



Teaching, Learning and Computing: 1998

A National Survey of Schools and Teachers

Describing Their Best Practices, Teaching Philosophies, and Uses of Technology

Report to Participants

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INTRODUCTION

Teaching, Learning, and Computing (TLC) is the Spring, 1998 national survey in which teachers, technology coordinators, and principals described their best instructional practices, teaching philosophies, and uses of computing technologies. Roughly 5,800 educators in over 1,100 schools across the U.S. shared information about such things as how often they gave different kinds of assignments, the types of software they had students use, and the level of support present for using computers. The survey included a nationally representative sample of 2,251 4th through 12th grade teachers in American schools as well as more than 1,800 other teachers from two targeted samples of schools – schools with the greatest presence of computer technology and schools that participate in one of more than 50 identified national or regional educational reform programs. More than 1,700 principals and school-level technology coordinators also made valuable contributions by characterizing the school context for these teachers' practices.

In this report to the educators who participated in the study, we share our findings about the availability and use of computers by teachers and their students, the prevalence of different philosophies and instructional practices, and the relationships between how teachers use computers and their general approach to teaching. We examine differences among teachers by subject-matter and school levels, the two variables that have the biggest impact on the way teachers practice their craft. In addition, we contrast teachers who are oriented primarily to their own classroom with teachers who frequently interact with colleagues in collaborative and leadership activities. We also report on how experiences like formal staff development workshops and informal contacts among teachers affect their computer use and their pedagogy. Finally, we also share some preliminary results that contrast teachers in high-technology or reform-oriented settings with the teachers from the representative national sample.

Details regarding survey and statistical methods are not included in this report, but can be found on the project web site:

<http://www.crito.uci.edu/TLC>. All of the other analyses from the TLC survey that could not be incorporated into this **Report to Participants**, including a study of how school investments in technology hardware, software, and support affect computer use, will also make their way to the project web site over the course of 1999. Many of the topics for these future analyses are outlined at the end of this report.

This report is divided into four parts, as follows:

- Part 1 addresses *the availability of computers and the Internet* to teachers and their *use of these technology resources* both for their own professional purposes and as part of the work their students do. We look at how frequently computers are used in general and with different types of software, and how teachers use computers and the Internet in different ways according to the subject and level they teach.
- Part 2 discusses differences in *pedagogical beliefs and practices* among teachers, with a focus on those beliefs and practices that are consistent with a *reform-orientation* predicated on a “constructivist” view of learning. We describe the frequency of different teaching practices, by subject, and then look at some reasons why some teachers have more of a reform-orientation than others do.
- Part 3 examines *the relationship between technology use and reform-oriented practices*, and whether computers and the Internet might be serving as catalysts for changes in teachers pedagogies.
- Part 4 presents a few findings from our preliminary analysis of the sample of *high-technology and reform-oriented* schools in our study, and how teachers in those schools differ from our representative national sample of teachers.

PART 1: AVAILABILITY AND USE OF COMPUTERS

Year by year, greater numbers of ever more powerful computers make their arrival in American schools and classrooms and in the homes of teachers and their students. More and more teachers have access to computers for their own use—in their own classrooms, in teachers' lounges, and at their own home. By last Spring (1998), more than 3/5 of all teachers (62%) had a desktop computer provided by their school for their own use while at school. Even among teachers who had no computers in their room for student use, a majority (53%) had a computer provided for their professional use.

Regardless of whether teachers have students use computers during class time, they are computer-users themselves. Over 88% of U.S. teachers across all subjects and school levels report computer use for professional purposes. Weekly or more often, 66% use computers to make handouts, 50% use computers to record or calculate grades, 43% use them to write lesson plans, 28% use them to get information or pictures from the Internet for lessons, and 23% use computers to correspond with parents. At least occasionally, 39% of teachers exchange computer files with one another, 31% use camcorders or digital cameras and 19% use computers to post student work, ideas and opinions and locations for resources on the World Wide Web.

Nevertheless, having a computer available for themselves is one thing, but having a sufficient number of computers available for the students in their class is another. Even though 51% of teachers had at least one computer in their classroom for students to use, only one teacher out of thirteen (7.8%) had 8 or more computers in their own classroom, and roughly the same number of teachers (10.5%) had between 4 and 7 computers. Since more than two-thirds of all teachers use computers with at least one of the classes they teach, that means that the vast majority of computer-using classes have to either operate with just a few classroom computers or do their computer work elsewhere in the school.

Which teachers have the greatest access to computing resources?

Generally, the teachers with the greatest access to computers, for themselves and for their students, are those who teach classes about computers and those who teach classes where students apply computer skills to adult tasks in business and industry. More than 80% of computer teachers and vocational teachers and 65% of business education teachers have a computer provided by their school for their own use. These are also the teachers who are best positioned to have whole classes of students use computers simultaneously.

Looking first at computer-to-student ratios in their own classroom, computer teachers, business education teachers, and vocational education teachers—along with secondary teachers of mixed academic subjects—were much more likely than any other teachers to have at least one computer for every four students. More than 80% of computer teachers, 67% of business education teachers and 23% of vocational teachers had at least one computer in their classroom for every four students enrolled. In comparison, only 14% of English teachers, 12% of math teachers, 7% of science teachers, 5% of elementary teachers, and just 2% of social studies teachers taught in classrooms with that many computers.

Yet it is having many computers in one place that makes it possible for teachers to use computers in a substantial way with their classes. Those who don't have access to a bank of computer stations in some location tend simply to do without student computer use at all. We found that 80% of teachers who have their students use computers do so in a room where there is at least one computer for every four students (most often a computer lab or media center). This is true for almost every subject. Where the teachers of different subjects differ is in where they find this access—in their own room or elsewhere. That difference in location, we found, has important consequences for how

much their students use computers at all. We discuss that below.

Assigning Students to Use Computers

Across all subjects, 70% of all teachers report having students in at least one of their classes use computers during class at some point during the school year. However, infrequent use of a resource like computers is not likely to have a great effect on most students, so perhaps a more useful measure of the penetration of computers into organized school instruction would be the proportion of teachers whose students use computers on a frequent basis. Using a criterion of use by a “typical” student in the class *on more than 20 occasions* during the school year (teachers completed the survey in the late Spring), we found that more than one-fourth of teachers from 4th through 12th grades could be termed “frequent computer-assigning teachers.”

However, variations across subjects are striking. The first column of numbers in Table 1 below shows that for computer classes (90%) and business education classes (69%), a majority of teachers reported their students to be using computers on more than 20 occasions. Also a substantial fraction of vocational education teachers (42%), teachers of self-contained classes (42%), and English or language arts

teachers (32%) have their students use computers frequently. At the other extreme, only between 5 and 15 percent of teachers of science, math, social studies, foreign language, and fine arts classes are frequent computer-assigning teachers, using this definition.

Frequent computer use can be looked at in another way—from the “pie-chart” viewpoint: That is, among all of the classes for which computers were used by most students on more than 20 occasions—call these “frequent computer-using classes”—what fraction of them are math classes, science classes, computer classes, and so on? The three right-most columns in Table 1 present that data separately for elementary, middle, and high school levels. In secondary schools as a whole, more “frequent student computer use” occurs in English classes than in any other subject—including computer classes. That is because at any one time, only a modest fraction of students are taking computer classes, but nearly every student is taking English. However, considering high schools only, frequent computer use occurs as often in business education classes as in English, and computer classes are a close third. It is in the middle grades where English is far ahead of the second most-common class for frequent computer use—which is mathematics.

