How Are Teachers Using Computers in Instruction?

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We often speak about computers in classrooms as if we and our audience have a common view of what they are and what function they serve. But the character of computers and their functionality have been very different at different points in time (Exhibit 1) and, as will be shown here, remain quite differccent for teachers of different subjects, teachers who teach students of different ages and backgrounds, and teachers who have characteristically different pedagogies.

EXHIBIT: 1 "EXPERT" WISDOM ABOUT USING COMPUTERS IN SCHOOLS

(1982) Program computers using BASIC
(1984) Thinking skills that will transfer--LOGO
(1986) Basic skills--ILS
(1988) Tools: word-processors, database, spreadsheets
(1990) Curriculum integration
(1992) Authentic work; real audiences; Hypercard stacks
(1994) Not programming again! Worldwide e-Mail links
(1996) The Web: Finally research is fun
(1998) Learning by producing: Publish student work on Web
(2000) Technology is not important; its just a tool for reform

This paper presents descriptive data from a large, national survey of teachers and their teaching practices in order to highlight some of the important differences in computer use patterns, and thereby to at least slightly contextualize general discussions about teachers' computer use. These findings may also be useful for considering the likely effects of current teaching practices, subject-by-subject, level-by-level, and pedagogy-by-pedagogy. A fuller treatment of the research literature on differential computer use practices will be provided in a later draft.

Data Source

Teaching, Learning, and Computing (TLC) is a national survey of more than 4,000 teachers from grades 4-12 conducted in Spring, 1998, under a grant from the National Science Foundation with funds also provided by the Field-Initiated Studies program of the U.S. Department of Education's O.E.R.I. Teachers provided information principally about their teaching philosophy and actual teaching practices in one specific class, their access to and use of computers as a classroom teaching resource and in also in their own professional work, other aspects of their work environment, their outside professional activities, and their personal background. In addition, school-level data was provided by the school's principal and the individual selected by the principal as "technology coordinator." Four different versions of the teacher survey booklet were used, with overlapping sets of questions. Survey instruments are available at http://www.crito.uci.edu/tlc/html/questionnaires.html.

Somewhat more than one-half of the 1,616 schools sampled for the study (56%) were a stratified national probability sample of elementary (299 schools), middle (253), and high schools (346), including 83 private and parochial schools. Schools were selected according to size and presence of computer technology, oversampling larger schools and those with a greater density of various computer technologies. The remaining samples of schools are referred to as "purposive samples" and were based on compiling, refining, and sampling from lists of two basic types of schools: "High-end Technology" schools are schools with substantial amounts of computer technology per capita, including schools selected from the upper-end of Quality Education Data, Inc's, Technology Index and schools identified through books, articles in magazines and school web-sites. "Reform Program" schools were compiled by identifying schools or individual teachers who had been long-term (3 year+) participants in one of 54 different national or regional externally-defined “programs” of major school or instructional reform.

In all three school samples, teachers were sampled from grades 4-12 and from all subjects except physical education and special education. At each sampled school, three to five teachers (3, elementary; 5, middle and high school) were selected with probabilities related to the teacher’s reputed use of technology and group projects and emphasis on higher-order thinking. A small number of teachers (a maximum of 2 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 to select both schools and teachers, all analysis employs weighted data using weights that are inverse to the probability of selection.[1] Much of the descriptive analysis makes use only of the schools and teachers in the national probability sample. Additional information about the sampling design can be found in Appendix B to TLC Report 3 – Teacher and Teacher-Directed Student Use of Computers and Software. (See also Exhibit 2.)

EXHIBIT 2: THE STUDY SAMPLE

- A representative sample of all U.S. schools
  (Probability Sample: 655 schools participated)
- Plus schools selected for a reason (Purposive Sample)
  - 378 schools participating from 52 major reform programs including
    - Schoolwide reform programs emphasizing technology
    - Programs that recruit individual teachers as participants
  - 182 schools with high-end technology, some designing their own reforms around technology
- Three-quarters of sampled schools participated in the study, carried out in Spring, 1998
- Over 4,100 teachers from grades 4-12 participated, nearly 70% of those sampled.
  - 3 to 7 teachers in any one school
  - Completed 20 page questionnaires

Across the three samples, 1,215 of the 1,616 schools selected for participation agreed to participate in the study (75%). Response rates of individually selected teachers, principals, and technology coordinators averaged about 70%. Altogether, responses were obtained from 4,083 teachers of grade 4 and higher, in 1,150 schools, as well as 845 technology coordinators and 867 school principals.

[1] As modified by stratum-specific non-response rates and within-school partial completions of teacher rosters.

Findings

Frequent Use of Computers

Although computers in schools by now number over 10 million, frequent student experiences with school computers occur primarily in four contexts--separate courses in computer education, pre-occupational preparation in business and vocational education, various exploratory uses in elementary school classes, and the use of word processing software for students to present work to their teachers. The one area where one might imagine learning to be most impacted by technology—students acquiring information, analyzing ideas, and demonstrating and communicating content understanding in secondary school science, social studies, mathematics, and other academic work—involves computers significantly in only a small minority of secondary school academic classes.

EXHIBIT 3: FREQUENT COMPUTER USE BY SUBJECT TAUGHT
(PERCENT OF TEACHERS REPORTING 20+ USES BY TYPICAL STUDENT IN CLASS DURING YEAR)

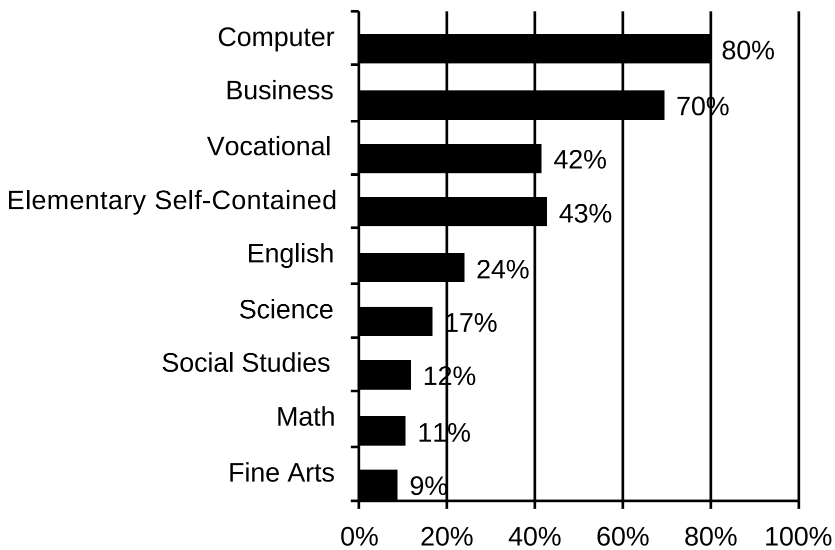
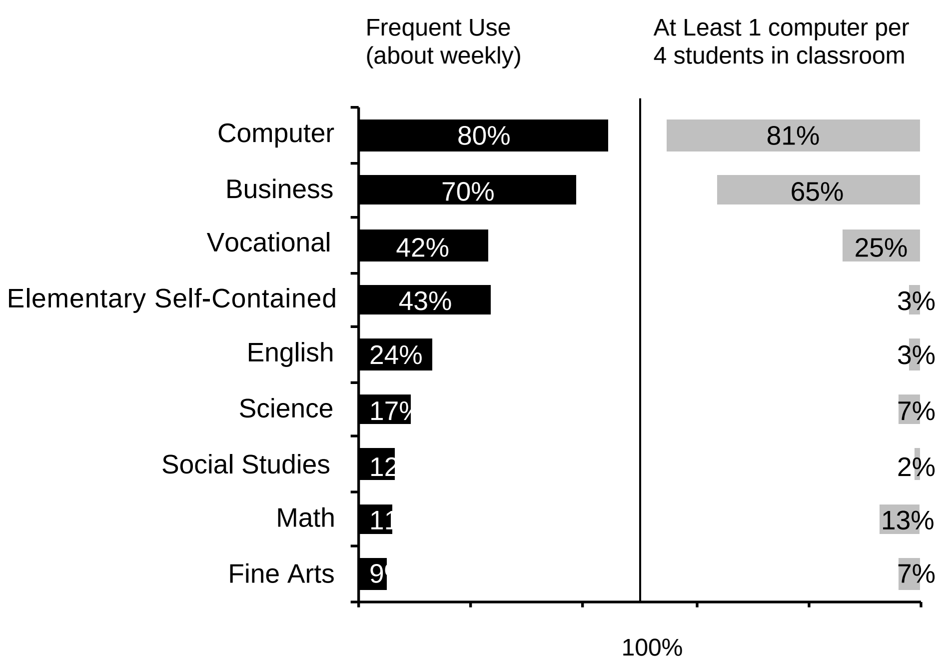


Exhibit 3 shows the proportion of teachers, by subject, who reported that a typical student in one of their classes used computers on more than 20 occasions during class over roughly a 30-week period. Apart from computer education teachers, a majority of only one other group—business education teachers—reported that computer use occurred on at least a weekly basis in their classes. About two-fifths of vocational education teachers and elementary teachers of self-contained classes also reported roughly weekly use. Among secondary academic subject teachers, the highest rate of frequent use was reported by English teachers (24%). Only one out of six science teachers, one out of eight social studies teachers, and one out of nine math teachers said students used computers that often during their class. Given the distribution of course-taking patterns in high school, it turns out that a majority of students' intensive computer experiences occur outside of academic work, as part of computer education or occupational preparation.

