

Teachers' Views of Computers as Catalysts for Changes in Their Teaching Practice

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Abstract: In this study we examined the use of computers by teachers in their instructional practices and their perception of the impact of computers on changes they have made to their classroom practice. These data draw from 47 teachers from 20 K-12 schools across 3 states who each completed a questionnaire, participated in 3 semi-structured interviews, and allowed 3 observations of their classroom. The teachers who had adopted more progressive teaching practices over time felt computers helped them change but they did not acknowledge computers as the catalyst for change. Instead, they cited catalysts that included: reflection upon experience, classes taken, and the context or culture of the school. We conclude that in order for teachers to implement the use of educational technology in a constructivist manner, they must have opportunities to construct pedagogical knowledge in a supportive climate.

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Teachers' Views of Computers as Catalysts for Changes in Their Teaching Practice

Many educators and policy makers believe that technology can be a catalyst for educational reform (Collins, 1991; Means, Olson, & Singh, 1995; Mehlinger, 1996; Newman, 1992; Sheingold, 1991). They suggest that the use of technology in classrooms will shift the roles of teachers and students. Teachers will act more as facilitators by helping students access information, process it, and communicate their understanding. However, not all teachers who use technology in their classrooms employ it as a tool.

The research on technology-using teachers characterizes different ways teachers employ technology in instruction (Becker, 1994; Hadley & Sheingold, 1993; Honey & Moeller, 1990; Means & Olson, 1995; Wiske et al., 1988). Data from this literature show that technology-using teachers range along a continuum of instructional styles from instruction to construction. In instruction, teachers conduct class in a teacher-centered way. They impart facts and procedural skills to students and integrate technology as a complement to this style. They employ it mainly for drill and practice. In construction or student-centered classrooms, teachers use tool software and information technologies to allow students to work in active ways. The technology supports the active learning; it becomes a tool with which the students may construct knowledge.

Longitudinal research from the Apple Classroom of Tomorrow (ACOT) project also reports this instruction-construction continuum. ACOT studies depict teachers' use of hardware and software as the first step in their evolutionary progress toward a constructivist orientation to teaching: "Gradually, new patterns of teaching and learning emerged at all sites. There seemed to be a predictable flow, a staged progression over time (Sandholtz, Ringstaff, & Dwyer, 1997, p. 34)." The ACOT reports also emphasize the role of teachers' beliefs in making this transition. The teacher's predisposition to the change is a factor that speeds up or slows down the inevitable reaction that occurs when technology is present as a catalyst of reform. However, conclusions that the change is a natural evolution may be due to the fact that the ACOT sites and teacher were selected volunteers. The entire ACOT project was oriented around its participants' interest in changing instructional styles, which is a premise not always present in schools.

Educational technology "popular" K12-oriented magazines are more technology-specific in their recommendations about how to operationalize technology as a catalyst of educational reform. They emphasize that providing access, technical support, and training is the key to successful educational reform via technology.

This literature is helpful in that it allows those who must plan for educational technology to form a typology of classroom uses of technology, to think of implementation in terms of gradual steps, and to see change in terms of years rather than months. Yet, the tendency might be to think of the characterizations of teachers along the continuum as the still life photos and the longitudinal ACOT research as the video, both illustrating the same change process. This makes the issue one of time. That is, given enough time, the variety of approaches to using technology will homogenize into a constructivist approach.

Re-conceptualizing Why Teachers Adopt the Use of Computers and Constructivist Practices

Largely absent in this discussion of teachers changing their instructional style and the role of technology as a catalyst in that process is a focus on the teacher and how he or she thinks and learns---

which many contend is the basis of a teacher's instructional style. Even granting that access, technical support, and training are important in the long, incremental process of implementing technology in a classroom, it seems that the educational technology field could benefit from examining how it might apply theory and research on the change process and teacher development.

Teacher as decision maker.