TABLE 1: FREQUENT COMPUTER USE BY STUDENTS, BY SUBJECT TAUGHT

	Percent of teachers of that subject having students (“a typical student”) use computers in 20+ lessons during class time	Percent of all frequent computer-assigning teachers at that level		
		Elementary grades (4+)	Middle grades	High school grades
Computer subjects	90%	1%	15%	16%
Business education	69%	0%	4%	19%
Vocational education	43%	0%	3%	13%
Self-contained (elementary)	42%	77%	10%	2%
English, Lang. Arts spec.	32%	12%	27%	19%
Science	15%	0%	12%	12%
Mathematics	13%	3%	16%	4%
Social studies	11%	3%	5%	5%
Fine arts	9%	0%	1%	3%
Foreign language	5%	0%	0%	2%
Other subjects	---	5%	7%	6%
Total, all teachers	27%	100%	100%	100%

Source: Teaching, Learning and Computing – 1998. <http://www.crito.uci.edu/TLC>

Interestingly, high school math classes constitute only a tiny fraction of the frequent computer use classes at that level.

Besides subject-matter, frequency of computer use also depends on how many computers a teacher has. For most subjects, the more computers present in the classroom, the more likely any one student will be able to use them frequently. This effect is strongest for vocational education classes and classes of “other” academic subjects like interdisciplinary classes, seminars, and psychology. However, having more classroom computers is also associated with greater student use in science, English, math, and fine arts classes as well. This does not seem to be as true for elementary self-contained classes, however. In those classes, teachers have their students for much longer periods of time and can use that extended time to orchestrate computer use among many students even when they have only a handful of computers present.

In addition to “numbers,” where computers are located is also important. Because computer labs have so many more computers than classrooms—the typical lab has 21 computers; the typical classroom has only 2—it would seem that a student would have more of a chance to use computers frequently if his class used computers in a lab. However, having to share the computer lab with other teachers limits each teacher’s opportunity to use such resources frequently. How does this tradeoff play out?

The answer is that despite the presence of so few computers in most classrooms, students are more likely to be frequent computer users when their teacher has them do that work in the classroom rather than only in a computer lab or media center. This finding is *not* caused by the heavy-using teachers of computer and business-ed classes being the ones with computers in their classroom. In fact, the advantage of classroom location is strongest for academic subjects. English, science, social studies, and math teachers all are more apt to have their students use computers frequently when the use occurs in the teacher’s own classroom than when it occurs only in a computer lab or media center. For

example, among English teachers, 57% of classroom-based computer using teachers frequently assign computer work compared to only 36% who have all computer work done in the lab or library.

The pattern is even stronger when one considers just those secondary academic subject teachers who have at least 5 computers in their classroom. That group of teachers is three times as likely to have students use computers frequently than are teachers of the same subjects whose students use computers only in labs or elsewhere (75% vs. 25%).

This seems counter intuitive since being in a lab with 20 to 30 computers would seem to give individual students more opportunities to use them. However, the computer’s value in most academic classes is not for concentrated whole-class use on a scheduled basis, but as a resource available for particular groups of students when needed to find information, analyze information, or communicate information.

Commonly Used Software

Studies of instructional uses of school computers conducted in the 1980’s or early in the 1990’s found that the primary uses of computer technology in schools involved skills practice and computer literacy (e.g., how to use different types of software). We can report now that those uses are no longer the most common ones. Instead, we are seeing large numbers of teachers having their students use computers as tools for searching for and obtaining information, analyzing information, communicating ideas, and producing intellectual products.

Of all of the various types of software available on school computers, word processing software is by far the most commonly used. Not only are English teachers more likely to have their students do word processing than any other computer activity, but so are science, social studies, and elementary teachers. Among elementary classes, games for practicing basic math and language arts skills are still common (second only to word processing). However in middle schools drills and games are used less

TABLE 2: PERCENT OF TEACHERS USING SOFTWARE USED IN 3+ LESSONS, BY SUBJECT TAUGHT

	Word Proc.	CD-ROM	World Wide Web	Skill practice Games	Simulations/ Exploratory Environments	Graphics	Spread-sheets/ Database	Presen-tation	Multi-media	E-mail
Computers	87%	33%	48%	35%	48%	55%	66%	45%	22%	16%
Business Educ	86%	22%	37%	23%	32%	40%	63%	34%	5%	13%
Vocational	41%	30%	35%	16%	41%	37%	24%	23%	11%	13%
Self-contained (elementary)	69%	56%	24%	63%	36%	27%	8%	7%	10%	8%
English	60%	42%	34%	18%	12%	17%	8%	11%	7%	6%
Science	41%	36%	35%	11%	22%	16%	17%	8%	8%	8%
Math	15%	9%	16%	25%	18%	8%	13%	6%	4%	2%
Social Studies	38%	33%	31%	14%	12%	12%	11%	16%	11%	9%
Fine Arts	22%	9%	20%	3%	12%	28%	8%	12%	7%	8%
Foreign Language	32%	17%	32%	16%	5%	13%	9%	2%	8%	3%
Total (incl. 'other')	50%	36%	29%	28%	23%	21%	16%	12%	9%	7%

Source: Teaching, Learning and Computing – 1998, <http://www.crito.uci.edu/TLC>.

than CD-ROM reference software and Web browsers and in high schools drill and game software is also less common than graphics software, spreadsheets, simulation and exploratory software, and computer-aided presentations (e.g., PowerPoint).

Math teachers, however, use skills-practice games more than any other type of software (except perhaps for graphing software, which was not in that survey question). Table 2 shows the percentage of teachers, by subject, who reported having their students use each of 10 different types of software on at least three occasions during the year.

Next to using word processing software to compose and edit text, the greatest use that students are making of school computers is for gathering information. Students are obtaining information from CD-ROM encyclopedias and subject-specific reference CDs as well as information on the Internet's World Wide Web. The more controlled information bases on CD-ROMs are particularly common in elementary classes' information gathering (research), but in secondary schools the World Wide Web is used at least as often as CD-ROMs in English classes, social studies classes, and science classes. However, the most common use of the Internet is in computer classes and business education

classes where students are using the Web to do research for reports.

Use of *analytic software*—such as simulations and exploratory environments and spreadsheets—and *product-oriented software*—such as graphics programs, presentation software, and multimedia authoring environments—are less often used than either word processing or information retrieval software. Nevertheless, most computer classes provide students with opportunities to explore those types of software as do many courses in business and vocational education. In many ways, it is the more elective and less college preparatory-oriented parts of the high school curriculum where the newer and more creative uses of computers are being found, rather than in the more standards-constrained academic subjects. Even in the elective classes, though, regular student use of electronic mail communication is a relatively rare phenomenon. Computer-based communication is not yet integrated into any area of the school experience on a widespread basis.

Staff Development and Support for Teachers' Use of Computers

As with any new and complex teaching resource, it is important for teachers to have well-constructed opportunities to become competent in the use of software and to solve

problems that arise in its use. How widespread are those opportunities? Our survey found that one half of all teachers participated in formal staff development activities related to computer technology and software during that school year or the previous summer. Most commonly, teachers attend workshops where the mechanics of using computers or software is a central topic. Somewhat less often they participate in programs that emphasize the integration of computer activities into subject-matter curriculum.

The teachers who most often participate in staff development workshops about computers, not surprisingly, are teachers of subjects that use computers most often. About 70% of business education and computer teachers attended staff development on computer mechanics during 1997-98. Vocational education teachers and teachers of mixed academic classes were next most often involved (57% of each). Teachers least likely to be included in technology-related staff development were fine arts teachers (29%).

However, also with reasonably high participation rates in staff development on computer mechanics were two groups of teachers who are rarely found among frequent computer-assigning teachers—mathematics teachers and foreign language teachers. What is interesting about those two groups is that, of all participants involved in technology-related staff development, teachers in those subjects (along with fine arts teachers), were the *least likely* to have workshops where the *integration* of technology with their subject-matter was a central topic. Instead, they were mainly presented with instruction in the mechanics of using technology. Thus, while math and foreign language teachers have had some opportunities to learn about technology, critical experiences for linking that learning to concrete teaching tasks have been missing.

