Pedagogical Motivations for Student Computer Use That Lead to Student Engagement

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Although increasing students' subject-matter understandings and competencies may be the most important goals of instruction, it is widely understood that students' attention, effort, and engagement in academic tasks is a critical intervening variable in determining whether those outcomes are attained. In fact, the widespread appeal of designing computer-based activities for students is at least partly due to teachers' accumulating experience that students are generally more "on-task" and express more positive feelings when they use computers than when they are given other tasks to do.

It seems likely, though, that not all computer activities attract the same degree of student interest and effort.[1] What uses of computers have effects on student engagement that seem most predictive of important learning? The research reported in this paper provides some evidence about this issue. In particular, we look at empirical associations between the kinds of software that students use, teachers' pedagogical motivations behind their use, and one measure of student engagement: teachers' estimates of the number of students who use computers to do work for their class on their own time—that is, before- and after-school, at lunch, during study hall periods, and at their own home or homes of friends. If teachers who use different software or who have different objectives for students' computer work differ greatly in whether they are likely to report that "most students use computers to do work for class outside of class time," it seems reasonable to infer that the group reporting greater out-of-class computer use is providing a more engaging activity for their students. This is especially so if one controls for differences in the types of students each group of students serve and the subjects they teach. Information to test whether that empirical conjecture holds true comes from a comprehensive national survey of teacher pedagogy and computer use, Teaching, Learning, and Computing, which I conducted along with Ron Anderson from the University of Minnesota.

Background to the Research

In the 1980's, Stanford professor Mark Lepper pointed to the likely motivational impact of certain uses of computers as classroom learning tools. His examination of the theoretical literature on intrinsic motivation suggested several ways that computer-based learning activities might lead to increased student engagement on academic tasks. First, to the extent that computer activities provide intellectual challenge, they motivate students to seek a solution to a problem. Second, computer activities that stimulate human curiosity or a desire to resolve an incongruity generate similar effort. And third, computer work that provides a sense of independent control and mastery over an environment also provokes sustained and intense effort (Lepper, 1985). Lepper further raised the proposition that active, self-directed, inductive, and exploratory computer activities might result in increased student learning, not just for the best students, but for a broad range of students, although he also cited cautionary warnings in the literature about less-than-satisfactory outcomes for less motivated students or less capable pupils (Lepper and Chabay, 1985).

Qualitative research on computer-rich environments have generally supported the idea that project-based work with computers is highly engaging for students. Sandholtz and her associates, studying a rich supply of reflective audiotape journals and written reports of teacher-participants in the Apple Classroom of Tomorrow (ACOT) program (1985-1991), found broad evidence of increased student engagement in academic work. They found that students often went beyond the requirements of their assignments and

[1] Neither is it likely that all engaging computer activities are equally valuable for improving important learning outcomes.

explored new computer applications and developed application-related skills on their own initiative. They found that students came in before school and stayed after school to work on the class' computers—and the researchers stressed that these were "quite ordinary" students, not those who were otherwise academic stars. Anecdotes included a comment about a student staying after class to discuss a programming language: "Do you know how unusual it is for a student to stay after class to discuss content?" (Sandholtz, Ringstaff, and Dwyer, 1997; p. 93)

However, the ACOT researchers found that increased student engagement occurred in certain settings:

- Where computers were used as only one of a set of tools rather than as the central learning modality.
- Where computer use was not a separate curricular focus ("computer time") but was a vehicle for accomplishing substantive curricular objectives.
- Where teachers emphasized "tool" applications like desktop publishing and hypermedia authoring that allowed for experimentation and exploration, rather than settings where drill-and-practice and similar learning games dominated computer use.
- Where teachers provided for individualized computer experience that was responsive to individual student interest and ability.
- Where teachers were more willing to give responsibilities to students for determining specific learning tasks and how to accomplish them.
- Where teachers were more willing to break down disciplinary and unit boundaries to permit content to be investigated across those boundaries (Sandholtz, Ringstaff, and Dwyer, 1997).

In Means' case studies of 17 intensive computer-using classes at nine reform-oriented schools during 1991-93, she found that "the most common—in fact, nearly universal—teacher-reported effect on students was an increase in motivation (Means and Olson, 1995). In some cases, teachers felt the improvement was in terms of students' effort at learning the specific subject-matter of the class. In other cases, the perceived improvement in motivation was more general—a "sense of accomplishment" gained from working with computers. These perceptions were supported by the researchers' own observations during their field visits. As in the ACOT study, this investigation attributed the improved student effort to how computers were being used in the studied classes—for project work in cooperative teams, where the teacher had become a co-learner rather than the primary source of knowledge for students.