Shulman's work (1987) on teachers' professional knowledge explained how during planning and instruction teachers are constantly making decisions about how they teach. Teachers' experience and knowledge base also influence their decisions about the best course of action. Shulman characterizes teaching as a constant stream of decision-making points. Viewing teaching this way underscores teachers' agency when changing instructional approaches.

Teacher as Learner.

A focus on how a teacher learns and develops instructional approaches is also prevalent in the study of staff development (defined as the actions and processes school and district staff design to improve teachers' skills, attitudes, understandings, or performance). Fullan (1992) describes the relationship between staff development and successful implementation of an innovation as "intimate". He explains the relationship between the two in terms of "teacher as learner." For teachers to implement any new instructional strategy they must acquire new knowledge about it and then weave this together with the demands of the curriculum, classroom management, and existing instructional skills. Fullan depicts these points as features of a dynamic system, each a sub-cog turning and interacting with the teacher as learner, and all of this integral to turning the gears of the classroom and school improvement processes.

Change as a process of learning.

The perspective of the individual teacher is given special emphasis by several other researchers of the change process. They acknowledge the systemic nature of change but examine the process as one which is experienced by individuals. Loucks-Horsley's work with the Concerns Based Adoption Model (CBAM) establishes that the individual holds a "critical place" (Loucks-Horsley & Steigelbauer, 1991, p.17) in the change process. This research based model puts individual teachers and their concerns at the center of the change process and in so doing acknowledges the personal and developmental nature of any teacher's learning and adopting a change in practice. McLaughlin's (1991) research on staff development and teaching and learning extended and amplified key findings of the RAND Change Agent study. She notes the "instruction as observed in a classroom at any point in time reflects a teacher's response to many elements in the school and classroom setting---students, competing demands, instructional goals, norms, and expectations, to highlight just a few. Teaching practice is embedded in...the 'nowness' of the teaching context (p. 69)." She portrays teaching as a dynamic activity, and the teacher as the key to its coordination and success. Thus, for any proposed change to take hold, individual teachers must work through how it will fit with the other components of the system.

Schools as a social context for learning.

Some researchers of the change process focus specifically on the influence of school context and culture on individual teacher development. Hargreaves' (1994) emphasis on context and culture

begins with the premise that teaching is a kind of work. Thus, the demands of the job and the culture and context of the workplace structure teacher's tasks and relationships in particular ways. He casts any initiatives for innovation as issues of individual and social learning. Underscoring the political dimension of change, Hargreaves cautions that the political or administrative devices for bringing about an educational change might be out of sync with teachers' capacities or desires for change. Lieberman and Miller (1991) also connect individual learning with the social dimension. Their research on staff development led them to recommend that staff development be framed both as culture building and as a chance for a teacher to inquire into his or her own practice.

Constructivism as a model for a teachers learning and making instructional changes.

The model of learning as constructed knowledge clearly resonates with this research on teachers as decision makers, social learners, and active system participants. The constructivist model of learning emphasizes that new understanding results when a learner acquires and organizes new information; new learning shapes and is shaped by prior schema (Fosnot, 1996). Prior schema are shaped by the experiences and beliefs of the learner as well as the local context in which learner constructed the schema (Cole, 1996).

The constructivist model of learning along with teacher development literature suggest that classroom teachers, over time, construct knowledge about which instructional approaches produce the effects they desire. The change process literature adds that while culture and context create norms of teaching practice, in most schools this constitutes a range of teaching styles, not a narrow prescription. Teachers can choose, within these limits, the approach that works for them. This autonomy provides teachers choices to adopt, adapt, or reject an instructional reform (Fullan, 1991).

It is this literature about teacher development, the change process, and construction of knowledge which we brought to bear upon this study. We sought the participants' views of the new instructional practices that they had adopted in recent years, why they had made those adoptions, and the role computers played in making them.

