achievement score in Science MAP. These results are comparable to other research in the effectiveness of CAI on students' achievement (Christmann, Lucking & Badgett, 1997; Kulik & Kulik, 1986; Ryan, 1991). For general computer availability at school, this study showed that the second to the highest computer availability group (2.75 to 3.36) had higher achievement scores than any of the other three groups, including the group with the highest computer availability (less than 2.74). Internet-connected computer availability at school, however, showed a different pattern. The group with the highest Internet-connected computer availability scored higher than the other three groups. Mann and Shafer (1997) researched the relationship between student-computer ratio and increase in students' achievement and found that when the ratio decreased to nine students per computer, there was a significant increase in students' achievement in college preparatory examinations. Although our study showed a smaller number of the student-computer ratio for increasing achievement than Mann and Shafer's study, however, this study consisted of only 80 school districts that were pre-selected and were relatively small. Therefore the pattern might be different when comparing to other studies. As explained in Mann and Shafer (1997), school size is associated with the effectiveness of technology. Computer technology had a larger impact in smaller schools (enrollment less than 600), especially for elementary and middle schools. These eighty school districts in our study had an enrollment size ranging from 273.75 to 442.65, much smaller than Mann and Shafer's standard of 600.

As shown in Figure 2, third graders performed better than 7^{th} and 11^{th} graders and this result was expected. Longitudinal studies and international studies across grade levels, such as the Third International Mathematics and Science Study (National Center for Educational Statistics, 1999) had shown a gradual decrease in students' science achievement in standardized tests as they moved up to higher grades. Researchers still need to investigate the reasons behind this achievement fall and investigate the issue from the orientation of change in attitude toward science.

The quantity of computers at school has a significant and positive impact on student learning as shown by the results. However, the way computers are used may be one of the factors contributing to the increase of students' achievement. For example, Internet is usually used for collaborative assignments and communication. Network projects provide the opportunity for communication with peers and professionals around the world. Our study showed that with less than 4.49 students sharing an Internet-connected computer, the students had higher achievement in science. Therefore it is more difficult for a group larger than 5 students to communicate with each other than a group with only 3 or 4 students; additionally, the students from the latter would benefit more from network projects and Internet communication. Similarly, cooperative learning is proved to be more effective on student achievement than competitive or individual learning (Johnson & Johnson, 1985). Consequently, students who cooperatively shared an instructional computer (i.e. 2.75 to 3.36 students per computer) would have higher achievement than those who used it more individually (i.e. less than 2.74 students per computer). We conclude that, from our study and others, the number of students per computer or per Internet-connected computer has an effect on students' achievement and may be due to collaborative factors.

This study was limited to the pre-selection of samples and need to be replicated using larger sample size, including more school districts of different types of communities and enrollment size. Similar studies in the future should emphasize the student-computer ratio in terms of cooperative learning with shared computers. More interests should be directed to the effect of cooperative learning and group size on computer-assisted instruction. The results of this study support public views that increased number of computers in the classroom helps student learning (American School Board Journal, 1997). Future research in similar orientation will direct policy makers how to spend money in school districts and how much computer technology is required for optimal learning.

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Table 1

Enrollment and Percent of Students Eligible for Free or Reduced Lunch by Computer Availability at School

Computer Availability	K-12 enrollment		Percent Free Reduced Lunch	
	M	SD	M	SD
# of Students/Computer				
<= 2.74	273.75	101.33	47.00	14.22
2.75-3.36	390.55	131.49	39.56	15.62
3.37-4.51	442.65	140.88	44.07	12.28
> 4.52	427.45	156.77	38.80	17.43
Total	383.60	147.48	42.36	15.10
# of Students/Internet-Connected Computer				
<= 4.49	336.05	135.03	46.87	13.90
4.50-6.69	374.10	149.96	37.65	16.39
6.70-11.09	429.25	140.53	44.43	14.76
> 11.10	395.00	158.60	40.47	14.67
Total	383.60	147.48	42.36	15.10

Table 2

Cell Mean MAP Scores and Adjusted Means for Students Per Computer and Grade Levels*

Students/Computer	Grade Levels 3	7	10	Total
<= 2.74 (Group 1)	51.40	49.95	49.49	50.28
	(51.87)	(50.42)	(49.97)	(50.75)
2.75-3.36 (Group 2)	53.02	51.03	51.09	51.71
	(52.73)	(50.75)	(50.81)	(51.43)
3.37-4.51 (Group 3)	49.85	49.41	49.92	49.73
	(50.03)	(49.59)	(50.09)	(49.90)
>= 4.52 (Group 4)	50.94	49.40	49.61	49.98
	(50.58)	(49.04)	(49.24)	(49.62)
Total	51.30	49.95	50.03	50.43

*Adjusted means in parentheses.

Table 3

ANCOVA for Students per Computer as a Between Subjects Factor, Grade Levels as a Within Subjects Factor, MAP Scores as the Dependent Variable and % F/R lunch as the Covariate

Sources	SS	DF	MS	F	p
Between Schools					
St/Comp (A)	122.05	3	40.68	3.36	.023
S/A	907.46	75	12.10		
Within Schools					
Grades (B)	92.36	2	46.18	5.35	.006
A x B	29.11	6	4.85	.56	.760
S/(A x B)	1311.71	152	8.63		
Total	2462.49	238			

Table 4

Cell Mean MAP Scores and Adjusted Means for Students Per Internet-Connected Computer and Grade Levels*

Students/Computer	Grade Levels			Total
	3	7	10	
<= 4.49 (Group 1)	53.00	50.31	50.61	51.31
	(53.53)	(50.84)	(51.14)	(51.83)
4.50-6.69 (Group 2)	50.35	50.58	49.91	50.28
	(50.03)	(50.26)	(49.60)	(49.96)
6.70-11.09 (Group 3)	50.61	49.14	50.29	50.01
	(50.80)	(49.33)	(50.49)	(50.21)
>= 11.10 (Group 4)	51.25	49.76	49.29	50.10
	(50.85)	(49.36)	(48.89)	(49.70)
Total	51.30	49.95	50.03	50.43

*Adjusted means in parentheses.