Consistent with teacher reports and these qualitative case studies, small quantitative project-implementation studies have also found improved motivation on the part of students using computers for product-oriented projects such as designing informative multimedia or hypermedia presentations (e.g., Lehrer, 1993; Liu, 1998). Lehrer, for example, found students volunteering to work on a hypermedia authoring activity during their study hall, after school, and on both Saturday and Sunday (the latter in order to meet a competition deadline).

Although case studies and curriculum-development projects such as these often report motivation outcomes for students, there is little nationally descriptive evidence about the relationship between various patterns of computer use and student motivational outcomes. In particular, it would be helpful to know:

- How broadly teachers experience various manifestations of increased student motivation or engagement in academic work?
- Are those manifestations primarily confined to certain computer activities—for example, project work, production of multimedia products, "authentic" work that results in a communication to an involved audience, or other rather specialized context?

- Are teachers who approach the use of computers in terms of certain pedagogical motivations (e.g., teaching objectives of a more "constructivist" sort) more likely to accomplish increased student engagement, net of the types of students they teach or the subject-matter they teach?

Furthermore, there are a number of different ways in which student engagement and effort in academic work might be measured. Typically, a researcher asks teachers about their perceptions of student interest under conditions of active computer use compared with their experience in teaching similar students without that extent or type of computer work. But the anecdotal evidence that Lehrer provided in his account and which was roughly alluded to in some of the case study data is of a different type—namely, that students were engaging in a much higher level of effort outside of class time in order to accomplish work for an academic class. And in these examples the work being done involved using computers and computer software in order to accomplish class assignments or objectives.

The ability of teachers to motivate students to do work outside of class time is perhaps one of the great sources of unequal achievement in American schools, particularly in secondary schools. National survey data report that students spend relatively few hours doing homework or similar academically-related productive work. For example, the NELS88 study reported a weekly average of between 5 and 6 hours of homework was done by 8th graders in 1988 (U.S. Department of Education, 1990). Successful secondary students report doing substantially more homework than students who perform poorly in school (Cooper, et al, 1998). Typically that result is interpreted as meaning that doing more homework helps students to get good grades; however, part of that relationship may be because students who are accustomed to being rewarded in school with good grades are more likely to do work that teachers want them to do on their own time.

Adolescents' non-school lives are increasingly taken up in informal peer-related recreational activities and part-time employment that is overwhelmingly unrelated to any competencies or understandings learned in their formal school work. In those situations where teachers can break through these competing influences, this is evidence of either a strong extrinsic motivation for high grades for use in college admission or an even more impressive impact of appealing to a rather tenuous and undeveloped motivation for accomplishment.

Based on the types of computer work that may be intrinsically motivating to a broad cross-section of adolescent and pre-adolescent students—activities integrated with substantive content objectives, work related to complex projects, "authentic" work done for an audience, and design and construction of multimedia and hypermedia information products—it was postulated that teachers whose students engage in such computer activities are more likely than other teachers to report students being engaged in doing additional computer work for their class outside of class time. Furthermore, teachers whose objectives for having students use computers are consistent with a constructivist view of learning (rather than acquiring a pre-selected and transmitted array of facts and skills) would be more likely to be successful at engaging students in doing computer work for their class outside of class time.

Data and Methods

The Teaching, Learning, and Computing (TLC) study is comprised of completed questionnaire responses from more than 4,100 teachers and from principals and school technology coordinators at more than 1,000 schools. A majority of respondents represent a national probability sample of schools. The remainder come from schools that were "purposively" sampled from two types of lists: “High-end technology schools” are schools with substantial amounts of computer technology per capita. “Reform Program schools” were long-term (3 year +) participants in one of 54 different national or regional

externally-defined "programs" of major school or instructional reform or had originated a technology-oriented program of instructional reform on their own.