An important determinant of whether a teacher uses computers frequently with her students is whether the computers she has access to are within her own classroom. The correlation across subjects – that is, which subject-matter teachers are most apt to be frequent users and which subject-matter teachers have, say, at least one computer in their classroom for every four students in their class—is rather striking, as Exhibit 4 shows. However, even within subjects, this relation holds. We found that secondary academic subject teachers who have 5 to 8 computers in their classroom are twice as likely to give students frequent computer experience during class than teachers of the same subjects with 1-4 classroom computers but whose classes use computers in a shared lab with at least 15 computers present (62% vs. 32%).[2] This may seem counter-intuitive since being in a lab with three times as many computers as these classrooms have would seem to be preferable. However, the scheduling of whole classes of students to use computers, at wide intervals determined well in advance of need (i.e., weekly or every-other-week use scheduled weeks in advance) makes it almost impossible for computers to be integrated as research, analytic, and communicative tools in the context of the central academic work of an academic class.

EXHIBIT 4: FREQUENT USE & CLASSROOM ACCESS BY SUBJECT



Two other factors that influence how likely teachers are to have their students use computers frequently during class are the way their school day is carved up into different classes and the extent to which they feel pressure (self-imposed or externally imposed) to cover large amounts of curriculum. With respect to scheduling, we found that secondary academic teachers who work in schools that schedule classes in longer blocks of time (e.g., 90-120 minutes) were somewhat more likely to report frequent student computer

[2] Based on a 50% random subsample of teachers who used computers with their selected class in both probability and purposive samples.

use during class (19% vs. 15%), even though they met their classes on perhaps half the number of days as teachers who taught in traditional 50-minute periods. With respect to content coverage, teachers of academic subjects are strong believers in transmitting a large amount of information or skills during the course of a year. Computer use is often seen as inhibiting the coverage of topics. Yet we found that when teachers don't try to cover a large number of separate topics, but instead teach "a small number [of topics]… in great depth" (only one out of every thirteen academic secondary teachers in the study), they are twice as likely teachers covering a large number of topics to have students use computers frequently (29% vs. 14%).

Teachers' lack of expertise with using computers could be another inhibiting condition of frequent use. Most teachers report at least modest competency in using computers in different ways. But it was not necessarily the case that the most computer-expert teachers were the ones who used computers more with their students. That was the case for vocational education teachers and English teachers. In those subjects, teachers who assigned more computer work also knew more about computers themselves; those who assigned less work, knew less. That was *not* true, however, for math teachers. In mathematics, teachers who assigned more computer work professed no greater knowledge about how to use computers than did those who assigned less.

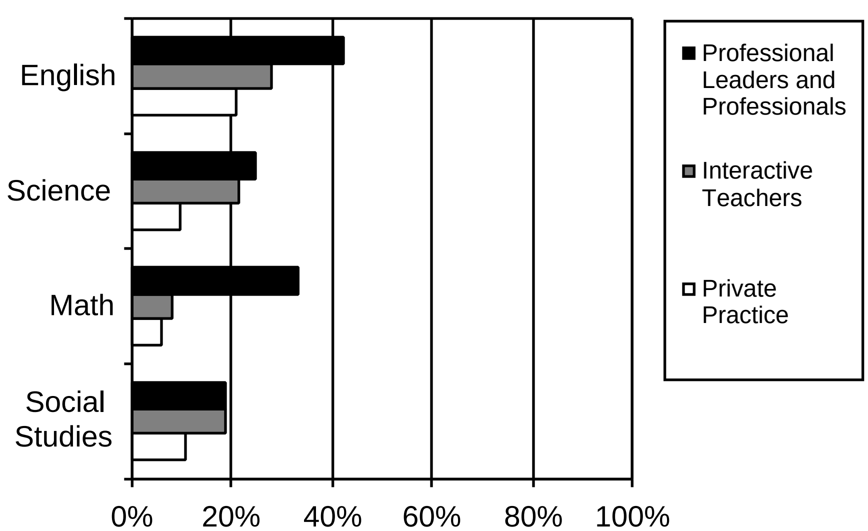
At the same time, the ways that teachers have their students use computers are certainly affected by their own level of technical expertise. In particular, teachers who feel capable of developing a document using multimedia authoring software have their students use computers more frequently and use a greater variety of software. This is independently true for teachers of almost every subject, and for most subjects, multimedia-authoring-capable teachers have students use computers more and with a greater variety of software than do other teachers teaching the same subject. A second computer skill associated with a teacher’s having students use computers more and with greater variety is knowing how to prepare a slide show. In particular, among elementary teachers and secondary English teachers, those who say they are able to produce slide shows using presentation software are among the most active computer-assigning teachers in their subject. There seems to be a clear order of difficulty among computer skills that relates to the variety of ways that teachers are able and willing to oversee student computer use. In other words, whether or not the teacher knows how to use a Web browser doesn't have much of an effect on whether they use a type of software with students. But some skills such as producing a slide show or a multimedia document clearly are indicators of a teacher’s ability and interest in having students use computers in a variety of different ways and on a relatively frequent basis.

Teacher Professional Engagement and Computer Use

Teachers vary in how they conceptualize their role–their duties and responsibilities as teachers. Some teachers view their work as taking place solely within their classrooms in what is essentially a private, individual practice. Others view their responsibilities as extending beyond classroom teaching to include participation in the larger community of educators and administrators. They see their role as trying to help other teachers be more successful and to influence how teaching occurs in other places. We created an index of teacher professional engagement based upon three aspects of teachers' role orientation (a total of 15 survey prompts): (a) the extent to which they had informal contacts with other teachers at their own school, through mutual observations of classroom teaching and through informal discussions on various teaching-related topics; (b) their contacts with teachers at other schools, through working on committees, attending workshops, and electronic mail communications; and (c) leadership activities such as mentoring young teachers, presenting at workshops and conferences, teaching continuing education courses, and publishing for teacher audiences.

When teachers were arrayed on this index, and the top 15% of scores (teachers termed "professionally engaged" teachers) were compared with the bottom 55% ("private practice teachers"), we found substantial differences between professionally engaged teachers and private practice teachers in their use of computers. In each academic area, the former group was at least twice as likely to use computers frequently with their students as the latter. (See Exhibit 5.) The greatest differences were in terms of the professionals' greater use with students of electronic mail, multimedia authoring software, and presentation software. On a more comprehensive index of sophisticated understanding of and use of computers (i.e., not only frequent use, but use of a variety of software, technical expertise, easy access to computers at home and work, use of computers by students for integrative projects, and increased use of computers over the previous five years), professionally engaged teachers were more than 6 times as likely as private practice teachers to meet the criterion for being judged an "exemplary computer user" (26% vs. 4%). Moreover, within the "professionally engaged" category, when we split out a very small group of those who were most engaged with their peers across formal and informal, internal and external activities, these high end "teacher leaders" (3% of the total sample) were even more likely to be judged exemplary computer users (40% were).

EXHIBIT 5: FREQUENT USE & PROFESSIONAL ENGAGEMENT BY SUBJECT



Use of Computers by Student Background

Issues of equity in the use of teaching resources are a critical issue in school policymaking. Equity, though, involves more than simply access; it involves using resources appropriately to improve student outcomes. Using resources appropriately, in turn, depends on how defensible a teacher's philosophy of teaching and learning is. Philosophical disagreements about equity and teaching practice usually revolve around the issue of whether students from low-socioeconomic backgrounds and students who present relatively unsuccessful school histories can be given the same kinds of demanding tasks and depended upon to act as responsibly as more advantaged and more academically successful students. In the absence of beliefs that poorer and less successful students can be given challenging tasks and a high degree of independence, teachers are apt to use computers with lower performing classes as a means of practicing lower-level skills and as a means of social control. What do the TLC data suggest about how teachers of academic subjects use computers with classes of students from different backgrounds?

First, in terms of the frequency with which their students use computers, each of the four secondary academic subjects presents a somewhat different pattern. Exhibit 6 shows differences within subject by school-level socio-economic status (SES).[3,4] Interestingly, math, social studies, and English teachers at schools in the bottom SES quartile are more likely to report having their students use computers frequently than at any other SES level. In contrast, among science teachers, those who teach at high-SES schools appear to be more likely to report frequent in-class computer use, but this difference was not statistically significant. When we examine the results by teacher-estimated class ability levels (Exhibit 7),[5] similar patterns hold for math and social studies but not for English. Moreover, in science, the advantage that high-SES schools had in access to computers does not carry over to the ability-level results.[6]

[3] SES was divided into roughly equal sized quartiles.

[4] These descriptive data come from the probability sample of teachers in middle and high schools. The multiple regression analysis shown subsequently adds the purposive samples as well.

[5] Across subjects, one-sixth of classes fell into both the "high" and "low" ability categories; the middle two categories had roughly one-third of all classes. The term "ability" is an approximation to the instruction given to survey respondents: to check all "achievement or ability levels" (of 5 given) that apply to at least 5 students in that class.

[6] The (unweighted) number of teachers represented by each bar in Exhibit 5 varies from 42 to 98; in Exhibit 6, from 21 to 123. Except where noted in the text, all differences discussed are significantly significant using one-way ANOVA. [Specific contrasts were not tested.]