Overall, 38% of teachers report that at least once a month they need help in integrating computers into a lesson they are planning. Of those teachers who report such a need, only 15% claim to always get it, and only 12% more say that support is “mostly” available. Thus, the need for

help in curriculum integration, while not frequent for most teachers, is being met for only about one-third of those teachers who report a need for it. When the support comes, fewer than one-fourth say that the support is either excellent or very good.

Roughly the same story exists with respect to technical support—keeping computers and software available and working. Slightly fewer than one-half of all teachers (46%) say that they need technical help at least once a month. However, of those who report that level of need, only about one-third (31%) report that technical support is always or mostly available when they need it. About one-third of all teachers report that technical help, when called, is excellent or very good. About one-third say it is “good,” and one-third give it a lower grade (fair or poor).

High school teachers are less likely to report a need for technical or curriculum integration support for technology than are teachers in the lower grades. However, among those reporting a need for support, high school teachers are somewhat less likely to say it is always or mostly available than are middle school and elementary teachers. This holds even when we eliminate computer specialists from the analysis.

Availability and Use of Internet

The presence of the Internet has become pervasive in recent years. As of last Spring, more than 90% of schools had some level of access to the Internet. More importantly, in our survey nearly 40% of all 4th through 12th grade teachers had access in their own classroom, and nearly one-half of those teachers (18% of all teachers) had LAN-based connections to the Internet in their classroom. Those “direct” connections would allow many computers to be simultaneously connected to the Internet if the teachers had those computers in their classrooms.

Just as there are many teachers who use computers professionally but do not have students use them during class, more teachers use the Internet for professional purposes than assign its use to students. More than two-thirds

of all teachers (68%) indicated that in 1997-98 they at least occasionally used the Internet to gather information and pictures for use in classes, and more than one-fourth (28%) said they did so on a weekly basis. In addition, a growing fraction of teachers e-mail teachers from other schools (16% said they did this more than a handful of times during the year) and share opinions, lesson plans, or student work on the Internet (18% did some of this).

With respect to student use, as we have already pointed out, having students use a World Wide Web browser for research has become the third most common student use of school computers after word processing and CD-ROMs. Relatively few teachers, though, have students use the Internet in complex ways such as publishing on the Web or long-term cross-classroom collaborative projects. Overall, only 7% of U.S. teachers had students use e-mail in as many as three lessons during 1997-98, only 6% had students participate in cross-school projects, and only 4% had students “become expert about a topic and publish text and pictures on the Web.” Still, that means that even for limited participation activities such as Web publishing, the absolute numbers of teachers and students involved is impressive. For example, by Spring 1998 more than 70,000 teachers had helped students disseminate their work via the World Wide Web.

Internet Use by Subject Matter and School Level

Although many teachers have had students do some research using the World Wide Web, only a small proportion of teachers have made Web-based research a major activity in their classes—that is, where students used the Web frequently throughout the school year. The leaders in this activity, not surprisingly, are computer teachers. In 1997-98, about 40% of all teachers of computer classes had students do research on the Web as part of 10 or more lessons during the year. For most other subject areas, though, only 10 to 15 percent of teachers had students use the Web that frequently. Science teachers were a bit more likely than

teachers of other academic subjects to have students involved in frequent use of the Web (21%). The lowest levels of participation were among math, foreign language, and fine arts teachers (all under 10%). As a group, high school teachers have students do Web research, e-mail, and Web publication more frequently than teachers at lower levels. On the other hand, elementary school teachers have students use the Internet for collaborative projects slightly more often than teachers in secondary schools.

Major Determinants of Internet Use With Students

In one of our special studies we examined the following question: “Which factors are most strongly predictive of a high level of Internet use by teachers?” We found that the most important predictors of Internet use are Internet connections in the classroom, the teacher’s computer expertise, and the teacher’s pedagogical beliefs and practices.

Classroom Connectivity. The highest level of student use, whether it involved student research or students posting their work on the Web, is reported by those teachers who have high-speed/LAN-based direct access in their own classroom—and where at least four computers are present. That situation allows several students to have Web access at one time and facilitates integration of Web research with other related classroom activities that don’t involve computers. Overall, just about one-half (48%) of all teachers who have 4 or more computers in their classroom and have direct LAN-based (local-area-network) Internet connections had students use the Web during 10 or more lessons during the year. That is double the percentage of those who had students use the Web who had only individual dial-up modem connections or who had LAN-based connections but with fewer computers. English and social studies teachers with that highest level of connectivity were particularly likely to organize many lessons around Web-based student research.

Computer Expertise. Computer expertise was the second most important predictor of frequent

Internet use by teachers and their students. Teachers were asked to assess their own computer skills in a number of areas. Those with high computer skills in such areas as file handling, setting up database files, and using presentation and multimedia authoring software, were twice as likely to use the Internet for their own professional purposes and with students as those with relatively limited computer skills.

Pedagogical Beliefs and Practices. Teacher pedagogy (a topic discussed in detail later) was the third most important factor in determining Internet use with students. Teachers who believe strongly that good teaching involves facilitating independent student work rather than emphasizing direct instruction and skills practice, and who put those beliefs into practice, along with an emphasis on complex thinking, were much more likely to have their students use the Internet than were those who put relatively limited value on such approaches to teaching. In addition, these teachers, whom we label “constructivist,” were twice as likely to believe the Internet in the classroom to be essential to their teaching as those who were least constructivist. Similarly, for teacher Internet use, the most constructivist teachers (19% of all teachers) were two-and-one-half times as likely as the most traditional teachers (the 22% closest to the “traditional” end of the scale) to use the Internet for their own professional use.

Other Determinants of Internet Use. Other conditions that predict greater Internet use include participation in staff development on Internet use, a high frequency of informal contacts with other teachers at their school, engaging in a substantial range of professional leadership activities in the previous three years, being relatively young, having home Internet access, having made more personal investments in their own education, and finally, having had a few years of teaching experience (at least four years).

Not surprisingly, formal staff development about the Internet is associated with greater use of the Internet. Three out of ten teachers report having attended a formal workshop teaching how to use

the Internet or other on-line activities, and those teachers were twice as likely to have students use the Internet than other teachers.

However, it was also the case that, completely apart from formal training, teachers who reported a high level of informal contacts with other teachers at their school—e.g., frequently observing other teachers' classes or having casual conversation about ideas for student projects or issues in their subject-matter field—were also more likely to use the Internet than teachers with fewer of these informal contacts. When more closely examined, this difference between high informal contact teachers and others was at least as substantial and even more widespread than the differences between those who attended formal staff development about using the Internet and those who did not.

These results are consistent with our findings on school culture discussed later in this report. In strongly professional school cultures, where teachers support one another, the effect of formal staff development programs becomes magnified, as teachers help one another in taking advantage of opportunities they had begun to learn about.

Finally, age and years of teaching experience, compared to other predictors, have relatively small relationships with Internet use. To a small extent, teachers in their first few years of teaching (at least those under age 30) are more likely to use the Internet in preparing lessons than more experienced and older teachers. They are also the teachers who consider the Internet to be essential in their classroom. However, those in their first three years of teaching are less likely to use the Internet with their students, perhaps due to the need to first master the routines of teaching before initiating innovative practices. In terms of actually using the Internet for student projects, teachers with four to seven years of experience were most likely to do so.

PART 2: TEACHING BELIEFS & PRACTICES

In our discussion of teachers' use of the Internet, we suggested that how a teacher uses computers might better be understood by knowing about that teacher's basic pedagogical beliefs and practices—what constitutes good teaching practice for themselves and how they go about organizing learning in their classroom. Traditionally, teaching practice is characterized by an emphasis on skill and knowledge transmission from teacher to students. This usually involves

- the use of an externally prescribed curriculum of discrete skills and factual knowledge;
- direct presentation and explanation to students of that procedural and factual knowledge;
- frequent assignment of written exercises to students aimed at their remembering factual knowledge and accurately performing skills; and then
- evaluation of students' mastery of skills and knowledge by giving them recall and recognition written tests.