Teachers were sampled from grades 4-12 and from all subjects except physical education and special education. At each sampled school, three (elementary) or five (middle and high school) teachers were selected with probabilities related to the teacher's reputed instructional practices and use of technology. A small number of teachers (a maximum of two per school) were selected with certainty based on the principal's attribution of that teacher having an exemplary instructional practice or based on their known participation in the selected program of instructional reform. Because unequal probabilities were used, at both school and teacher level, all analysis employs weighted data with weights inverse to the probability of selection, as modified by stratum-specific non-response rates and within-school partial completions of teacher rosters. Schools participated in the study at a 75% rate, and individual teachers sampled had a 68% response rate within those schools. Altogether, 2,251 teachers from the probability sample participated in the study and an additional 1,832 teachers from the purposive samples. (Additional information about the sample design and field procedures can be found in Appendix B to Becker, Ravitz, & Wong, 1999; and on the project website: http://www.crito.uci.edu/TLC.)

The teacher respondents each completed a survey booklet about their teaching practice and teaching beliefs that was 21 pages in length and required approximately 60-75 minutes. Four different versions of the teacher survey booklet were used, with overlapping sets of questions. Among the questions in the teacher survey were three that form the focus of this paper:

Objectives for Computer Use. Which of the following are among the objectives you have for student computer use? Which three objectives from the list have been your most important ones?

- Mastering skills just taught
- Remediation of skills not learned well
- Expressing themselves in writing
- Communicating electronically with other people
- Finding out about ideas and information
- Analyzing information
- Presenting information to an audience
- Improving computer skills
- Learning to work collaboratively
- Learning to work independently
- Other (describe)

Proportion of Students Using Computers Outside of Class Time to Do Work for the Class. Whether or not students use computers during class time, some students may use computers to do work for this class at other times. How many students in this class have done work for this class using computers in each of these settings on at least several occasions? (choices: none or few; 1/4; 1/2; 3/4; all students)

- At other times while at school (lunch, before or after school, etc.)
- At home (or outside of school)

Frequency of Student Use of Different Types of Software. For each of the following types of software, please indicate for how many lessons your students have used that type of software this year in ANY of your classes: (choices: No lessons, 1-2 lessons, 3-9 lessons, 10+ lessons)

- Games for practicing skills
- Simulations or exploratory environments

- Encyclopedias and other references on CD-ROM
- Word processing
- Software for making presentations (e.g., Powerpoint)
- Graphics-oriented printing (e.g., Print Shop)
- Spreadsheets or database programs (creating files or adding data)
- Hyperstudio, Hypercard, or other multimedia authoring environment
- World Wide Web browser
- Electronic mail

The first two of those survey items—the question about teachers' objectives (or as phrased here, their pedagogical motivation) and the question about out-of-class computer use for class work—were asked of teachers who had students use computers for a single selected class. The class selected was the one in which the teacher felt she most frequently accomplished her objectives. The third question, about software use, was asked of teachers who had students use computers in any of their classes. In addition, the question about out-of-class computer use appeared in only two of the four versions of the questionnaire (randomly allocated among teachers). Thus, based on the screening question about computer use and the 50% inclusion of the out-of-class use question, the data in this paper that relate to out-of-class computer use come from 753 teachers in the probability sample and an additional 665 teachers in the purposive samples. Descriptive data about the other variables that don't have the question sub-sampling limitation are based on a substantially larger sample.

Results

Across all teachers in the probability sample who assigned computer work to their selected class, 25% said that all or most (3/4) of their students have done computer work on at least several occasions outside of class time while at school. About the same number (28%) said that all or most students had done class work at home or other places away from school. These two types of out-of-class activities are correlated; a majority of teachers who reported one type of activity also reported the other.

Teachers who reported that most students did out-of-class-time computer work differed from other teachers in terms of which subjects they taught, the overall level of student achievement in their class, the socio-economic level of the school’s population, and which objectives they prioritized for student computer use. Thus, student characteristics, teaching responsibilities, and pedagogical motivation for computer use all affect the likelihood that students will supplement their in-class computer work with time before or after school or at home, at least as measured by teacher surveys.

Pedagogical Motivation

Teachers' objectives for their students' computer use represent their pedagogical motivations— what they hope students will accomplish through the computer activities which they do for their class. The TLC survey gave teachers a list of 10 objectives and asked them to select the three that were most important to them in their use of computers by students. Table 1 compares two groups of teachers for each objective: those who selected that objective in their top three and those who did not.

By far the highest level of at-school non-class-time computer work was found for teachers who value computers for helping students to present information to an audience. More than twice as many teachers who valued that objective said that most students did computer work for the class at other times of the school day (44%) as those who listed only other objectives among their top three (21%). Similar

differences were found in terms of home computer use between presentation-valuing teachers and other teachers (44% vs 25%).