EXHIBIT 6: PERCENT OF SECONDARY ACADEMIC TEACHERS REPORTING FREQUENT COMPUTER USE, BY SUBJECT AND SCHOOL SES

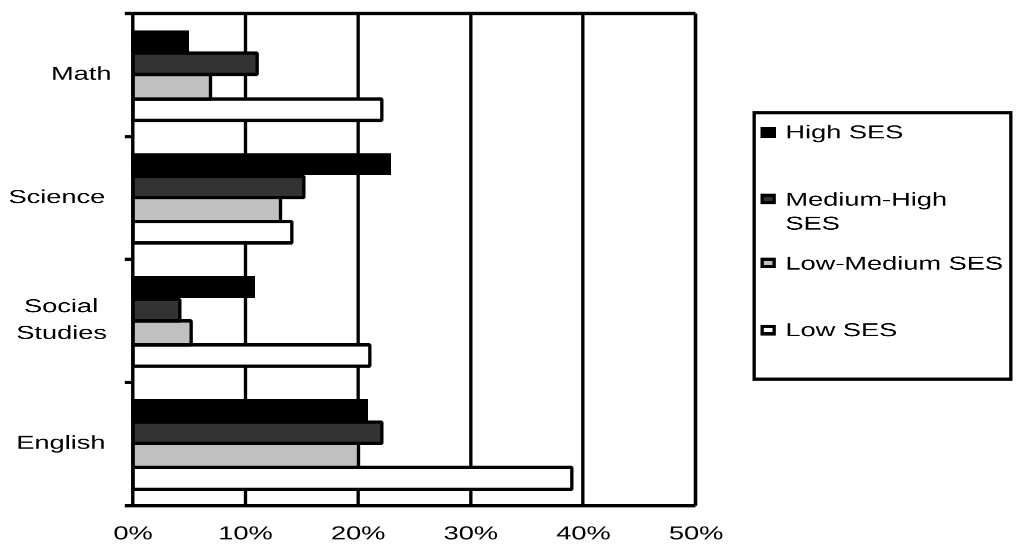
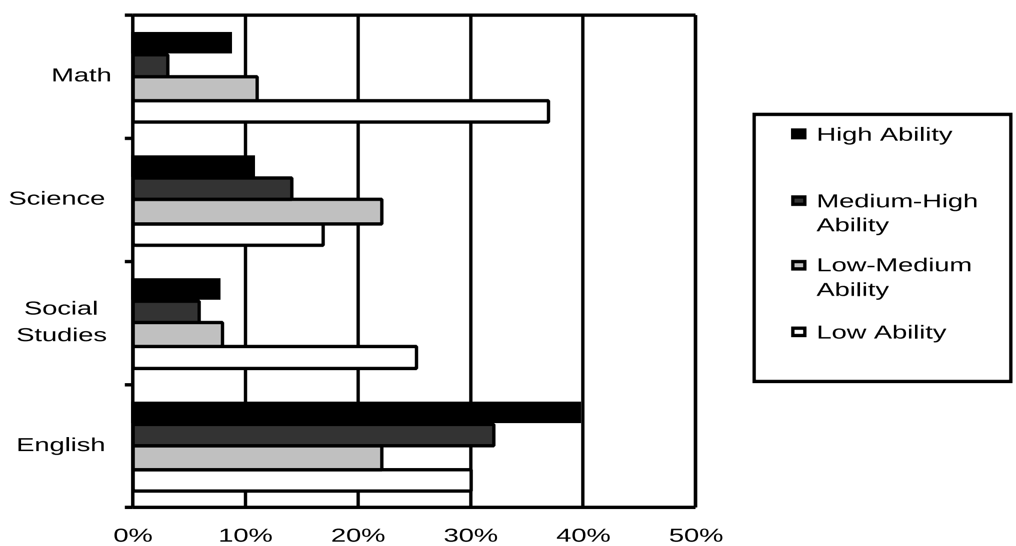
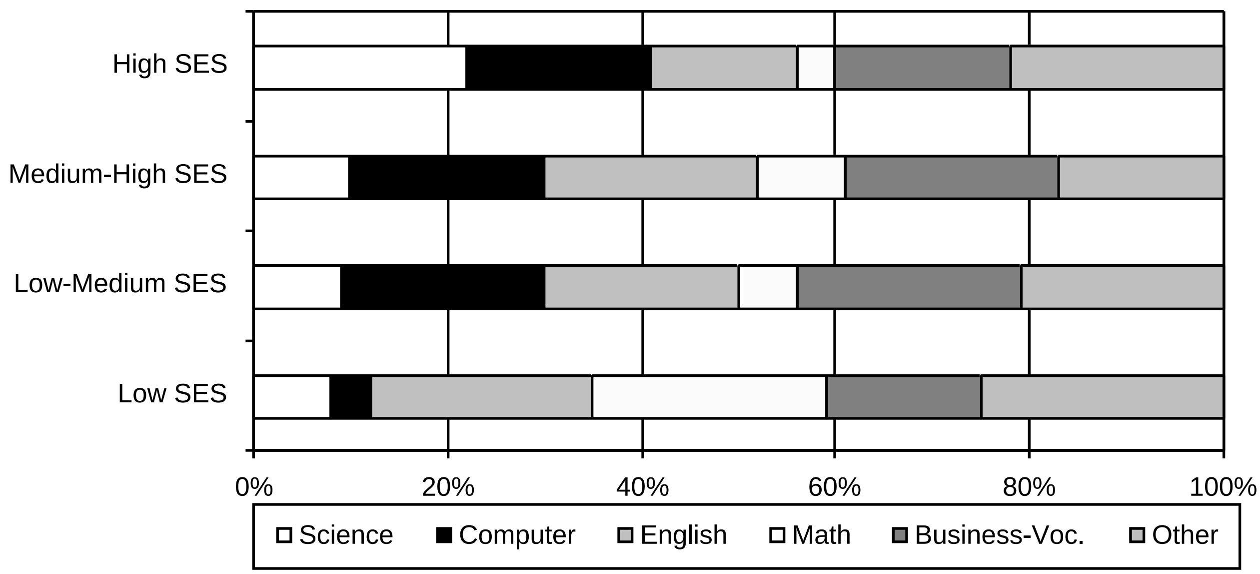


EXHIBIT 7: PERCENT OF SECONDARY ACADEMIC TEACHERS REPORTING FREQUENT COMPUTER USE, BY SUBJECT AND CLASS ABILITY LEVEL



The result of these different probabilities of experiencing frequent computer use, combined with different course-taking patterns between advantaged and advanced students and disadvantaged and less advanced students means that if one looks at where in the school's program, students get frequent computer experience, the picture looks quite different in high-SES and low-SES schools. Exhibit 8 shows this pictorially. While business and vocationally-based high frequency experiences are common at schools of all SES levels, the distinct character of computer experience in high-SES schools is its presence in science classes, while the distinct pattern in low-SES schools is having high frequency computer experiences in mathematics classes and not in computer courses.

EXHIBIT 8: SUBJECT MATTER OF HIGH FREQUENCY COMPUTER USE CLASSES, SECONDARY SCHOOLS, BY SCHOOL SES



To get a clearer picture of how ability, SES, and school level (middle vs. high school) interact, both multiple regression and logistic regression were performed. The two analyses produced reasonably similar patterns, but we report the logistic regression findings here. The analysis used continuous variable measures of SES and class ability rather than quartiles, incorporated pairwise interaction terms among the three predictors, and added the contrast between teachers in the national probability sample and teachers working in the high-tech and reform-program-participating schools (purposive samples). Exhibit 9 summarizes the findings of this analysis.

EXHIBIT 9: WHICH TEACHERS ARE MOST LIKELY TO HAVE THEIR STUDENTS USE COMPUTERS FREQUENTLY?
(Logistic regression with interaction terms. Significant parameters, strongest first.)

- In Math
  - Middle Schools
  - Low Ability Classes in Low SES Schools
  - Low Ability Classes in Middle Schools
- In Science
  - High SES Schools
- In Social Studies
  - Reform/High Tech School Sample
  - Low SES Middle Schools AND High SES High Schools
  - Low Ability Classes
- In English
  - Low SES Schools
  - High Ability Classes in High SES Schools & Low/Low
  - High Ability Classes in general

For English and social studies, there are indications that high frequency computer use occurs in two contrasting settings—one advantaged and/or advanced in school achievement and one disadvantaged and not so advanced. In social studies, for example, a significant interaction term involving both school SES and school level (combined with analysis of the individual cells) suggests that computer use is higher in both low SES middle schools and in high SES high schools than in the opposite situations. In English, frequent computer use seems affected both by the presence of high achieving students and in low SES schools, particularly in low achieving classes in low SES schools. Thus, in these subjects, there may be quite different purposes served by computers—one focused on routine skills mastery or providing opportunities to children from poorer families; the other on providing opportunities to the highest achieving students, particularly those who are close to being ready for college.