Data and Methods

We collected these data as part of a preliminary study for a national survey of teachers' instructional beliefs and practices and their use of computer technologies. A team of researchers administered a questionnaire, conducted three semi-structured interviews, and made three observations in the classrooms of each participant, generally within a one- to two-week period during the spring of 1997. This report focuses on the responses made during the third interview by 47 teachers at 20 elementary, middle, and senior high schools. This third interview examined the use of computers in their instructional practices and their perception of the impact of computers on changes they made in their classroom practice.

School sites were nearly evenly divided among the three states of California, Minnesota, and New York. Participants had from one to over twenty years of experience and taught academic subjects in grades 4-12. We selected both traditional and reform-oriented schools. Most schools were selected on the basis of their reputation as technology-using schools. Principals within each school selected three teachers to participate based on their practices which ranged from traditional to highly innovative.

Participation was voluntary, and teachers were paid a modest honorarium for their participation that involved about five hours of time.

Interviewers followed a prescribed list of open-ended questions and recorded the interviews on audio tape. First, they asked teachers to describe their best and worst experiences with computers and the computer software they found most essential to their teaching. Second, they asked them to describe critical experiences that caused them to rethink how they went about teaching. Finally, they asked the teachers to comment on whether computers changed what they wanted to accomplish or helped them to make changes they already wanted to make.

Next, the first author transcribed the teacher interviews and analyzed them for statements indicating the classroom computer uses the teachers valued most. The types of uses and software employed by them were noted. The teachers' responses to the question "What are the major ways that you have changed as a teacher in the things you do in your classes?" and its subsequent probes were coded. We also analyzed and coded the teachers' responses to the interviewer's probes about what led the teacher to make changes and whether computers were related to these changes. Their responses to the direct question "Overall, would you say that computers have helped to change what you want to accomplish as a teacher, or have they mainly helped you make changes you already wanted to make, or haven't they had either of those impacts?" were also analyzed and coded.

Categories used to depict instructional styles.

In addition, the teachers were categorized by instructional philosophy according to their responses on a questionnaire, which contained over forty different subcategories of information about their valuing of socially-mediated learning, their goals for the development of students' higher-order thinking capability, and their strategies to make learning more meaningful to students. Their responses were validated by several measures including observation coding, interview coding, artifacts coding, completing the survey instrument "as if" the teacher, and summative coding. Then we combined these measures to obtain an overall score used to designate teachers as either "non-constructivist", "weak constructivist", or "substantially constructivist."

Non-constructivist. Non-constructivist teachers were those who believed that the primary objects of learning are the mastery of a set of skills, the recall of important facts, and the learning of discipline-valued abstract concepts through direct listening, reading, note-taking, and practice in the solving of related problems or exercises. They also believed that student work was motivated by reference to grades, recognition, or promise of some other future benefit.

Weak constructivist. Weak constructivist teacher's practices were somewhat distinct from traditional teaching. These teachers incorporated a greater-than-average focus on understanding concepts rather than merely automating skills or remembering facts, and made use of interpersonal processes as well, including discussion. However, the discussion might be led primarily by the teacher, and mainly as a recitation. Weak constructivist teachers might attend to motivating students through making classroom activities interesting and understandable, but the use of grades, recognition, or the promise of other future benefits were a strong undercurrent as well.

Substantially constructivist. Substantially constructivist teachers were those whose practices were sharply distinct from traditional teachers. These teachers frequently incorporated creative instructional practices, innovative interdisciplinary themes, individual or group projects of some complexity and duration, and content linked to student interests and/or personal concerns. The learner's depth of understanding was valued over external mandates for broad content coverage. These teachers'

practices reflected a belief that understanding is deep and long lasting when students are cognitively engaged with ideas that are personally meaningful.

The instruction of substantially constructivist teachers had a strong focus on having the students themselves formulate and investigate important, substantive questions. These teachers used collaborative learning arrangements frequently, and encouraged interactions between students and people in real-world settings beyond the classroom. They valued both types of interaction not just for their effect on student motivation, but because they promoted important cognitive activity through individuals negotiating their respective points of view and forming common understandings.