TABLE 1: PERCENT OF COMPUTER-ASSIGNING TEACHERS REPORTING ALL OR MOST STUDENTS USING COMPUTERS OUT-OF-CLASS TO DO CLASS WORK, BY OBJECTIVE FOR STUDENT COMPUTER USE

		% Reporting That Most or All Students Did This on Several Occasions			
		Out-of-class In-School		Out-of-class Out-of-school (At home)	
Objective for Student Computer Use	Number of teachers with that objective (out of 720)	Among teachers with that objective (among top three)	Among other computer-assigning teachers	Among teachers with that objective (among top three)	Among other computer-assigning teachers
Presenting information to an audience	(143)	44	21	44	25
Expressing oneself in writing	(295)	29	21	36	21
Communicating electronically	(54)	27	24	41	26
Finding out about ideas and information	(363)	26	23	34	21
Analyzing information	(216)	28	23	27	28
Improving computer skills	(234)	24	25	27	28
Learning to work collaboratively	(189)	22	25	25	29
Learning to work independently	(163)	21	26	11	32
Remediation of skills	(158)	18	27	17	32
Mastering skills	(248)	16	30	19	33

Sample: Probability sample; questionnaire 1 and 2; teachers who used computers with students in selected class.

Seeing computers as valuable for helping students improve their written expression was the second pedagogical motivation associated with greater at-school, out-of-class use of computers for class work (29% reported most students doing this vs. 21% for other teachers). Writing objectives were associated even more strongly with at-home computer use by students (36% vs. 21%). Two other objectives for students' computer use—communicating with other people and finding out about ideas and information—were associated with greater at-home use for class work, but not with use at other times of the school day.[2]

In contrast, three groups of teachers are much less likely than other teachers to report students using computers out-of-class: those whose objectives are reinforcement of skills, remediation, and students "learning to work independently."[3]

Frequent Users of Different Types of Software

Teachers' objectives tend to be accomplished by having students use specific types of software. Thus, it is not surprising that teachers who report their classes frequently using certain types of software are the

[2] When these findings are converted to effect sizes based on the full range of variation in the question about the percent of students who used computers for class in each context and combining at-home and at-school computer use, the effect size for presentation objectives (those with vs. those without that objective) was .68, while the effect sizes for the other three objectives discussed so far were close to .40.

[3] Effect sizes all about –.50. It is interesting that teachers who value computers to help students to work independently are much less likely than others to report students actually using computers outside of their own presence! It seems plausible that for many teachers, having students "work independently" means that they prefer students to be working quietly, not that they really want them to do independent work!

same teachers who report the highest levels of participation in computer work being done outside of class time. The students who are most likely to be doing computer-based classwork at school but outside of class time are those who have had frequent exposure to one of six types of software during class: electronic mail, presentation software such as Powerpoint, multimedia authoring programs such as Hyperstudio, graphics-oriented printing programs, World Wide Web browsers, and CD-ROM reference software. However, it is also true that with the exception of teachers whose students used skill-based games, just about any frequent use of computers during class is associated with greater use of computers outside of class time. Teachers whose students use computers only occasionally (or who use games frequently) are less likely to initiate computer-based activities for class at other times of the school day. (See Table 2; the purposive sample was included in these tabulations in order to increase the sample of frequent software users.)

TABLE 2: PERCENT OF COMPUTER-ASSIGNING TEACHERS REPORTING ALL OR MOST STUDENTS USING COMPUTERS OUT-OF-CLASS TO DO CLASS WORK, BY TYPE OF SOFTWARE USED FREQUENTLY

% Reporting That Most or All Students Did This on Several Occasions

		Out-of-class In-School		Out-of-class Out-of-school (At home)	
Type of Software Used Frequently By Students	Number of teachers using that software frequently (out of 1365)	Among teachers using that software frequently (10+ lessons)	Among other computer-assigning teachers	Among teachers using that software frequently (10+ lessons)	Among other computer-assigning teachers
Presentation software	(138)	51	28	41	29
E-mail	(101)	53	28	36	30
Multimedia authoring	(109)	46	28	37	30
Word Processing	(660)	38	22	38	22
CD-ROM Reference	(299)	44	26	34	29
Graphics oriented	(177)	46	27	33	30
WWW Browser	(315)	44	26	30	30
Spreadsheet/Database	(138)	40	29	31	30
Simulation/Exploratory	(158)	38	28	27	30
Skill Games	(249)	26	30	14	33

Sample: Probability and purposive sample; teachers who used computers with students in selected class, questionnaire versions 1 & 2.