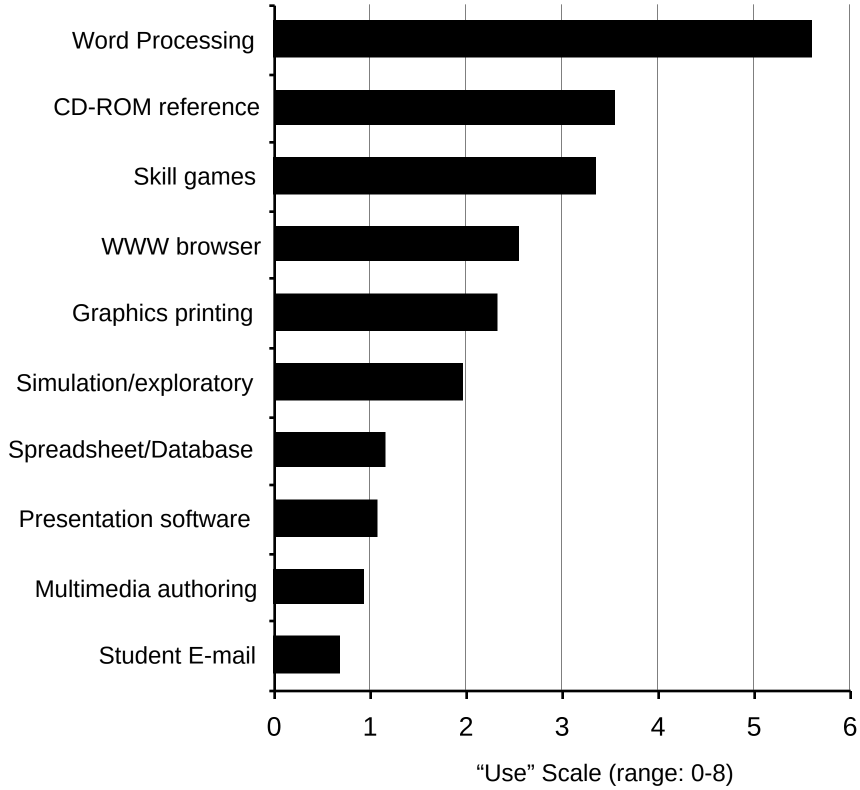
In mathematics and science, the logistic regression analysis suggested that only one of these groups dominated the "frequent computer use" picture—advantaged students in science classes and at risk students, particularly younger students, in math. In math, frequent computer use most often occurs in low ability classes in middle schools attended by economically disadvantaged families. Computers thus seem to be primarily used for drilling basic skills to children who are otherwise disadvantaged. In science, high frequency computer use is mainly associated with attending high SES schools, regardless of class ability level or age of student. Here it may be that, in science classrooms, access to a sufficient number of computers to make frequent use possible is particularly limited except in economically advantaged schools.

Types of Software Used

As noted earlier, word processing is the primary application of computers in secondary schools today. Across grades 4-12, among academic subject-matter teachers who used computers frequently, word processing was used nearly twice as much as the next-most common types of software—CD-ROM reference materials and games for practicing skills.[7] (See Exhibit 10.) However, it is quite clear that not all computer-using classes in a given subject follows this same pattern or any other.

[7] The measure of software use comes from a simple four-value response to a question about the number of lessons the respondent had had students use each type of software during the school year: none; once or twice; 3-9 times; or 10 or more. These responses were recoded into values of 0, 1, 3, and 8, respectively.

EXHIBIT 10: SOFTWARE USED BY FREQUENT COMPUTER USING TEACHERS
(ELEM. & SEC. ACADEMIC SUBJECTS)



In fact, there are some substantial differences between high-ability classes and low-ability classes in the same subject in the software that students use. Exhibit 11 shows differences in software use by ability, although the unit of analysis in this case is the teacher rather than the class, so the attribution of "class ability" is in terms of the average attributed ability levels across all of the classes that the teacher instructs. Teachers are included only if they use computers with their students.[8] The measure whose values appear in the table in Exhibit 11 is the "effect size," the difference in software use between teachers of higher- and lower-ability students, measured in standard deviation units among teachers of that subject.[9]

[8] Only for math teachers are there any differences by attributed student ability level in the proportion of teachers who use computers with their students. Somewhat fewer teachers of high ability math classes use computers with their students at all than for math teachers of average and low ability classes (47% vs. 54-56%).

[9] On average, about 30% of teachers are part of the low-ability teaching group and 30% are in the high-ability teaching group, although the pattern of attribution of student ability does differ by subject. For example, science and social studies teachers generally regard their students as being of higher ability than math teachers do.

EXHIBIT 11: DIFFERENCES IN SOFTWARE USE BETWEEN
LOW- AND HIGH-ABILITY CLASSES
(EFFECT SIZES >±.15 ARE HIGHLIGHTED)

	Math	Science	Social Studies	English	Elem. Self-C.
Student e-mail	.19	.42	.44	-.03	.37
Word Processing	.14	.20	-.07	.59	.26
Spreadsheet, database	.20	.25	.35	-.01	.39
Multimedia Authoring	.02	.08	.22	.11	.13
Presentation	.17	.17	.29	-.02	.01
Simulation/exploratory	.27	-.01	.09	-.04	-.09
World Wide Web	.09	-.23	.33	.29	.26
Graphics printing software	.10	.10	-.45	.23	.32
CD-ROM Reference	-.06	-.07	-.13	.25	.12
Skills Games	-.31	-.25	-.64	-.64	-.25

Low-ability use more

High-ability use more

In one respect, Exhibit 11 shows a common pattern between teachers of different subjects: games for practicing skills are used much more by teachers of low-ability classes in all subjects than they are used by those who teach high-ability classes. The differences are strongest for social studies and English teachers, but they are significant in the other academic subjects, as well as among 4th through 6th grade elementary classroom teachers.

In other respects, the kinds of software used by teachers of high-ability students does reflect different emphases in each subject. For example, electronic mail use by students, although not a common practice as of 1998 in any subject, is used much more by science and social studies teachers of high-ability classes than by those who teach low-ability classes, but this differential use by ability is much less true in English. In contrast, English teachers differentially use word processing according to their judgments of the ability level of their students: English teachers of students felt to be higher-than-average in ability and achievement have students do word processing during class time much more than do English teachers of lower-ability students.

Presumably these differences have much to do with the objectives that teachers of students of different ability have. That is, English teachers of more advanced classes focus on helping students improve their ability to articulate ideas in writing while English teachers of less advanced classes work on improving students' knowledge of language arts mechanics. Similarly, perhaps the objectives of science and social studies teachers of higher-ability classes are more in the direction of having students articulate and communicate ideas than when science and social studies teachers teach classes they perceive as relatively low in ability. This seems particularly likely in social studies, where the effect sizes are at least modest (above .15) also for multimedia authoring and presentation software—two other types of software used for having students articulate and communicate ideas.

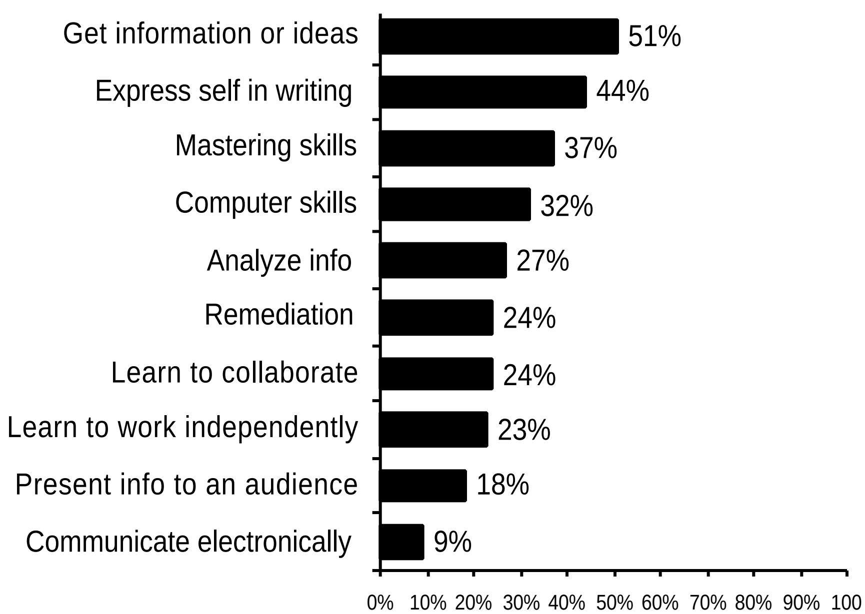
Math teachers of higher ability classes are more apt than those teaching low-level math classes to have their students use spreadsheet software and exploratory math software. Spreadsheet work is also more disproportionately used by teachers of high-ability classes in science and social studies, while using the World Wide Web is a differential practice favoring high-ability classes in both social studies and English. Interestingly, Web use is more associated with low-ability classes in science, suggesting the difference between analytic work in high-ability science classes and mere information-gathering in low-ability classes.

Many of the differences apparent in Exhibit 11 contrasting high- and low-ability student clientele also seem likely a consequence of teaching students of different ages. In fact, the attribution of "ability" seems perhaps less appropriate than thinking in terms of "more advanced" and "less advanced" students, taking both perceived ability and age into account.