Table 5

ANCOVA for Students per Internet-Connected Computer as a Between Subjects Factor, Grade Levels as a Within Subjects Factor, MAP Scores as the Dependent Variable and % F/R lunch as the Covariate

Sources	SS	DF	MS	F	p
Between Schools					
St/Comp (A)	156.29	3	52.10	4.47	.006
S/A	873.22	75	11.64		
Within Schools					
Grades (B)	92.36	2	46.18	5.50	.005
A x B	64.85	6	10.81	1.29	.266
S/(A x B)	1275.97	152	8.39		
Total	2462.69	238			

Figure 1. Mean Science MAP Scores for the Four Levels of Number of Students per Computer

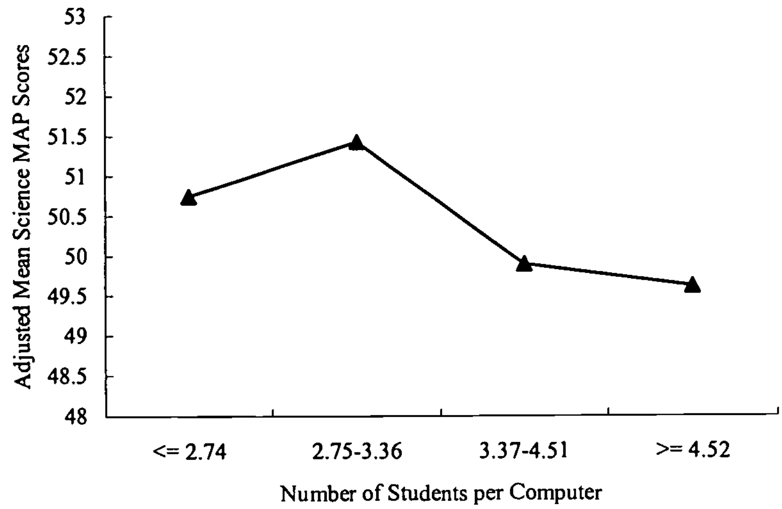


Figure 2. Mean Science MAP Scores for Grade Levels 3, 7, and 10

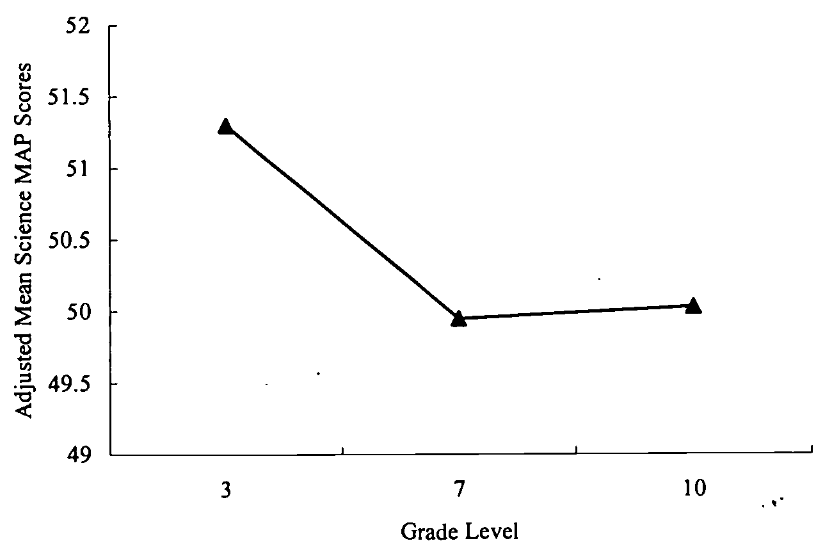
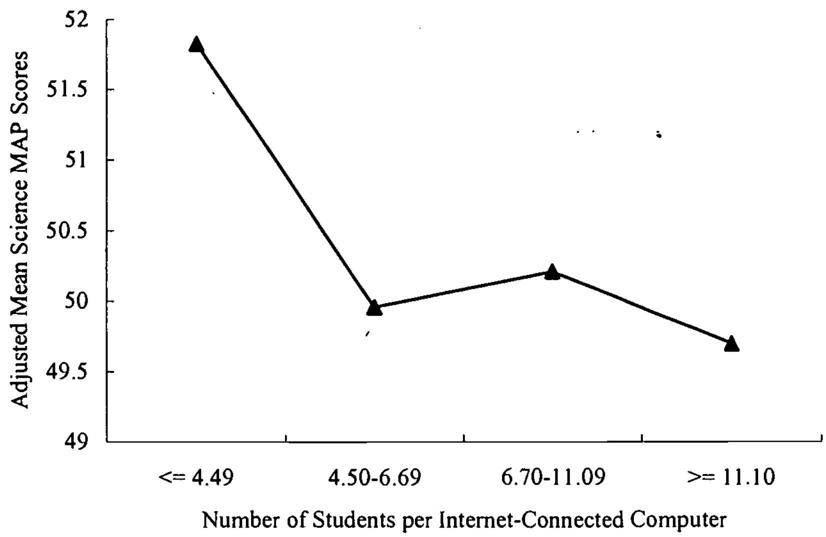


Figure 3. Mean Science MAP Scores for the Four Levels of Number of Students per Internet-Connected Computer



26

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