Outside of school, the students who are most apt to use computers to do school work are those whose teachers gave them frequent opportunities to work with presentation software, email, multimedia authoring programs and word processing. The strong relationship to classroom word processing experience is doubtlessly due to the ease with which that type of software carries over to non-supervised computer time. The fact that students experiencing complex multimedia authoring software in class are among the most likely out-of-school users of computers (for schoolwork) suggests that such in-class experiences develop a wide range of computer skills that can be exploited in a relatively open and yet unsupported environment outside the school. (Of course, non-school efforts may be strongly supported by peer expertise.)

To more accurately interpret these associations between student out-of-class computer use and teacher pedagogical motivations and software assignment practices, it is important to consider other factors that might affect both student out-of-class computer use and teacher approaches to instruction. We examine three of these: subject-matter responsibilities, student ability level, and schoolwide socio-economic-status (SES).

Teacher Subject-Matter Responsibility

In terms of subject-matter, two-fifths (39%) of all science teachers who assigned computer work during class reported that most or all students did computer work at school outside of class time. Teachers of computer classes and social studies teachers also had higher-than-average rates of reporting before- and after-school computer use. On the other hand, only 10% of computer-assigning math teachers did. Table 3 shows not only the percent of teachers reporting most or all students doing out-of-class school-located computer work, but the percent reporting that no students did this at all. Besides math teachers, three other groups of teachers reported limited out-of-class-time computer work by students—vocational education teachers, business education teachers, and elementary teachers of self-contained classes.

TABLE 3: PERCENT OF COMPUTER-ASSIGNING TEACHERS REPORTING DIFFERENT LEVELS OF OUT-OF-CLASS AT-SCHOOL COMPUTER WORK (FOR THE CLASS), BY SUBJECT AND LEVEL TAUGHT

	Fraction of students using computers outside of class time AT SCHOOL for class work on at least several occasions			
Subject Taught to Class	% reporting none or few students did this	% reporting 1/4 to 1/2 students did this	% reporting most or all students did this	Total (N) %
Elem. Self-Contained	44	36	20	100 (160)
Elem. Other	29	46	25	100 (54)
English	29	49	22	100 (108)
Science	32	29	39	100 (98)
Math	54	37	10	100 (53)
Social Studies	14	54	33	100 (52)
Miscellaneous Academic Secondary	26	51	23	100 (47)
Computers	25	39	36	100 (43)
Business	37	47	17	100 (40)
Vocational	33	47	20	100 (32)
All computer-assigning teachers	34	42	25	100 (718)

Sample: Probability sample; questionnaire versions 1 and 2; teachers who used computers with students in selected class.

With respect to students using computers to do work for the class at home, more computer-assigning *English* teachers reported students doing this than any other group of teachers (48%). That is probably due to the wide accessibility of word processing software on home computers. Science and foreign language teachers were also above-average in this regard, also suggesting that word processing is the dominant class-related use of computers at students' homes. The computer-assigning teachers *least likely* to report most students engaged in away-from-school computer use for class-related work were fine arts teachers (none of them did), math teachers (5%), and vocational education teachers (10%). For two of those groups, fine arts and vocational education, that is probably due to the specialized and costly nature of the software used in those courses. For math teachers, this appears to be the continuation of the relatively low involvement of math teachers in computer work that we have found evident throughout our reports from the TLC study. (See Becker, 1999; and Becker, Ravitz, and Wong, 1999 for additional details.) It should be noted that while a majority of fine arts and vocational education teachers reported *some* student computer use outside of school, 71% of computer-assigning secondary math teachers reported *no* outside-of-school use by students for math class *at all*. (See Table 4.)

TABLE 4: PERCENT OF COMPUTER-ASSIGNING TEACHERS REPORTING VARIOUS LEVELS OF OUT-OF-SCHOOL COMPUTER WORK FOR CLASS, BY SUBJECT AND LEVEL TAUGHT

	Fraction of students using computers outside of class time AWAY FROM SCHOOL for class work on at least several occasions			
Subject Taught to Class	% reporting none or few students did this	% reporting 1/4 to 1/2 students did this	% reporting most or all students did this	Total (N) %
Elem. Self-Contained	34	48	19	100 (158)
Elem. Other	20	52	28	100 (53)
English	21	31	48	100 (109)
Science	18	40	42	100 (100)
Math	71	24	5	100 (50)
Social Studies	7	63	30	100 (53)
Miscellaneous Academic Secondary	20	54	26	100 (47)
Computers	27	55	18	100 (40)
Business	40	43	17	100 (40)
Vocational	43	47	10	100 (33)
All computer assigning teachers	29	44	28	100 (718)

Sample: Probability sample; questionnaire versions 1 and 2; teachers who used computers with students in selected class.