One contrast to a skill and knowledge transmission-oriented practice points to two emphases which it largely excludes:

- helping students to develop a deep understanding of a concept or topic, in all its complexity, rather than covering a specific and rather comprehensive curriculum; and
- designing instructional tasks specifically to make each one meaningful to each student—for example, connected to their own personal experience—rather than arbitrary from the student's world view.

Both of those emphases are associated with current efforts to improve teachers' effectiveness, and both, particularly the emphasis on meaningful instructional tasks, are associated with discussions of pedagogy based on a theory of learning called "constructivism."

Complex Thinking: The first emphasis, on teaching for understanding rather than its specific factual or skill components, has students working on some of the more challenging tasks within the teachers' repertoire—tasks such as articulating reasoning (not just answering questions), revising their work after feedback from teacher or peers, engaging in serious discussion with their fellow students, and doing meta-cognitive assessments of their own understanding and learning strategies.

Although it is not always easy to design tasks that engage students in that kind of critical thinking, it may be more feasible to do so when students have a rich array of information to work with (rather than only pre-selected, quality-filtered textbook content), when communications structures enable students to pose relevant questions to appropriate individuals (both within the class and outside), and when technology-based tools such as databases, analytic software, and composition software help them to extract understanding from information. These activities may sometimes best be accomplished by giving students greater responsibility to define problems and organize their own investigations, and would clearly be better accomplished when teachers become more expert at facilitating this type of independent inquiry.

Meaningful Tasks: The second emphasis of instructional reform extends from the first, making meaningfulness a primary attribute of student tasks. This is accomplished by assigning contextually rich learning tasks such as projects that integrate the use of many different skills and have a real purpose beyond the students' learning the facts and skills themselves. In this model, meaningfulness is presumed to arise from the "genuineness" of the problems addressed, the inherent interest of such real problems to students, and a structure that gives students more freedom in the nature of the problem studied and the methods of problem-solving.

Constructivist learning theory suggests that tasks that are more meaningful to those engaged in them result in learning that is more likely to be carried over to different concrete situations than when taught without context and without the learner's "ownership." As with the emphasis on critical thinking, the emphasis on making tasks meaningful also involves more collaborative work among students, and requires teachers to act as facilitators of student inquiry instead of performing their traditional responsibilities for providing direct instruction.

Before discussing what we found concerning the relationship between teachers' use of computer technologies and their basic pedagogical beliefs and practices, we thought it useful to describe what our survey found the distribution of those beliefs and practices to be among U.S. teachers.

Constructivist versus Traditional Beliefs and Practices of U.S. Teachers

Teaching Philosophies

A majority of U.S. teachers claim to adhere to philosophies consistent with a constructivist view of learning, though wide disagreements do prevail. For example, when presented with pairs of contrasting alternatives about the most appropriate stance to take as a teacher, 40% favored acting as a facilitator of independent student inquiry while 30% said that it was more important for teachers to "explain, show students how to do the work, and to assign specific practice." (The rest, 30%, found themselves unable to state a preference between these two choices.)

About one-half of all teachers (48%) believe that having a variety of activities going on in the classroom is preferable to having the whole class do 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." Still the latter choice was favored by about one-fourth (26%) of the teachers.

When teachers were given more concrete portraits of how two teachers approached class

discussions, twice as many (57%) believed that students learned more useful *skills* when faced with a constructivist teacher who brought out substantive questions from students and led them to investigate their own questions than when students were taught by a traditional teacher who used a rapid pace of simple, straightforward questions to students that were based on their recent reading assignment (29%). However, asked which teaching method provided students with more *knowledge*, opinions were much more evenly divided—44% believed the traditional approach was better and 42% believed the constructivist approach was.

In short, for most of our survey questions, teachers were more likely to say they believed in a reform-oriented pedagogy. However, we found, not surprisingly, that teachers found the constructivist pedagogy more difficult to accomplish in practice.

Teaching Practices

The survey asked teachers a variety of questions about the frequency that they employed different teaching approaches. For example, at least weekly, about half of all teachers (52%) have students do "hands-on or laboratory" activities. However, about the same percentage report use of students doing individual seatwork at least weekly. About 44% of teachers have students work in small groups to come up with joint solutions, but only 8% have students "suggest or help plan classroom activities or topics" on a weekly basis. More than one-fourth (28%) have students write in a journal at least weekly, but slightly fewer (22%) have students write an essay explaining their thoughts that often.

When comparing the overall amount of time spent on activities associated with a constructivist approach to teaching (e.g., hands-on work, group work, and reflective writing) with the amount of time students spend on more traditional activities (e.g., individual seat work), our results suggest that on average, about an equal amount of time is spent on traditional and constructivist activities despite the prevalence of constructivist philosophy among U.S. teachers.

Teachers' responses to one very concrete question (summarized here in a general sense) suggest a reason: Most teachers (64%) report themselves to be more comfortable teaching in a traditional style than a constructivist one (28%), and more believe that even students prefer that type of instruction (53% to 37%) even though they believe that constructivist teaching is better for students in helping them gain useful skills.

Another reason for teachers' greater conservatism in practice than in philosophy comes from the pressures teachers felt to be under. When teachers feel a large amount of pressure to organize their teaching in a way that is inconsistent with their personal judgement, their own voice concerning what defines good teaching is undervalued. Teachers feel more pressure around the issue of assessment than around any other issue measured.

A majority of teachers (58%) felt either "some" or "a lot" of pressure to prepare students for standardized tests, and 48% felt a similar pressure around performance-based assessment.

The other area in which many teachers feel external pressure to act against their better judgement concerns the curriculum. Just over half of the teachers find there is too much external pressure to cover a large number of curriculum topics. Half of the teachers are also concerned over having to cover specific curriculum topics. Nearly two-fifths of teachers (39%) also signal this pressure by indicating that the grade level expectations of next year's teacher serves to constrain what they teach. Also consistent with these results is the response to the required use of specific textbooks. More than one-third of the teachers (35%) expressed a concern over the use of specified textbooks.

In contrast to pressures regarding the curriculum and assessment, teachers feel relatively unimpaired in terms of how they choose to instruct their class. For example, only about one-fifth of teachers felt pressure to use computers or the Internet. Comparable percentages were recorded for other aspects of classroom instruction.

Teacher Practices by Subject Taught

Frequently Assigned Activities

Teachers of different subjects responded very differently when asked about how often they have students take part in various activities that are associated with a constructivist model of teaching versus those associated with emphasizing skill and knowledge transmission.

In general, English and elementary teachers reported the most constructivist-compatible practices. Foreign language teachers, math teachers, and business education teachers, in contrast, practice in a way more resembling skill and knowledge transmission. However, in all subjects teachers report specific practices that can be viewed as being consistent with constructivist reforms.

Traditional Practices

In this section, we discuss four items that can be viewed as being "traditional" in pedagogy:

- Students working individually answering questions from textbooks or worksheets
- Teachers leading whole-class discussions
- Teachers asking questions to see if students know the correct answer
- Using introductory drills to start a new unit

The most common student activity reported by U.S. teachers is a very traditional one—students working individually on problems from a textbook or worksheet. Math teachers have students do this the most often, with 79% reporting such activity at least weekly, 15 percentage points higher than any other group of teachers. Math teachers also reported spending more time leading whole-class discussions than any other subject teachers, again by a wide margin. Of the teachers of major academic subjects, English teachers were least likely to spend time in whole-class discussion. Business education teachers spend less time having students lead class discussions than in any other subject. Only 3% of business education teachers

spend more than an hour per week with students taking class leadership roles, compared to 38% of English teachers.

Our survey respondents were given several reasons for asking students questions (e.g., “to elicit student ideas”; “to relate what they are working on to their own experiences”). Another reason was simply to “see if students know the correct answer.” Most teachers give that reason sometimes and those that did so most often were foreign language teachers (81% said “always” or “very often”), business education teachers (69%), and math teachers (62%). In contrast, only a minority of science teachers, English teachers, and vocational education teachers gave that response.