The assessment practices of substantially constructivist teachers incorporated complex and qualitative judgment, going well beyond fixed-choice, short answer paper and pencil tests. They also often involved the students in self-assessment and the assessment of each other. In leading the class, the substantially constructivist teacher focused student attention on the tasks themselves rather than on the rewards or benefits the students might expect from completing the tasks. These teachers regarded their role as facilitators of student learning, rather than as direct providers of knowledge, and often modeled for students by demonstrating their own learning processes.

We compared teachers' degree of constructivism against the codes we assigned to the uses of technology they valued, the changes made over the last few years of practice, and their report of the impact of the computer on making that change. The patterns that emerged from this comparison are reported in the next section.

Results

Constructivist Teachers

Thirty two out of the 47 teachers interviewed in this study were categorized as constructivists. Ten were categorized as substantially constructivist and 22 as weak constructivist. All 32 of the constructivist teachers used computer software for their own productivity (e.g. for grading and word processing). Thirty one used computers in class with their students. Of these, 25 indicated the software they valued most was tool software, such as word processing and multimedia authoring, and/or digital information sources, such as encyclopedias on CD-ROM and the Internet. Two teachers indicated that they valued most highly the use of grading or other productivity software for their own work, stating that limited access to technology made students' classroom use difficult. However, one of these teachers reported that occasionally he was able to gather together enough computers so his students could use them to produce classroom products. Five of the 31 teachers described instructional software (i.e. drill or educational games) as the prevalent use of computers in their classroom; 3 of these 5 teachers indicated that they also used tool software at times. Thus, most of the constructivist participants used, at least in part, progressive teaching practices and successfully integrated technology. This uniform pattern is somewhat predictable given the criteria for selecting the participant schools and teachers.

Those who imagine educational reform catalyzed by technology wish for the scenario these data provide: constructivist-oriented teachers using tool software and information technologies for their students' construction of understanding. If this is the sort of technology use and instructional approach that is desired, it is important to understand what these teachers felt brought them to these uses. The interview questions asking respondents to describe recent changes in their instructional practices and the role of the computer in making those changes provide some insight into this.

All of the 32 teachers categorized as substantially or weak constructivists said they had made changes in their practice over their years in the classroom. This change was to a more student-centered practice. When asked directly if technology had changed how they taught or if, instead, technology had helped them make changes they already wanted to make, 22 out of these 32 teachers indicated that it was the latter. Three teachers indicated that the computer both helped them make changes and changed what they had wanted to do. Three teachers either weren't asked or didn't answer this question. Two teachers indicated they had made little change to their instructional practices over the last few years. Only 2 of the 32 teachers indicated that the computer changed the way they taught. So while all 32 teachers had adopted more progressive teaching practices over time and nearly all felt computers helped them to make that change, they did not state that computers were the catalyst of their changed practice.

Instead, the primary reason was of internal origin and agency: change was the consequence of reflecting on teaching practice, its goals, and its efficacy. Nineteen of the 32 teachers categorized as constructivist cited themselves as the catalyst for change. A second reason, offered in combination with the first, had elements of internal agency and external origin: the teacher's learning in formal class settings. Although stated by a lesser number of teachers, 7 of the 32, and also mentioned in conjunction with experience and reflection on it, the third reason stood out because it was associated with the teachers who had the strongest constructivist leanings. They mentioned specifically a catalyst of external origin: schoolwide expectations and instructional emphases, such as performance assessment, or a new instructional focus adopted at their school, like cooperative learning. In addition to these three reasons, one teacher cited changes in learner readiness as a reason for changing how she taught, and 5 of the 32 teachers did not describe any cause of the changes they had made. The reasons for making changes in practice given by "non-constructivist" teachers is reported in a following section.

The next three sections explore the constructivist teachers' descriptions of what served as a catalyst for adopting constructivist-oriented practices and the role technology played in making that change. For the sake of clarity, these reasons are presented here as distinct; however, the teachers often mentioned more than one reason for having made changes. The teachers' remarks are categorized according to the most strongly emphasized reason.