Student Characteristics

Both student ability and family socio-economic status (SES) are likely to be related to out-of-class computer use for class work. Higher-achieving students and students from better off families are much more likely to have a computer at home. (For the latter relationship, see Becker, 2000.) Both variables also appear to affect a student's motivation to use computers at school during their free time (or before- or after-school). However, because the TLC survey is teacher-based rather than student-based, we cannot control perfectly for either ability or SES. Nevertheless, we can show two relationships: the association between teacher-estimated class ability (prior achievement) level and out-of-class computer use and the association between schoolwide average socio-economic status and out-of-class use. In order to provide more stable data, information from teachers in the purposive sample is included in this analysis.

Table 5 shows that although the relationship between school-level SES and in-school, out-of-class, computer use is small, the other three relationships are huge. Computer-using classes at schools in the highest quartile on socio-economic status are more than three times as likely to have widespread at-home computer use for class work than computer-using classes at schools in the lowest quartile on SES. Specifically, 50% of the high-SES teachers vs. 14% of the low-SES teachers said that all or most students did computer work for class away from school on at least several occasions during the year.

TABLE 5: PERCENT OF COMPUTER-ASSIGNING TEACHERS REPORTING ALL OR MOST STUDENTS USING COMPUTERS OUT-OF-CLASS TO DO CLASS WORK, BY CLASS ABILITY LEVEL AND SCHOOL SES

	% Reporting That Most or All Students Did This on Several Occasions		
Control Variable and Category	Out-of-class In-School	Out-of-class Out-of-school (At home)	(N)
School Socio-Economic Status			
Highest Quartile	36	50	(325)
Second Quartile	28	27	(348)
Third Quartile	28	22	(362)
Lowest Quartile	26	14	(321)
Class Ability Level (teacher-judged)			
High (highest 17%)	50	51	(213)
High-Average	30	38	(492)
Low-Average	29	21	(470)
Low (lowest 11%)	18	15	(139)

Sample: Probability and purposive samples; questionnaire versions 1 and 2; teachers who used computers with students in selected class.

With respect to student ability, classes of the highest-ability students were about three times as likely as classes of the lowest-ability students to involve widespread use of computers out-of-class, both at home and at school. The differences in computer use at home were somewhat larger than the differences in at-school out-of-class use, probably because of the association between class ability-levels and school SES. Classes of intermediate ability groups are appropriately mid-way between the high- and low-ability classes in terms of out-of-class use of computers for class work although the pattern is quite different for school use than for home use. For home use, the biggest differences are between the upper two quartiles in student ability and the lower two quartiles. For school use, only the top quartile of classes report substantially higher free-time computer use than the others.

Effects of Pedagogical Motivation and of Frequent Software Use Controlling on Conditions of Teaching

It is also the case that the kinds of software that teachers use and their objectives for its use are related—not just to their subject-matter responsibilities which would be obvious (e.g., social studies teachers use different software and have different pedagogical motivations than fine arts teachers)—but to school socio-economic status and class ability level as well (Becker, Ravitz, and Wong, 1999; Becker, 2000). For example, 30% of middle school teachers in high-SES schools selected "presenting information to an audience" as a main reason for having students use computers compared to 17% of middle-school teachers in low-SES schools. Among elementary teachers in grades 4-6, those who taught classes average or below in ability were twice as likely to list remediation as one of their major objectives than were teachers who taught classes in the upper-half of the ability scale (39% vs. 19%).[4] Thus, some part of the explanation for why teachers with different pedagogical motivations have a correspondingly different likelihood of reporting that their students use computers for class work outside of class time is that they teach different varieties of students in different types of communities. Therefore, a clearer understanding of the actual causal effects of teacher pedagogical motivations and software use on students' out-of-class behavior can only be had by statistically controlling for these other important influences.

[4] Data based on the probability sample of the TLC survey.