Finally, teachers were asked about several approaches they took when starting a new unit, such as having the students discuss the topic in groups or making conjectures about what they will learn or discover during the unit. In contrast to those “constructivist” choices, a large percentage of certain groups of teachers said that in their current unit, they had started it out with

students practicing introductory drills. The teachers who used this approach the most were business education teachers (78%) and foreign language, fine arts, and computer teachers (roughly 60%). In contrast, fewer than 40% of

English teachers and (elementary) teachers of self-contained classes reported using skill or fact drills to introduce their current unit. Not surprisingly, the teachers who used introductory drills the least were the ones most likely to introduce new units by having students make conjectures or discuss the new topics in small groups.

Constructivist Practices

We now turn our attention to teaching practices we have categorized as “constructivist.” Table 3 shows some of these practices that were part of one survey question about the frequency that teachers had students engage in different activities. Of the constructivist activities in that survey question, the most frequently reported were hands-on or laboratory work, group work, journal writing, and essay writing.

Overall, almost as many teachers have students do hands-on or laboratory activities on a weekly basis as have students engage in seatwork (answering textbook or worksheet questions).

However, hands-on activity is concentrated in certain subjects—computer classes, business education, vocational subjects, science classes, and elementary self-contained classes. Only a minority of math, foreign language, English, and

TABLE 3: PERCENT OF TEACHERS ASSIGNING VARIOUS ACTIVITIES WEEKLY OR MORE OFTEN

	Answer questions from textbook or worksheet	Hands-on or laboratory activities	Work in small groups	Journal writing	Re-flec-tive essay writing	Long projects	Problems with no obvious method of solution	Students plan activities
Math	79%	24%	52%	8%	10%	2%	20%	4%
Foreign Language	73%	27%	40%	12%	5%	9%	1%	3%
Self-Contained (elementary)	68%	64%	59%	58%	35%	21%	21%	17%
Business Ed.	55%	78%	27%	4%	1%	26%	1%	3%
Science	47%	67%	42%	15%	16%	10%	18%	4%
Social Studies	43%	33%	34%	15%	23%	7%	12%	6%
English	39%	36%	37%	44%	36%	20%	18%	9%
Computers	25%	90%	30%	12%	10%	43%	16%	1%
Vocational	24%	88%	49%	19%	10%	50%	24%	12%
Fine Arts	14%	84%	24%	6%	3%	78%	18%	8%
All teachers (incl. 'other')	53%	51%	44%	28%	22%	19%	17%	8%

Source: Teaching, Learning and Computing – 1998. <http://www.crito.uci.edu/TLC>.

social studies teachers have students do “hands-on” activities as often as once per week. Thus, except for science classes, where laboratory work has a long tradition, in the secondary grades, active manipulation of “stuff” is confined to non-academic subjects.

On the other hand, student small group work is a reasonably common practice in most subjects, including subjects like math and foreign language where other measures of pedagogy suggest a more traditional practice. Still, only among elementary teachers and secondary math teachers do a majority of teachers assign group work on a weekly basis.

Most teachers do *not* involve students in long-term projects lasting at least a week on a regular basis. Only 20% of all teachers said that students worked on long projects during most weeks. Long projects were most common in fine arts (78% reported that students did this during most weeks), vocational education classes (50%), and computer classes (43%). In contrast, in each of the academic subjects, no more than 10% of the teachers said that project work occurred during most weeks. Only 2% of math teachers and 7% of social studies teachers reported that level of project work by students.

Elementary and English teachers are the ones who most often engage students in writing journals or writing reflective essays. Well over half (58%) of elementary self-contained teachers have students write in journals at least weekly. Interestingly, although the word “problem-solving” is associated with mathematics, English teachers are as likely as math teachers to say that roughly once per week they had students work on “problems with no obvious solution” (18% vs. 20%). In sharp contrast, almost no business education teachers have students keep journals (only 4% do), write reflective essays (1%), or solve ambiguous problems (1%). Other teachers who make limited use of reflective writing assignments are math, fine arts, foreign language and computer teachers.

Finally, student participation in planning classroom activities or topics is not a common practice among teachers. Those who do so more

frequently are teachers of elementary self-contained classes (17% weekly). Except for vocational education teachers, where 12% follow this practice, fewer than 10% of all other teachers do this weekly or more often.

In another survey question, we identified specific constructivist-compatible practices that commonly occur in certain subjects but not in others. For example, social studies and English teachers are more likely than other teachers to have students work on “problems with complex truths or with no clear right or wrong answer.” These two groups also more frequently report having students debate issues or make cases for different points of view. Interestingly, dealing with complex truths and debating issues are the among the only ones where elementary teachers do not seem particularly constructivist, suggesting that teachers perceive that only the older students have the intellectual skills required to handle that level of complexity.

Math teachers, although low on most measures of constructivist practice, demonstrate a willingness to have students at least *occasionally* solve problems that have only limited procedural direction. About half of the math teachers (47%) said that at least monthly they had students decide on their own procedures for solving problems and then have group discussions of the alternative solutions proposed. Math and science teachers also had students *design their own problems* to solve more often than, for example, social studies teachers did. However, student design of problems is most commonly found in vocational education classes and in “other secondary subjects” (which are primarily subjects of student initiative such as “exploratory,” “life skills,” and “community service”).

Two other practices are also found most frequently in non-academic courses: having students make a product to be used by others and demonstrating their work to an outside audience. These central components of constructivist-compatible teaching are found most often in vocational education classes (50% reporting making products for use monthly; 25%, outside demonstrations), computer classes (34% and

14%, respectively), and fine arts classes (26% and 33%). Among the academic subjects, only among English teachers are these activities reported to occur monthly by more than 10% of academic subjects teachers, and only 12 to 15 percent of English teachers engage students in those ways.

In contrast, it was in academic subjects where teachers most often reported using “multiple representations” of a concept or idea as a pedagogical approach. Multiple representations was an approach used “monthly” or more by about one-half of the teachers of all four major academic subjects (plus elementary teachers), proportionally twice as many teachers as in any of the non-academic subjects, or, interestingly, by foreign language teachers as well.

Changes in Practice over Last Three Years

Besides describing their current teaching practice, teachers were asked to tell us in what ways their practice had changed over the preceding three years. Sixteen different aspects of instruction were included in this part of the survey, including changes in a constructivist direction and changes in a more traditional direction. Teachers were much more likely to report constructivist-oriented changes than an increase in skill- or knowledge-transmission practices. Changes reported by a *majority* of teachers included:

- increasingly having students teach or help one another,
- having students work in groups,
- having them review and revise their own work,
- evaluating students based on their products instead of by tests,
- having students explore a topic on their own without close direction, and
- having multiple activities occur simultaneously in their classroom.

In contrast, none of the practices of a traditional sort (e.g., using the textbook as a primary guide through units; or planning lessons using principles of direct instruction) were reported to be used now more than three years ago by a

majority of teachers, although one-third of teachers said they now more often closely supervise student work.

There were some interesting differences by subject in some of the changes that were reported. An increase in the use of student group work was reported more often by mathematics teachers and business education teachers than in any other subject. In the case of mathematics, this may be due to the influence of the NCTM-led reform movement which may have influenced teachers in how they organize their class even other NCTM goals are not yet widely adopted. In the case of business education, this could be due to an increased use of student work with computers, which often involves students working in pairs or groups for both practical (too few computers) and pedagogical (sharing of expertise) reasons.

Vocational education teachers, another group of heavy computer-assigning teachers, but who were already above-average in using student group work, reported a greater increase in *having students teach or help each other* than other subject-matter teachers did. Also, and probably even more likely a result of computer use, teachers of both computer classes and vocational education classes were the most likely to say that they increasingly had *many different activities going on at once* in their classes than they used to have. Because of the diversity of activities possible with computers, computer work lends itself to a more heterogeneous classroom environment.

On the other hand, computer teachers were among the *least likely* to report increased use of student *group work*, perhaps because they have enough computers available to their classes and because they tend to focus on individual mastery of computer skills.