Teachers' Objectives for Student Computer Use

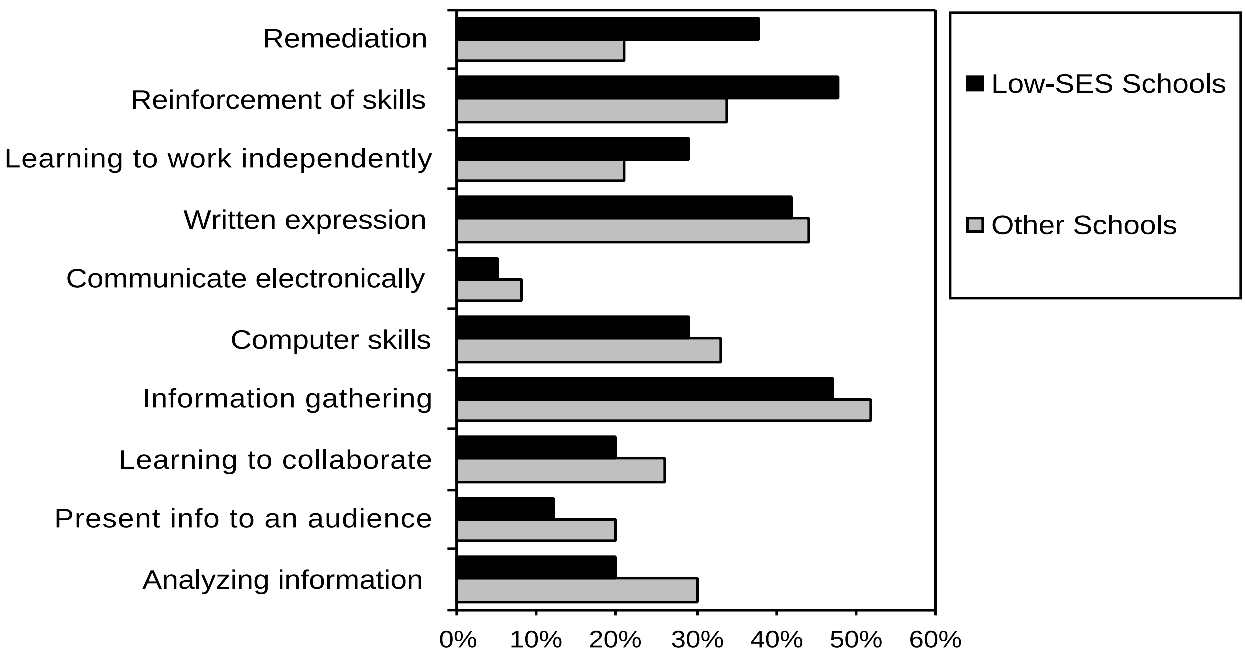
The TLC survey asked teachers who had students in their classes use computers to select the 3 objectives (from a list of 10) that were closest to their reasons for using computers. Exhibit 12 shows that, across all subjects and levels, computer-using teachers most commonly have three types of objectives: information-gathering objectives such as "finding out about ideas and information," constructivist objectives such as "expressing oneself in writing," and skills-related objectives, such as "mastering skills just taught."

EXHIBIT 12: TEACHERS' 3 PRIMARY OBJECTIVES FOR COMPUTER USE



However, again teachers differ substantially in their objectives for computer use based on the types of students they teach. Based solely on the SES-level of their school, there are clear differences in objectives between the bottom quartile SES schools and the other 3/4 of TLC sample schools, as shown in Exhibit 13. Teachers at schools in the bottom SES quartile are much more likely to select remediation and simple reinforcement of skills than are teachers in other schools, and they are somewhat less likely to have other kinds of objectives.

EXHIBIT 13: MAJOR OBJECTIVES FOR STUDENT COMPUTER USE AMONG COMPUTER-USING TEACHERS: LOW-SES SCHOOLS VERSUS OTHER SCHOOLS



Teaching Philosophy

The types of software that teachers use and the objectives they have for using that software are affected, not only by the clientele whom the teachers serve, but by their deeper beliefs and understandings about teaching and learning. One emphasis in the TLC national survey involved an effort to measure teachers' underlying philosophy of teaching and to relate those teaching philosophies to their use of computers in instruction.

Teaching philosophy is a broad subject. In the TLC survey, we conceptualized the major dimension of interest to be the commonly-discussed contrast between a "transmission" view of learning and a "constructivist" one, and the valuation of alternative teaching practices in terms of their consistency with one of these theories of learning.

- Traditional Transmission Instruction is based on a theory of learning that suggests that students will learn facts, concepts, and understandings by absorbing the content of their teacher's explanations or by reading explanations from a text and answering related questions. Skills (procedural knowledge) are mastered through guided and repetitive practice of each skill in sequence, in a systematic and highly prescribed fashion, and done largely independent of complex applications in which those skills might play some role.

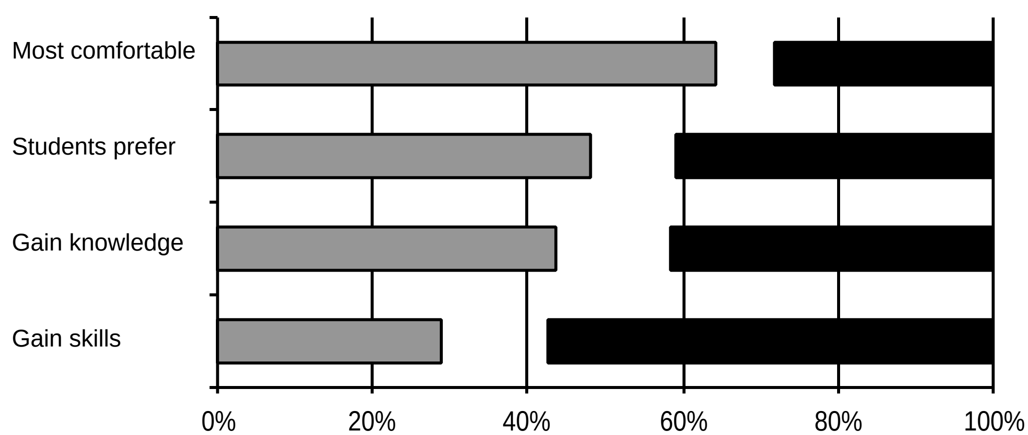
- Constructivist-Compatible Instruction is based on a theory of learning that suggests that understanding arises only through prolonged engagement of the learner in relating new ideas and explanations to the learner's own prior beliefs. A corollary of that assertion is that the capacity to employ procedural knowledge (skills) comes only from experience in working with concrete problems that provide experience in deciding how and when to call upon each of a diverse set of skills.

Teachers' beliefs about good teaching, and more implicitly, their beliefs about the nature of learning, were measured mainly through three questions in the TLC survey: one question which presented a paragraph-length vignette describing how two hypothetical teachers—Ms. Hill and Mr. Jones—characteristically taught their class; a second question in which several pairs of contrasting statements of teaching philosophy were presented, asking respondents to choose on a 5-point scale which statement among the pair came closest to their own point of view; and a set of general statements about teaching and learning, presenting respondents with 6 alternatives from "strongly disagree" to "strongly agree."

EXHIBIT 14: TWO TEACHERS COMPARED

Ms. Hill:
Asked questions the students could answer quickly, based on reading they had done before. New material is taught using simple questions to keep students attentive.

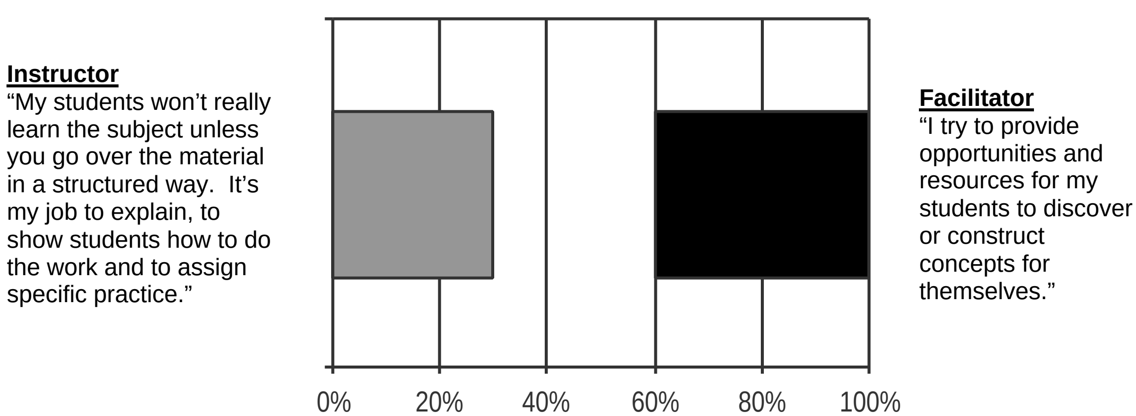
Mr. Jones:
Many questions came from students themselves. Though Mr. Jones could clarify questions and suggest sources of relevant information, he couldn't really answer most of the questions himself.



The "Ms. Hill vs. Mr. Jones" vignettes were used to gauge teachers' overall preference for, and beliefs about, contrasting direct instruction and constructivist instructional styles. (See Exhibit 14 for the vignettes used.) Although most teachers can see value and a reason to teach like either teacher, in different situations, a preference for Mr. Jones' pedagogy suggests a clearer belief in the value of constructivist instructional reforms. Respondents were asked to evaluate the two alternative teaching styles with respect to four criteria: with which approach were they more comfortable, which approach did they think students preferred, from which approach did they think students gained more knowledge, and from which approach did they think students gained more useful skills.