TABLE 6: RELATIONSHIP BETWEEN OBJECTIVES FOR STUDENT COMPUTER USE AND STUDENT USE OF COMPUTERS FOR CLASSWORK OUTSIDE OF CLASS, WITH STATISTICAL CONTROLS

	Standardized Partial Regression Coefficients (shown only if >±.07) (correlations in parenthesis)	
Objective for Student Computer Use During Class	Use Out-of-class In-School	Use Out-of-school (At Home)
Presenting information to an audience	.21 (.23)	.12 (.20)
Expressing oneself in writing	.12 (.10)	.14 (.23)
Communicating electronically		.16 (.22)
Finding out about ideas and information		.19 (.26)
Analyzing information		–.08 (–.00)
Improving computer skills		
Learning to work collaboratively		
Learning to work independently		–.18 (–.26)
Remediation of skills	–.08 (–.14)	–.15 (–.26)
Mastering skills	–.16 (–.18)	–.15 (–.26)

Control variables entered: 11 dummy variables representing subject matter taught, school socio-economic-status, teacher-estimated class ability levels.
Sample: Probability sample; questionnaire versions 1 and 2; teachers who used computers with students in selected class.

The statistical control procedure used was multiple regression. Standardized partial regression coefficients, comparable in magnitude to correlation coefficients, were used to assess whether teacher objectives or frequent use of different types of software is associated with greater out-of-class use of computers by students—net of subject taught, class ability level, and school SES. Table 6 shows the effects of teachers' having different pedagogical motivations; table 7 shows the effects of frequent use of different types of software during class. The tables show the statistical coefficients only when they are of at least modest magnitude when controlling on subject, ability, and SES. The correlation coefficients that express those same relationships without controls are shown as well (in parentheses).

TABLE 7: RELATIONSHIP BETWEEN FREQUENT USE OF DIFFERENT TYPES OF COMPUTER SOFTWARE AND STUDENT USE OF COMPUTERS FOR CLASSWORK OUTSIDE OF CLASS, CONTROLLING ON SUBJECT-TAUGHT, SCHOOL SES, AND CLASS ABILITY LEVELS, BY SITE OF OUT-OF-CLASS COMPUTER WORK

	Standardized Partial Regression Coefficients (shown only if >±.07) (correlations in parenthesis)	
Type of Software Used Frequently By Students	Use Out-of-class In-School	Use Out-of-school (At Home)
Presentation software	.14 (.15)	
E-mail	.12 (.15)	
Multimedia authoring	.15 (.16)	.08 (.09)
Word Processing	.20 (.18)	.18 (.22)
CD-ROM Reference	.25 (.24)	.11 (.12)
Graphics oriented	.19 (.19)	
WWW Browser	.16 (.19)	
Spreadsheet/Database		
Simulation/Exploratory	.13 (.09)	
Skill Games	.15 (.04)	

Control variables entered: 11 dummy variables representing subject matter taught, school socio-economic-status, teacher-estimated class ability levels.
Sample: Probability sample; questionnaire versions 1 and 2; teachers who used computers with students in selected class.

The effects of teachers' pedagogical motivations on the fraction of their students whom they report using computers to do class work outside of class remain important even when controlling on subject, ability, and SES. Teachers who prioritize the objective of students learning to present information to an audience report more in-school out-of-class use of computers and teachers who prioritize skills mastery report less in-school out-of-class computer use, even when student ability, socio-economic characteristics and subject taught are taken into account. Out-of-school uses of computers are more affected by student ability and socio-economic factors, and so the effects of teacher pedagogical motivation are smaller when these other factors are taken into account. However, it is still the case that reasonably strong effects are noted for the objective of information-gathering and, somewhat less so, for electronic communication, written expression, and presentation to an audience as well. Negative effects remain for teachers whose objectives are skills reinforcement, remediation, and that students learn to work independently.

Teachers who have students use almost any type of software more frequently than other teachers do report more in-school out-of-class computer use even with our statistical controls on subject taught, ability, and SES. Moreover, with those factors controlled, even teachers who have students frequently use skill games and simulation exercises report more out-of-class computer use at school than teachers who use that software less often. However, home use of computers for class work remains associated only with frequent use of word processing software during class.

The different patterns between Table 6 and Table 7 suggest that teachers' particular objectives for student computer use have a larger effect overall than the specific kinds of software that they have students use during class—although frequent use of some kind of software is an important condition for high levels of in-school out-of-class computer use.