While many teachers are moving towards evaluating students through their products rather than solely through tests, this characteristic was found more often among elementary teachers and business education teachers than among others. In the former case, this might be due to the growing support for portfolios and

performance testing in district and state policy. Such policies tend to impact practice faster in elementary schools than among subject-specialized secondary practitioners. In the case of business education teachers, an increase in performance testing over written tests could conceivably be due to their increased use of computer-based projects.

Foreign language teachers reported an interesting pattern of recent changes in pedagogical practices. They were more likely than any other group of teachers to say that they increasingly allowed themselves to be taught by students and that they allowed students to explore a topic on their own without direction. However, they were the least likely to report increases in student inquiry activities (“make predictions and investigate them”), in long projects, or in letting student interest partly influence the topics in the lessons. This suggests an instructional “letting-go,” but a rather stable view regarding curriculum priorities.

Fine arts teachers, as a group, seemed to be relatively little changed in practice over the past few years. On almost every measure, they were one of the least likely to report changes, particularly in terms of constructivist practices (where in some ways they were already at the “top”), or in the use of more traditional direct instruction. It might be significant that fine arts classes are among the least frequent users of computers, particularly outside of specialty multi-media courses.

Compared to the groups of teachers we have been discussing, teachers of other academic subjects (English, science, and social studies) tended not to be distinct as groups, but to vary among themselves in how much they had changed over the past few years. (English teachers, though, do report an increased use of long projects in their classes; and social studies teachers tended to report somewhat less movement towards more student inquiry work than in other fields.) In these subjects, variations among teachers in the conditions of teaching may be different enough between schools that no particular pattern is emerging for teachers of these academic subjects as a whole.

In summary, in terms of both their current array of teaching practices and the changes they report making over the past three years, teachers of different subjects display very correspondingly different patterns of pedagogy. The specific ways that they engage students in meaningful tasks around cognitively complex issues varies substantially subject-by-subject. Still, as we just suggested for teachers of English, science, and social studies with respect to *changes* in practice, even among teachers of the same subject there are substantial differences in pedagogical style. We now turn to our analysis of factors related to different pedagogical styles, moving towards examining our central research question—the relationship of teachers’ pedagogical style to how they use computers.

Correlates of Constructivist Practices

When asked “why” they changed towards constructivist practice, teachers (that is, the ones who changed most in that direction) selected a variety of reasons, but most commonly they attributed the changes in their practice to (a) changes in the main goals they had for students; (b) changes in their understanding about how people learn or understand things; (c) staff development experiences they had; and (d) their experiences with computers.

In Part 3 of this Report, we will look at the relationship of computer use to pedagogy. Here we will discuss some of our findings about other factors that seem to be related to the use of constructivist practices, besides computer experiences and besides the teacher’s particular subject-matter responsibilities, which we have already examined.

School Experiences – Staff Development and Informal Contacts

Both formal and informal experiences in school appear to affect the ability of teachers to engage in constructivist practices. Teachers who report having attended, during the past year, a greater number of staff development sessions focused on constructivist pedagogy were more constructivist in practice. We also found that constructivist teachers had more frequent informal contacts with other teachers at their

school—that is, they had more discussions about teaching methods, subject content, and technology, and they observed instruction by other teachers or experienced their own classes observed. Does participation in such activities actually cause someone to become more constructivist in practice? One might argue that constructivist-oriented teachers may already have been more likely to participate in staff development focused on teaching practice and interact with other teachers in their building around teaching issues in the first place. However our analysis still suggests that these types of experiences actually have an impact on teachers' practice even so.

Our reasoning is based on the following: we make a distinction between teaching philosophy (what teachers say is good pedagogy) and teaching practice (what they tell us they actually do in their classes), knowing, of course, that they are related. Furthermore, we assume that philosophy is less apt to change in response to circumstances than is practice—in other words, that experiences influence how one organizes instruction, but only more slowly influence basic beliefs. Our analytic method “holds constant” philosophy (compares teachers with similar levels of constructivist beliefs) and looks at the correlates of practice among teachers with the same philosophical bent.

Doing that, we find that the relationship between constructivist practice and attendance at staff development workshops even about teaching practices remains positive, controlling on philosophy.

The same is true about frequency of informal contacts. In other words, taking teachers with roughly the same teaching philosophies, those who spend more time talking about teaching issues with other teachers (and who observe one another's classes) are more constructivist in practice. Those with fewer contacts (discussions and classroom observations) are less constructivist.

Leadership

Discussing teaching issues with other teachers at one's school and observing each other teach brings teaching out from a private practice into a more public sphere. Going beyond same-school contacts, teachers who interact with teachers from other schools, through attending conferences, participating on committees, or even informally exchanging e-mails, are moving in the direction of making their practice a professional one. Full professional leadership goes even beyond that, involving mentoring of another teacher, teaching peers in workshops, teaching a college class for other teachers, or publishing articles for fellow practitioners. Only a minority of teachers engage in these leadership activities—for example, over the previous three years, about one-fourth (24%) of all teachers formally mentored another teacher, 30% taught peers in workshops, 12% taught a college class, and only 5% published an article on education—but these activities are very significant.

The more that teachers extend their activities beyond their own classroom towards having a leadership orientation, the more constructivist their teaching practice. Again, it may be that teachers with more constructivist practices are the ones who choose to engage in more professional behaviors. But it also may be that the professional interactions themselves influence teachers' pedagogies. One theory is that the teacher's professional interactions come to serve as a model for their own classroom practice. That is, teachers who learn from their peers and present their ideas and opinions to their peers are more likely to see that this is a type of learning and activity that their students can profit from as well.

School Professional Culture and Teacher Pedagogy

What if a whole school takes on a professional orientation? Does this impact teachers' pedagogies as well? We have begun this examination of school culture by first defining a professionally oriented school culture as one where there exists:

- Shared school goals: common goals and priorities among the teachers and administrators at the school and where discussion of goals is public and frequent
- A community of learners among teachers, where teachers feel they are always learning how to teach, where they encourage innovation with each other, discuss ideas together, and share samples of student work
- An integrated teacher-respecting staff development program—a program where teachers help plan staff development activities, where the various activities are related to one another, and where teachers are provided with support for implementing the ideas discussed
- An environment in which teachers are both recognized for success and given constructive criticism by their own peers

We found that in the schools where the school culture is most professionally oriented—we focused on the 5% of all schools where this culture seemed most evident—teachers’ instructional practice is more constructivist than one would predict simply by knowing their own personal orientation towards their job. That is, whether teachers are more classroom-focused or involved heavily in collaborative and leadership activities beyond the classroom, they exhibit higher levels of constructivist pedagogy in schools with substantial professionally oriented teacher cultures. Such school cultures may aid teachers in orienting their professional activities beyond the boundaries of the classroom, which in turn, as we have seen, may move them towards a more constructivist practice.

PART 3: TECHNOLOGY AS A TOOL FOR REFORM

We now turn our attention to the relationship between computer use and the types of teaching practices we have been discussing.

Many people believe that technology can be a critical component of a constructivist-compatible teaching practice. This is because technology provides students with almost unlimited access to information with which to test ideas against facts, it can facilitate communication and interaction with people whose knowledge and opinions are relevant to student inquiry, and it provides students with tools to help them both articulate ideas and to communicate them to audiences who may profit from their understandings.

Although our analysis of our survey data on this issue is not complete, we can present what we do know now about the relationships between teachers’ use of computers and their pedagogy—their teaching methods more generally. We present four of our findings here: the relationship between amount of computer use and constructivist pedagogy; between the

importance that computers play in a teacher’s practice and pedagogy; between the types of software programs a teacher uses and her basic pedagogy; and between a teacher’s use of computers and her perception that experiences with computers have affected her pedagogy.

Extent of Use With Students and Constructivist Practice

Overall, teachers who had each of their students use computers on more than 5 occasions during the year have a more constructivist pedagogy than those who did not. Those who never had students use computers are the least constructivist of all.