Overall, more teachers *felt comfortable with* (64%) and thought *students preferred* (53%) the traditional style of Ms. Hill. Moving quickly over content may pose fewer problems for teachers and students and therefore seem easier. However, in terms of the *consequences* for students, teachers were more likely to believe that Mr. Jones' approach was better. Concerning students gaining more *knowledge* from Hill or Jones, teachers were evenly split — with more than 40% favoring each approach. Concerning the acquisition of *useful skills* many more teachers favored Mr. Jones' approach (57% favoring Jones, 29% favoring Hill). This suggests that teachers think students will benefit from some use of inquiry-oriented teaching that places more responsibility on students. At the same time, they recognize that it is difficult to carry out many of those practices, particularly because not all students are eager to participate in classroom learning organized around those practices.

EXHIBIT 15: TEACHER AS A FACILITATOR VERSUS AN INSTRUCTOR



In the paired comparison question, five pairs of philosophical positions were presented, four of which we discuss here. One expressed the contrast in the role of the teacher between being a facilitator of student learning versus an explainer of material to students, very much encapsulating the difference in approach between Ms. Hill and Mr. Jones in the earlier question. (See Exhibit 15.) A second pair contrasted a teaching approach where multiple activities were going on in class at the same time, activities suggestive of complex project work and a fair amount of latitude for students, versus a classroom where everyone was working on the same assignment, one with "clear directions, and…that can be done in short intervals that match students' attention spans and the daily class schedule." A third comparison was between prioritizing curriculum content coverage versus giving emphasis to "encouraging sense making" among students, and the fourth was whether promoting student interest or having them learn textbook content was more important.

Exploratory factor analysis suggested that, like the two survey questions just discussed, most of the items about teaching philosophy could be interpreted as indicators of a common underlying construct that contrasts constructivist versus transmission and skills-practice orientations. Reliability analysis of 13 of these items produced an index with an alpha of 0.83. The following are these 13 survey items, which are expressed in constructivist terms when both poles were presented to respondents, and marked as “reversed” when the prompt asked the respondent to “agree or disagree” with a transmission-oriented statement.

- Jones’ inquiry approach produces more student knowledge than Hill’s direct instruction
- Jones’ inquiry approach produces more student skills than Hill’s direct instruction
- Believes in being a facilitator rather than explainer
- Student interest and effort is more important than textbook content
- Sense-making and thinking are more important than the specific curriculum content
- Different students engaged in different project-type activities is better than the whole class working at the same time on a series of short-duration assignments
- Students will take more initiative if they are free to move around the room
- Students should help establish the criteria on which their work is assessed
- Instruction should be built problems with clear, correct answers (reversed)
- Teachers know more than students and shouldn’t let students muddle around (reversed)
- Student learning depends on background knowledge — that’s why teaching facts is so necessary (reversed)
- It is better for the teacher, not students, to decide what activities are to be done (reversed)
- A quiet classroom is generally needed for effective learning (reversed)

Exhibit 16 provides an alternative summary of the contrasts contained in this scale.

EXHIBIT 16: COMPETING TEACHING PHILOSOPHIES

Traditional Transmission Philosophy

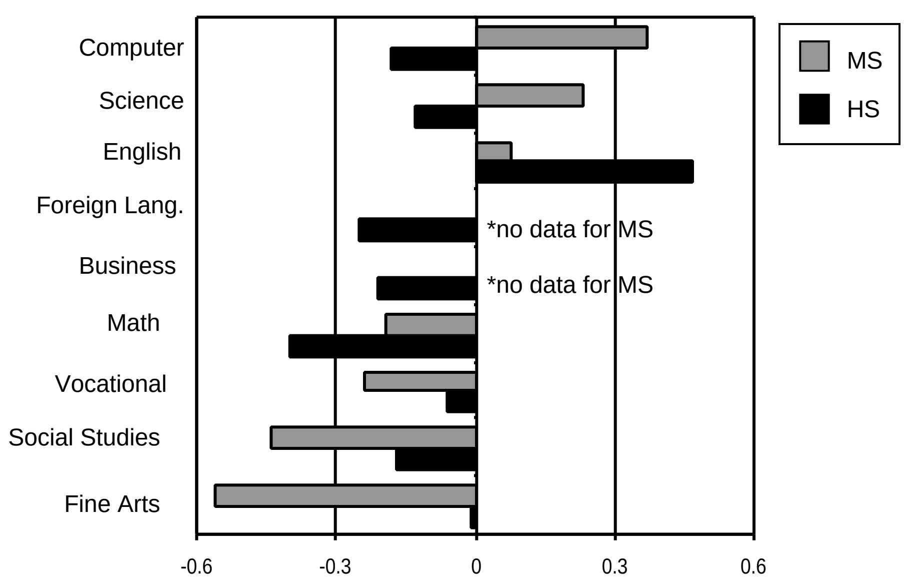
- Teachers describe and explain concepts
- A quiet classroom is important for learning
- Acquiring basic content knowledge and skill primary
- Teacher - not students - determine activities
- Problems have correct answers which most students can give
- Teaching facts and skills provides the foundation for later learning

"Constructivist" Reform Philosophy

- Knowledge is built through class and group discussions
- Students need to find answers to their own questions and problems
- Students construct concepts for themselves
- "Sense-making" and guided inquiry
- Authentic, integrated tasks
- Diverse classroom projects

Teachers differed substantially by subject and by school level in their agreement with a constructivist teaching philosophy as manifested in this scale. (See Exhibit 17 for those differences measured as z-scores among the probability sample of teachers.) Of the four groups of secondary academic subject-matter teachers on whom this paper focuses, by far the most "constructivist" in philosophy are the high school English teachers, while the most transmission-oriented are middle school social studies teachers and high school mathematics teachers. However, within every group of subject-matter teachers, there are some who are more constructivist than others and those who are more transmission-oriented. It is those comparisons that are central to our next two issues: (1) Whether differential teaching philosophy accounts for differential computer use among teachers of the same subject and school level. And (2), whether teaching philosophy explains any of the differences in computer use practices by teachers of high- and low-ability classes or high- and low-SES school communities.

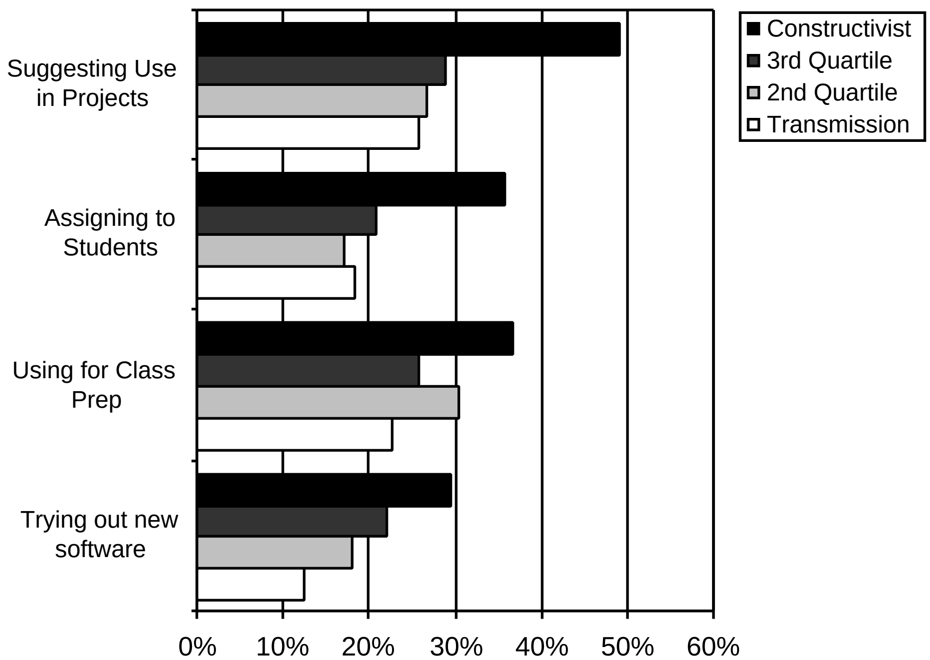
EXHIBIT 17: PHILOSOPHY BY LEVEL AND SUBJECT



Universe: Probability sample.
Notes: Z-scores based on means for teachers of all subjects and levels.

Overall, it is clear that teachers with the most constructivist teaching philosophies are stronger users of computers: They use computers more frequently, they use them in more challenging ways, they use them more themselves, and they have greater technical expertise. [Not all of these results are presented here.] Constructivist teachers are also much more likely to report having increased their use of computers over the past five years. As Exhibit 18 shows, the most constructivist quartile of teachers is particularly distinct in their increased use of computers with students. In terms of professional uses and exploring new software, they are also more likely than others say they are now doing so much more than five years ago, but their true distinctiveness is in terms of student use—both direct assignments and encouraging students to use computers in their work.