Discussion

It is not too much of an exaggeration to say that American adolescents live in a world defined by their age-peers and that they visit the alien adult world during their time in teachers' classrooms. Whether they are personally affected by their experiences in the adult world can in some sense only be measured by examining what they choose to do in their free time. Deborah Meier, the founder of New York's Central Park East Secondary School, wrote that her goal was largely to break a hole in the wall between the teenagers' world and the adult world—to achieve a state where "the children are willing to let us catch them acting like nice young people who want to be smart" (Meier, 1995; p. 59). When students can be found to be taking their school work seriously enough to be investing their energy in academic work outside of class time, then, whether extrinsically motivated by grades or intrinsically motivated by sincere interest in accomplishment, schools have succeeded in advancing Meier's vision.

This paper has investigated the extent to which teachers' use of computers during class time are predictive of their students' continued use of computers to do school work at other times. As measured either by frequent use of computers during class or by a teacher having certain pedagogical purposes for that use, we have found that certain patterns of in-class computer use are clearly related to students' use of computers for school work during their free time. Moreover, when we took into account that students' voluntary use of computers outside of class time is affected by their general record of academic success and their opportunities to use computers at home (using the best measures we had available—school-level SES and class average ability), our general findings remained strong. This left us with greater confidence that specific findings about teachers' pedagogical motivations for using computers and the extent of their students' use of software during class did have effects on student out-of-class behavior independent of ability and SES. In particular, if teachers' principal objectives for student computer use include having students make presentations of their work before an audience, this appears to result in greater use of computers for school work at other times of the school day. Home computer use appears to be greater

when teachers prioritize having students use computers to find information and to communicate electronically and when they give students frequent opportunities to use word processing software during class time.

Why These Effects Occur

Being asked to defend one's research and one's reasoning before an audience provides a highly motivating challenge for most people. Note that it may not be experience with presentation software in particular that accounts for the relationship between this objective and out-of-class use of computers but, instead, the kinds of assignments that a teacher gives which has that result. The fact that the effect is observed more for in-school than out-of-school use is likely to be due to the group nature of many student presentations and the opportunity for student groups to gather to prepare their presentations while everyone is present at school.

Two other teacher objectives associated with out-of-class computer use—acquiring information and communicating electronically—have stronger associations for at-home use than at-school use. That result is probably due to the limited number of school Internet connections present in 1998 at the time of the study. At that point, students who were asked to use the World Wide Web and electronic mail (or even telephone) to do their school work may have had greater access to those resources at home than at school. (Of course, teachers' knowledge of who has home access no doubt influences the expectations and objectives for computer use that guide teachers' practices to begin with.) School access to a sufficient number of Internet connections remains a problem for orchestrating Web-related and electronic mail activities at school sites (Becker, 2000).

Finally, the ubiquity of word processing software on both school and home computers means that teachers who provide students with sufficient opportunities during class to become competent users of that software are more likely than other teachers to give students the confidence they need to exploit word processing software on their family's home computer. Those of us for whom word processing is the primary means by which we communicate with other people sometimes forget that for perhaps a majority of young people, word processing software is the only software, besides computer games, that they come to know sufficiently well to be able to use on their own and without need of further instruction and support.

We Need Better Measures of Effects on Students

What, then, is the importance of knowing that certain approaches to computer use have these effects on students? Policymakers and the public continue to ask whether and under what conditions computers make a difference in student achievement. However, direct measures of student achievement that can be used to answer that question are hardly up to the task. Nearly all instruments used in standardized testing situations to compare students having various levels and types of computer experience are composed of paper-and-pencil tasks that exclude the very same computer resources and tools by which students with computing expertise might be able to demonstrate their greater competencies to do academic work. The recent evidence gathered about the under-performance of word-processing-capable students on paper-and-pencil tests of writing quality is one manifestation of that fact (Russell and Haney, 2000). By measuring only a limited range of tasks and by employing a minimum-resource "standardized" testing environment, the tests to which policymakers and the public pay attention deny computer-capable students the ability to demonstrate important competencies they may have acquired.

In order to more directly understand the consequences of high intensity computer experiences or computer-based instruction motivated by different pedagogical objectives, we badly need a new set of assessment instruments. Those assessment instruments need to be able to be used to compare students with and without different types of computer experiences, but they need to be sensitive to the particular competencies that students using computers are likely to gain (Becker and Lovitts, 2000). However, until we have more appropriate measures of student outcomes, we have to use less direct approaches—using measures that are putatively consequential for student competency, such as their initiative in using computers to do academic work on their own time. The data analyzed for this paper provides one small indication of the kinds of effects that computer experience might be having on young people. It is, however, but a small indication of the distance we have yet to travel to fully understand the ways in which computer experience may be transforming future generations of students.

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