The differences can be seen most clearly when we look at the information provided by teachers of specific subjects. First we took all of the information about teaching practices (about 20 different survey items) and combined it together into a scale going from the most skill-and-knowledge transmission-oriented practice at one extreme to the most constructivist at the other.

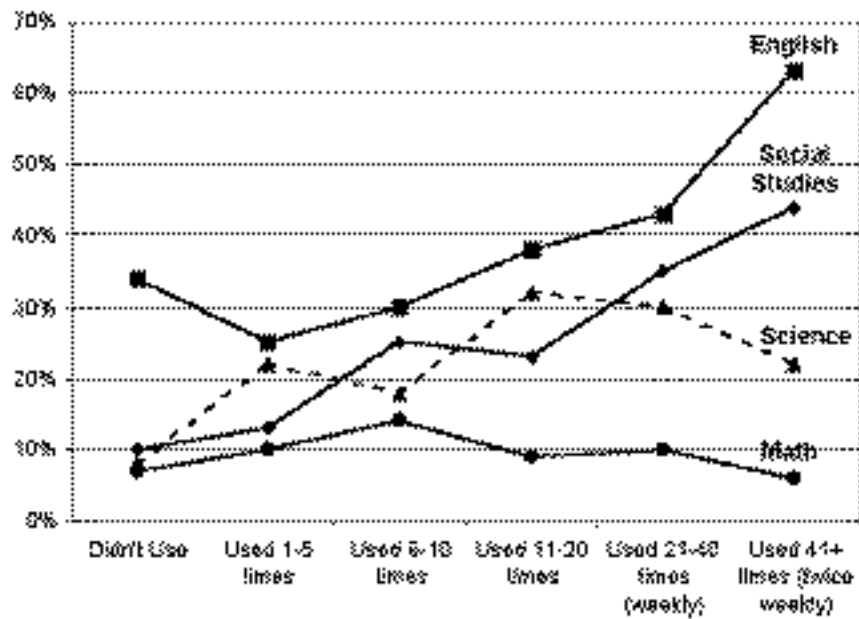
Then we divided teachers into four groups representing a strong transmission (traditional) orientation (28% of all teachers), a mixed orientation leaning towards traditional practice (25%), a mixed orientation leaning towards constructivist practice (25%), and a strong constructivist practice (22%). Then we looked at how the proportion of teachers who belong to this last group (strong constructivist practice) changes according to how often they had students in their “selected” class use computers during the year. (They chose their “selected” class as the class where they most often accomplished their teaching goals. It doesn’t necessarily mean the class with their most accomplished students, though that class was often chosen.)

Figure 1 below shows how this percentage (percentage in the ‘strong constructivist’ category) changes as one moves from teachers who did not have students use computers at all to those who had students use it on more than 40 occasions (for example, twice each week or more). Each line represents secondary teachers of one of the four main academic subjects—English, science, social studies, and math. Elementary teachers are not included in this figure.

The figure shows that among secondary English teachers and social studies teachers, and somewhat among science teachers as well, the more that teachers used computers the more likely they were to be in the ‘strong constructivist’ category. For example, among social studies teachers, those who didn’t have students use computers or who used computers only rarely (1-5 times), only about 10% of such teachers were ‘strong constructivists.’ About 25% of the social studies teachers whose students used computers 6-10 times or 11-20 times were ‘strong constructivists.’ That percentage rose to 35% among the 21-40 times per year users (roughly once per week), and to 44% among those whose students used computers even more often.

The differences among English teachers are just as dramatic except that those who had students use computers very little or not at all were fairly constructivist even so. There were similar differences among science teachers, except that those who had students work at computers a great deal (more than 40 times) were not as constructivist as those whose students used them moderately often (11 to 40 times). And for math

FIGURE 1: PERCENT OF TEACHERS IN THE TOP QUARTILE OF CONSTRUCTIVIST PRACTICE BY FREQUENCY OF COMPUTER USE



teachers, there is no relationship at all—few of the math teachers were in the ‘strong constructivist’ category, regardless of how often they had students use computers. It should be pointed out that the use of graphing calculators was not part of this study at all.

This pattern suggests that for most of the academic subjects in secondary school, computers represent an important set of tools and resources for teachers to implement a constructivist pedagogy in their teaching. In other analyses not shown here, we confirmed this point by showing that English, science, and social studies teachers who have constructivist *philosophies* are more likely to be strong constructivists *in practice* if they also use computers at least weekly with their students.

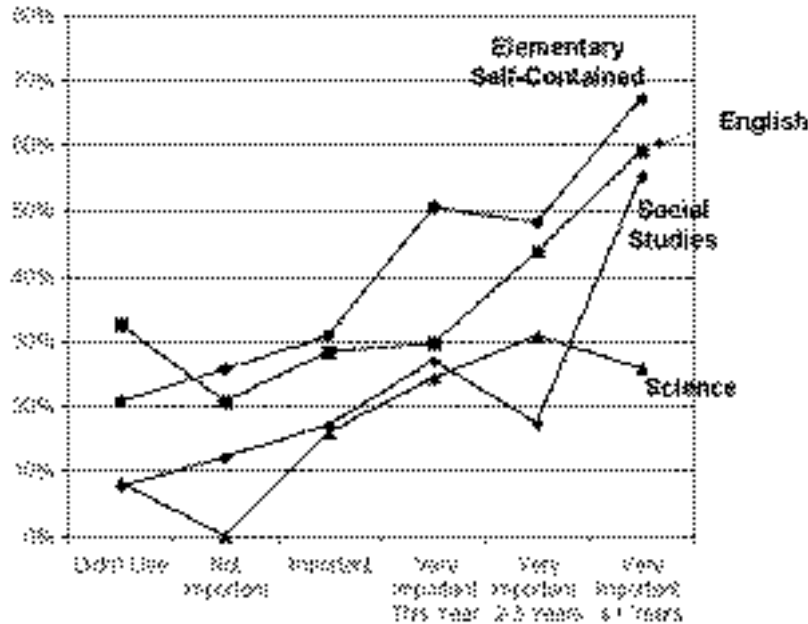
Perceived Importance of Computers in Teacher’s Practice

Frequency of use may not be the best measure of the effects of computer use on a teacher’s overall pedagogy. Frequent use may merely represent, from the teacher’s perspective, a comfortable and routine use of time and not

necessarily a significant vehicle for accomplishing the teacher’s most important teaching objectives. So we also examined the relationship between constructivist practice and *how important* a teacher believed computers were in his or her practice—and, if “very important,” for how long the teacher regarded computers as very important to her practice.

We found that the more important teachers regarded computers in their practice, the more likely they were to be strong constructivists. The biggest differences were between those who felt computers to be “very important” in their teaching compared to the ones who believed computers to be merely “important.” Figure 2 shows the pattern for secondary English, science, and social studies teachers, and for elementary teachers of self-contained classes. (The pattern for math teachers was, again, fairly flat.) In general, for these four important groups of teachers, the more important computers were regarded in their practice, and, in particular, the longer they had been regarded as “very important,” the more likely the teacher was to be a strong constructivist.

FIGURE 2: PERCENT OF TEACHERS WHO ARE STRONG CONSTRUCTIVISTS BY BELIEVED IMPORTANCE OF COMPUTERS TO THEIR PRACTICE



Moreover, among the English, science, social studies, and elementary teachers who have a constructivist *philosophy*, those who regarded computers as very important were more likely to be strong constructivists in practice than those with a similarly constructivist philosophy who did not value computers in that way (54% vs. 31%). In addition, those who had regarded computers as very important for at least the past four years were the most likely of all to be strong constructivists in practice (65%).