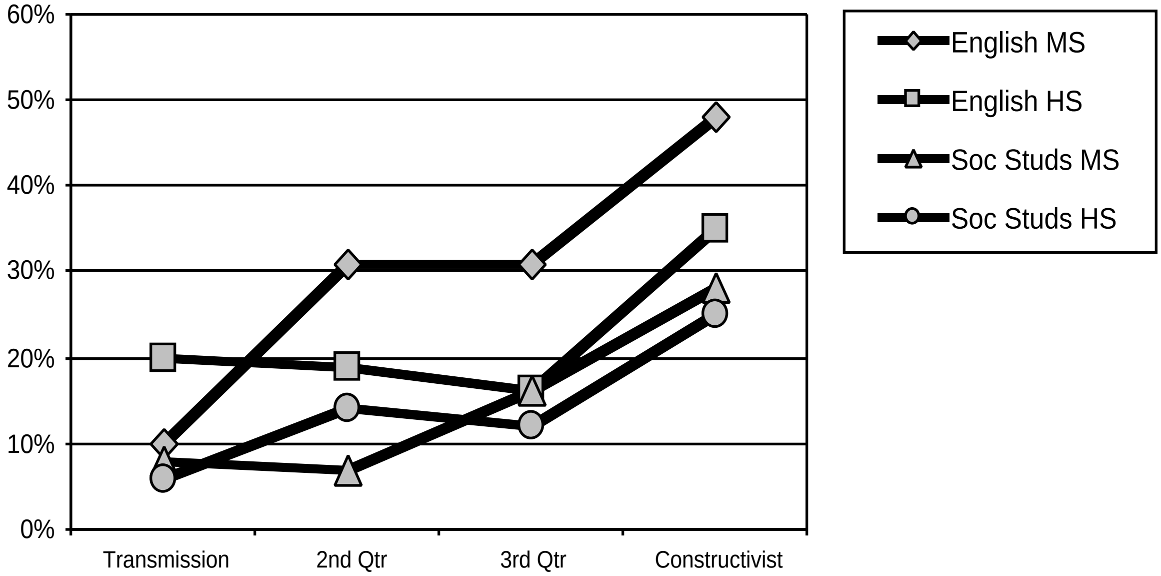
EXHIBIT 18: BY TEACHING PHILOSOPHY: "COMPARED TO FIVE YEARS AGO, USING COMPUTERS MUCH MORE FOR…"



Universe: Probability and purposive samples; with >5 years experience.
Notes: Philosophy quartiles based on teachers of all subjects.

The next two exhibits examine in more detail the question of teaching philosophy and frequency of assigning student use. When teachers are grouped from the most transmission-oriented philosophies to the most constructivist ones, those in the most constructivist quartile among all teachers are twice as likely to have their students use computers on a weekly basis as those in the least constructivist (more transmission- and skill-oriented) teachers. Generally, this is even more true within subjects. The red line in Exhibit 19 shows that, of the middle school English teachers who placed into the most constructivist-believing quartile of all teachers (a little more than 1/3 of all middle school English teachers did), nearly one-half (48%) have their students use computers weekly. Only 31% of the "more typical" middle school English teachers in the middle two quartiles on philosophy do so, while for the most transmission-and-skill-oriented middle school English teachers (the bottom 16% of that group), only 10% have their students use computers on a weekly basis. For high school English and social studies teachers, it is primarily the most constructivist group who assign computer work to students — only half as many teachers in any of the other three philosophy quartiles appear to do so.

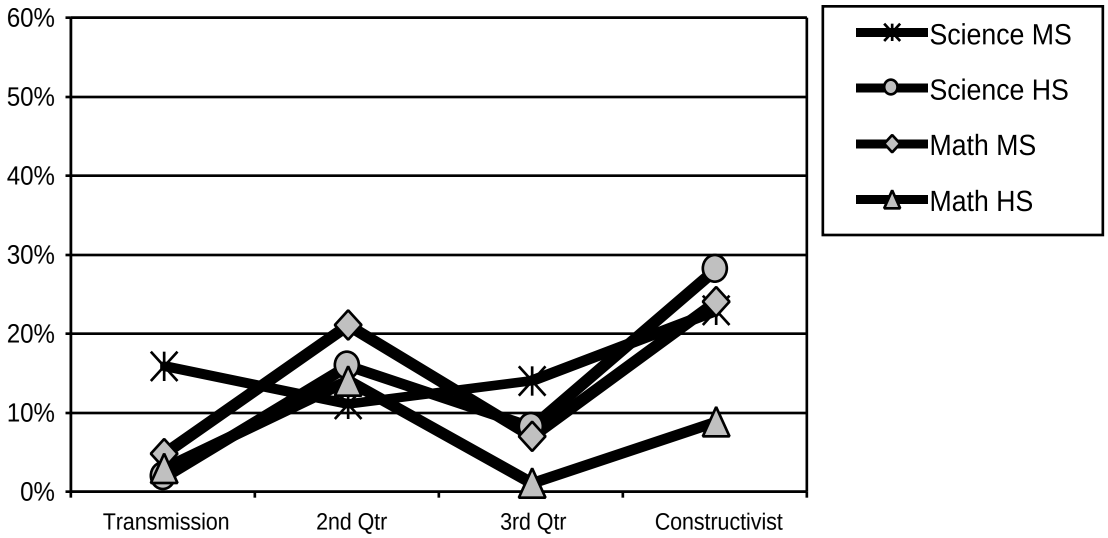
EXHIBIT 19: FREQUENT COMPUTER USE BY TEACHER'S PHILOSOPHY: ENGLISH AND SOCIAL STUDIES BY SCHOOL LEVEL



Universe: Probability and purposive samples.
Notes: Philosophy quartiles based on teachers of all subjects.

In mathematics and science, the pattern is somewhat different, as shown in Exhibit 20. Although, as with the case of the other academic subjects, teachers who have the most constructivist philosophies are more likely than other teachers in their subject to assign frequent computer work, there is also a "peak" among teachers who are "moderately traditional"—that is, quartile #3 measuring down from the most constructivist. In fact, among high school mathematics teachers (and math teachers as a whole), those who are moderately traditional use computers more than any other group. This suggests that in these subjects, although we did not find numerical dominance at both high-performing and low-performing settings the way we did for English and social studies, where frequent computer use <u>does</u> occur in math and science, it may still be of two types: activities such as gathering or analyzing information, writing about it, and then sharing it with others, activities assigned by constructivist teachers; or more skill- and fact-oriented work embodied in vocabulary and skill games assigned by teachers not so traditional as to avoid computers altogether, but traditional enough in terms of teaching objectives for drill-and-practice activities to dominate their use of technology.

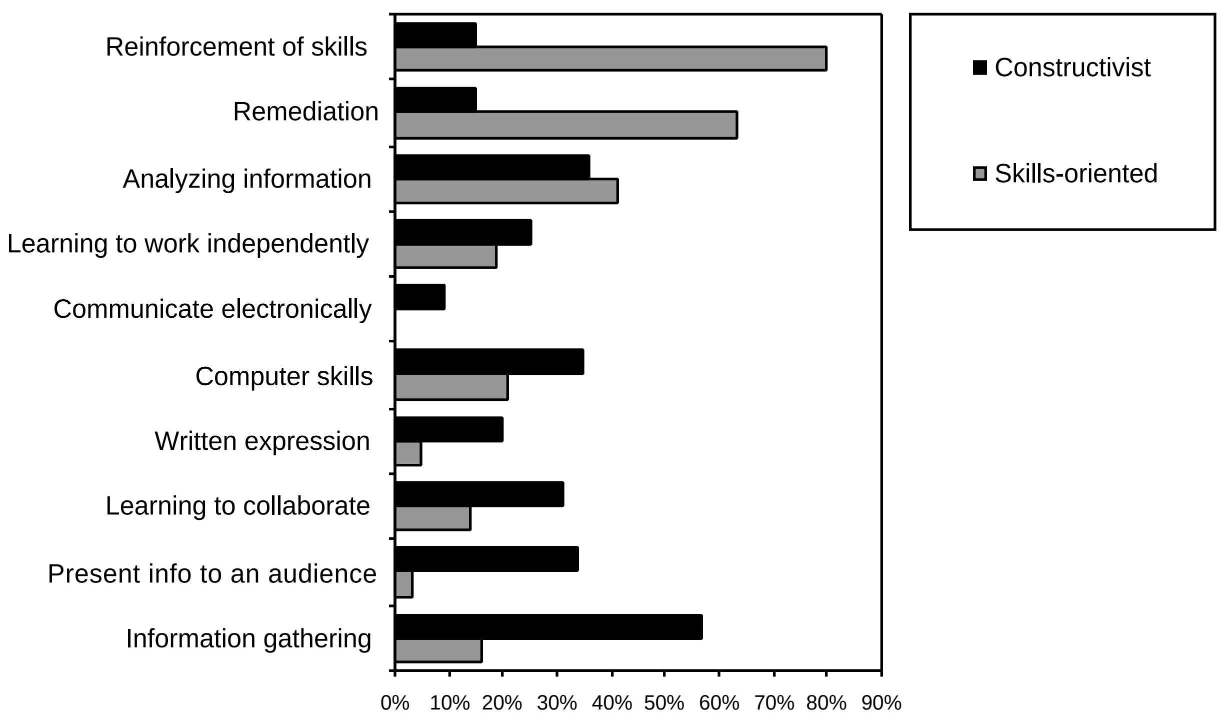
EXHIBIT 20: FREQUENT COMPUTER USE BY TEACHER'S PHILOSOPHY:
SCIENCE AND MATHEMATICS BY SCHOOL LEVEL



Universe: Probability and purposive samples.
Notes: Philosophy quartiles based on teachers of all subjects.