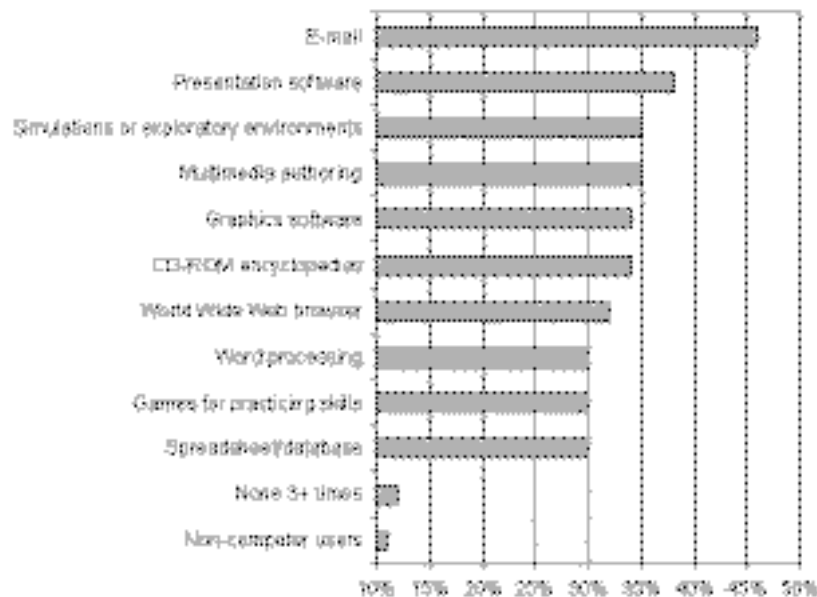
Types of Software Used and Constructivist Practice

Many people have pointed to the fact that computers are an almost infinitely flexible medium for instruction and learning. It is what teachers have students *do* with computers that suggests most clearly what their ambitions are for their use. We compared teachers who had students use different types of software (on at least 3 occasions) in terms of the proportion of those teachers who were classified as strong constructivists by their survey responses to questions about their teaching practice.

Figure 3 shows that by far the most likely to be strongly constructivist teachers are those relatively few teachers who had their students engage in electronic mail communication as part of their class work. Altogether, nearly one-half (46%) of that small group of e-mail using teachers (who constituted 7% of all teachers) were strong constructivists.

Although there were some differences among teachers according to which other types of software they had students use, the differences were relatively small. Even 30% of teachers having students use computer games for practicing skills were strong constructivists. The reason is that most of the teachers who reported at least occasional use of skill-game software also had students use many other types of software as well. If we limited ourselves to teachers whose students *only* used skill-based game software or at most one other type of software, only 18% would be in the strong constructivist category. But in Figure 3, the largest difference is between teachers using any of these types of software on at least an occasional basis versus those who reported using computers in a limited way or not at all.

FIGURE 3: PERCENT OF TEACHERS USING CERTAIN SOFTWARE IN 3 OR MORE LESSONS WHO ARE IN TOP QUARTILE ON CONSTRUCTIVIST PRACTICE



Computer Use and Recent Changes in Teaching Practice

Computer-using teachers report more changes in their teaching practice in the past three years than non-users. Computer users were about twice as likely to report an increase in the frequency of constructivist practices (such as being taught by students, handling multiple simultaneous activities, assigning long projects, giving students more choice of tasks, and using interdisciplinary content). In addition, when asked what their reasons were for making these changes, most of the teachers who had changed most clearly towards constructivist practices indicated that their experiences with computers played at least a “moderate” role in those changes, and one-fourth of those teachers said computers were a “major reason.”

In this group of budding constructivist teachers, experience with computers was fourth most-often named as a major reason, behind changes in their main goals for students (30%), changes in their understanding of how learning and understanding take place (29%), and staff development and workshop activities in which they had participated (26%). Computer experiences were more often mentioned as an important reason for their changed practice than discussions with colleagues at school or with other people, changes in textbooks, changes in district policies and expectations, changes in their school’s climate or emphases, changes in their teaching responsibilities, or changes in the types of students they served.

PART 4: A BEGINNING LOOK AT REFORM PROGRAMS AND HIGH-END TECHNOLOGY SCHOOLS

One of the unique features of our study is the effort we made not only to study a representative sample of U.S. teachers and schools, but to pay special attention to schools that are making major investments in computer technologies and schools that are participating in major programs of school reform that have been developed around the country.

In an analysis that has just begun, we are examining the high-end technology-present schools and the reforming schools more closely and comparing each of them with the nationally representative sample. The reform sample itself consists of two groups, schools whose reforms do not particularly emphasize technology versus schools involved in reforms where technology plays a highly visible role. Both types of reform programs also differ according to whether they are schoolwide, department-specific (e.g., a math program), or just involve a single individual teacher participating through their own classroom instruction. These analyses are quite tentative, based only on a preliminary examination of the survey data, but it is an analysis that employs statistical procedures to

control on extraneous differences between these various groups of schools that might otherwise interfere with the making of appropriate conclusions.

Teacher Pedagogy: We are finding that pedagogy in schools participating in schoolwide reform programs is somewhat more constructivist, on average, than in the nationally representative schools. However, both representative school faculties and those in schoolwide reform programs look similar compared to the very strong constructivist pedagogy of individual teachers who participate in reform programs that focus on single teachers rather than whole schools. On the other hand, the individual-teacher-focused programs themselves exhibit no discernible spillover in pedagogy from the individual program participants to the other teachers at their own school. Thus, when measured in school-level terms, only schoolwide reform appears to be having any impact at all.

Technology Resources: Individual program participants tend to make greater use of

computer resources than other teachers at their own school, regardless of whether their school's programs emphasize technology or don't. Moreover, individual teachers who participate in reform programs have objectives for computer use and patterns of use that are primarily constructivist. However, teachers in schools involved in schoolwide reform that don't emphasize technology do not use computers very much nor do they have very constructivist objectives for their use. The problem is simply that the high cost of the other elements of schoolwide reform leaves very little money available for computers or for the development of teachers' understandings of how to use computers to fulfill reform goals—except in those programs where technology is explicitly emphasized. Without that explicit emphasis, educational technology is not likely to be a facilitator of constructivist pedagogy, except in those reform settings that involve only an individual teacher or a small handful of program participants.

High-End Technology Schools: Interestingly, the teachers in schools we studied that had a great deal of technology (relative to the size of the school) but which were not part of reform programs were still rather constructivist in their approach to using computers. Because of a high level of technology presence, teachers in these schools actually implemented a relatively constructivist program with their computers, despite the lack of a formal program providing a theoretical basis for instructional reform.

FORMAL REPORTS AND OBTAINING ADDITIONAL FINDINGS

This *Report to Participants* has contained initial findings related to central aspects of this research—teachers' pedagogy and how their experience with computers has affected it. Further detail on topics covered in this *Report to Participants* can be found in Teaching, Learning, and Computing's completed reports: Report #1 - *Internet Use by Teachers*, Report #2 - *Computer Presence in American Schools* and Report #3 - *Computer Use by Teachers*. These

reports can either be ordered by mail or downloaded for free from our web site: <http://www.crito.uci.edu/TLC>.

The large variety of information provided by teachers, technology coordinators, and school principals in responding to the Teaching, Learning, & Computing survey will enable many other research studies to be accomplished over the coming months. Future studies will provide information in greater depth on

- Computer use and pedagogy in each subject area
- How schools are approaching staff development and support for teachers' computer use—and how that relates to teachers' opinions about and use of computers
- School technology investment allocations between hardware, software, and support for teacher users—and whether and how such decisions impact computer use
- School contexts and personal background factors that influence teachers' use of computers—in particular, differences between teachers with a classroom orientation versus a collegial orientation and the effects of a professional climate
- Computer use and pedagogy in reform and high-end technology settings
- Principal and teacher judgments concerning the value of computer technology, including judgments about the most useful software
- Differences in computer use between Macintosh and Windows users
- Changes in pedagogy over time.

Most of these topics will also become formal reports also available on the web site listed above. Also available on our web site are snapshots of recent findings as well as a discussion forum for greatly appreciated comments and questions.