It may be, then, that pedagogical differences among math and science teachers foster contrasting patterns of computer use, while high-frequency computer users in English and social studies vary not so much by teaching philosophy as by contrasting situations to which they put to use a constructivist philosophy of teaching—both while working with disadvantaged students and while working with advantaged and advanced students.

EXHIBIT 21: MAJOR OBJECTIVES BY TEACHING PHILOSOPHY:
FREQUENT COMPUTER-USING MATHEMATICS TEACHERS



We can easily see the effects of mathematics teachers' philosophies of teaching on how they use computers in their classes. Our slice at the data looks only at the math teachers who used computers frequently with students—in particular, those who reported that a typical student in the particular class studied used computers more than 20 times during the year. The contrasting objectives for computer use by the more constructivist and the more skills-oriented computer-assigning math teachers are shown in Exhibit 21.

Strong majorities of the computer-using transmission-and-skill oriented teachers selected "mastering skills just taught" and "remediating skills not learned well" (80% and 63%, respectively) as their major objectives for student computer use. Among the constructivist math teachers, the primary objectives included "finding out about ideas and information (57%), improving computer skills (35%), presenting information to an audience (34%), learning to work cooperatively (31%), and expressing themselves in writing (20%)—all of these mentioned more often than either skills remediation or reinforcement (15% each).[10] Not surprisingly, the two different groups of computer-using math teachers used different types of software. However, the pattern was not what might be expected. Both skills-oriented and constructivist math teachers had their students use "games for practicing skills" on at least 10 occasions (38% and 29% respectively). It was the greater variety of software use that distinguished the more constructivist computer-using math teachers. They were much more likely to have students do word processing on at least 10 occasions (47% vs. 8%), to at least occasionally obtain information from CD-ROM reference materials (42% vs. 6%), to use the Web for the same purpose (48% vs. 28%), and to use graphics software (35% vs 9%), most likely for visualizing numerical relationships.

For science teachers who used computers a great deal in class, differences between the more transmission/skills-oriented one and the constructivist ones in how they used computers were somewhat more subtle. The biggest difference between them was in the constructivists' more often having students using computers to present work to the class—both in terms of their primary objectives for computer use (34% vs. 19%) and in actual use of presentation software (34% vs. 6% using presentation software at least occasionally). Constructivist computer-assigning science teachers were also more likely to have students use computers for information-gathering although, in principle, both groups valued computers for this reason almost equally, and, in fact, had students use the World Wide Web to a similar extent. Occasional use of student e-mail was another way the two groups differed (32% vs. 11%). So one must conclude that the differences in how these two groups of science teachers used computers were more subtle than could be observed with the broad brushstrokes of a survey.

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[10] Both groups of computer-using math teachers named "analyzing information" relatively frequently (between 36% and 41%).

Overall Prediction of Which Teachers Have Students Use Productivity Software Frequently

Most of this paper has presented analyses of how secondary math, English, science, and social studies teachers' use of computers during class time appears to be affected by the teacher's general beliefs towards constructivist teaching and how it is affected by the nature of the teacher's students—attributed class ability levels, school SES, and school level, middle- or high school. However, early in the paper several other factors were also mentioned as key to the frequency that a teacher used computers during class—access to clusters of computers in the teacher's own classroom, their orientation towards their role (between an outward "professional" orientation and an inward "private practice"), the amount of technical expertise a teacher possesses about computers (including their use of computers to accomplish their own professional tasks), whether their school provides periods of classtime that are longer than usual ("block-scheduled"), and whether they typically cover many topics or a smaller number in greater depth.

The final analysis presented here brings all of these other variables in along with the variables of clientele characteristics and personal educational philosophy and examines which combination of variables appear to best predict extensive use of specific types of software by teachers of specific secondary subjects. A total of 14 combinations of software type and subject-matter were examined—selected on the basis of their overall prominence in teaching in that subject and their plausible relationship to a constructivist teaching practice. Social studies teachers were examined in terms of their students' use of email, presentation software (e.g., Powerpoint), multimedia authoring environments (e.g., Hyperstudio), the World Wide Web, and spreadsheet and database software. English teachers were examined on Powerpoint and Web use by students; science teachers, on Powerpoint, Web, exploratory software, and spreadsheets; and math teachers, on exploratory software, Web, and spreadsheets. Word processing was not examined in this instance because of its common presence in most computer-using teachers' classroom practices.

Exhibit 22 provides the result of multiple regression analyses, using the admittedly crude 4-point dependent variables on which each teacher responded in terms of the frequency of their students' use of each type of software (no use, 1 or 2 occasions, 3 to 9 occasions, 10 or more occasions). On average, the 9 independent variables explained roughly 14% to 19% of the variation in these 14 specific combinations of software and subject-matter. Typically, at least 3 predictor variables had standardized partial regression coefficients above .10 and at least 1 was above .20 in all but two cases.

EXHIBIT 22: REGRESSION PREDICTORS OF FREQUENT USE OF SPECIFIC SOFTWARE

			Prior to including Teacher Expertise							
		Teacher Computer Expertise & Prof'l Use	Profes-sional Engage-ment	Class-room Com-puter Den-sity	Cons-truc-tivist Beliefs	Block Sched-uled	Schl. SES (high)	Class Ability (high)	Topic Cover-age (small)	High School (vs. Middle)
Social Studies	Email	.22	.16	.24			.13	.13	-.11	
	Powerpoint	.29	.16	.16			.13	.11		
	Media Authoring	.30	.15	.12			.16			
	Web	.37	.20	.23					-.15	
	SS/Database	.28		.20	.15				-.23	
English	Powerpoint	.22	.19	.27	.14	.11			.07	
	Web	.24	.18	.11	.15	.13				.09
Science	Powerpoint	.22	.28	.10	.18					
	Exploratory	.16	.16	.28						
	Web	.18	.21	.10	.11					
	Spreadsht/DB	.17	.25	.17						
Math	Exploratory	.17	.09	.25	.08				-.10	
	Web	.29	.16	.13	.09					
	Spreadsht/DB	.28	.13	.21			.12		.09	

The strongest predictor of frequent use of these types of software by academic secondary teachers was their technical expertise and use of computers for professional purposes. The second strongest predictor was the extent of professional engagement by the teacher—involvement in informal leadership roles at school and in more formal roles beyond the school. The third strongest predictor was the number of computers in the teacher's own classroom. The teacher's philosophy was the fourth strongest predictor. One could argue that technical expertise mediates the effects of a teacher's philosophy in that more constructivist teachers may be more apt to become expert users of computers. However, even with teacher computer expertise taken out of the equations, both classroom computer density and teacher professional engagement are stronger predictors of the teacher's frequent orchestration of student use of these productivity-oriented types of software.

Compared to these four teacher-specific predictors, student characteristics were less powerful.[11] However, high ability and, more strongly, high school-level SES, both characterize social studies students' greater use of email, presentation, and multimedia authoring software during class, net of other factors. Those English teachers aided by block scheduling assign students to do more Web work and Powerpoint presentations. But consistently, it was the teacher-specific variables—technical expertise, access to classroom computers, professional engagement, and, to a lesser extent, having a

[11] Note, however, that these regression models were entirely linear ones, whereas much of the bivariate analyses in this paper pointed to interaction effects among student and school characteristics and often suggested that contrasting situations often led to similar levels of computer use.

constructivist philosophy, that predicted their use of these constructivist-compatible uses of computers during class.

Conclusions

Large-scale surveys of teachers, such as the one providing data for this analysis, can only provide suggestions about the kinds of forces that lead teachers to use resources like computer technology to different extents and in different ways. The numerical precision of these descriptions and analyses should not be mistaken for certitude. Yet many of the findings about academic subject-matter teachers in middle and high school would probably withstand the test of having alternative empirical approaches applied to them.

Frequent use of computers by middle and high school teachers and their students in math, science, social studies, and English is, as Larry Cuban argues, still very much a rare phenomenon. Outside of word processing, very few teachers have their students make frequent use of computers during class. Students in lower-ability classes are often given computer games and drills related to the subject area of their class, but it is primarily those rare classes of <u>other</u> students and <u>other</u> teachers who use more sophisticated computer software as resources and tools for doing productive and constructive academic work. The teachers' philosophy of education certainly plays a role in determining whether she will use computers and how they will be used, but there are even stronger factors at work in determining whether teachers will make use of computers during class time for constructivist learning approaches. Specifically, those stronger factors are the teacher's own technical expertise and professional experience in using computer applications, the number of computers in their own classroom, and their personal involvement in their profession, both within their school building and beyond. Each of those factors, explored only in a small way in this paper, appear to be stronger determinants of constructivist uses of computers during class than the teacher's philosophy itself.

Will computers continue to play a "niche" role in the academic education of secondary students? Cuban continues to believe that that is so (Cuban, 2001); however, with continued development of the capability of computer hardware, the Internet infrastructure, and applications software; with increasing numbers of classrooms having sufficient computer access to this technology; with the increasing experience and expertise of teachers in using computers; and with the facilitating influence of the teachers most professionally active among their peers, the niche may be growing. The final and critical piece may yet turn out to be teachers' philosophies of learning and teaching and whether they can be brought around to be supportive of constructivist applications of computer technology. One thing, however, is certain. Four, eight, twelve, and sixteen years from now, there will be new mantras about the way computers should be used in schools, and they will take us as far from those of today—about computers as the tool for instructional reform—as today's ideas are from 1982's "Teach BASIC: it's the language that comes with your computer."