Teaching experience and reflection upon it.

The most often mentioned influence on teachers' changed practices were insights about their own effectiveness, gained as a result of reflection. They described these changes as the obvious and gradual outcomes of their day-to-day work. As one teacher said, in struggling to articulate whether and why she had changed her teaching,

I think there have been some big changes. But in the last three years my general philosophy and practice have not changed. Well---they do, it's that I learn and that is reflected in my practice. I would say that sometimes the changes looked at over the last three years have been major but I can't point to a particular time. (Teacher 34.2)

Many teachers, especially those in their first ten years of teaching, spoke of their first year in the classroom as an epiphany. It was a time where they reexamined their beliefs about teaching and determined which would serve them as a foundation. Those teachers only a few years into their career remembered vividly the lessons they learned their first year and laughed about how, with the benefit of hindsight, they had originally viewed the job of teaching. One secondary teacher from New York could

remember well how her main classroom concerns had evolved and that this translated into a new understanding of her role as a teacher

My first year teaching...I really wanted to mix curricula together, and I had these really rambunctious, outrageous children; that really changed my view of what teaching was. I saw a need for discipline and classroom management and what a foundation that was. I had thought that with a curriculum foundation the kids would be fine, which was correct to a point, but I now find that management comes first. When that is done the curricula will really finish. When I first started teaching, I really just looked at the next year, or the final grade at the end of the year...now I look more long term. How will they do in college, picturing them in the future. Earlier on my philosophy was...I think I was just an information giver really. It was just what they needed to know and ...what they did with it wasn't really my concern. I didn't need to be concerned about it...I see my role now... I have multiple purposes...One is to be a standard keeper... not necessarily just giving information. They get information, but I have them much more active in the classroom. (Teacher 37.2)

The first few years of this teacher's career brought significant changes in her classroom practices. Some changes were oriented around management, and others were more instructional in nature. Later in the interview, she also described how an incident of cheating among students had resulted in her emphasizing character as a "background" to other classroom activities. She concluded by commenting on whether or not the computer had contributed to these changes, "I use the computers very minimally...They have just made things easier. Computers have not played a role at all." Her not attributing the cause of her changes to the computer is typical among this group of teachers. However, depending on the nature of the changes they had made, the computer was seen as a help to greater or lesser degree.

Another teacher, a secondary teacher from California, said the computer played a greater role in the changes he had made. As he described it, "[Computers] have allowed me to do what I am trying to do in a more efficient manner and bring what I want to bring to the class in a timely manner." (Teacher 16.1) He gave an example of technology aiding some classroom work. Like other secondary teachers, he wanted his students to have the skills that allow them to mentally play with the subject matter, both to think with it and to think about it, thereby doing the sorts of things he thought were important intellectually. The computer aided him in his approach to teaching. He explained how this approach changed as he learned from experience

Every year, yeah, I look into something different that is a shift in my teaching...Most things I change are over a period of time, gradual...Especially when it comes down to, What is more important, basic skills or knowing how to learn? I think I was leaning more to basic skills when I was first teaching. Now I am saying it has to be an understanding of how one learns. I always felt that intuitively but my focus from my student teaching and on through my first years was, Do I know enough? Do I know the grammar and curriculum? Now that is past me, I am certain that I've got it. Now I realize that that is really not the difficulty as a teacher. The difficulty is connecting and getting the kids to pull what you want pulled. I kind of understood that when I realized that it was not what we teach, as far as a subject...it is about teaching. It is not about the content specifically...[it] has shifted more and more to teaching kids how their brain works and how they organize information and re-utilize it. (Teacher 16.1)

His description of changes in his practice shows the deep thinking and gradual knowledge construction that resulted in his shifting his role as teacher. The computer was a tool he put toward this goal, not vice versa.

Another teacher, an elementary teacher from New York, found that classroom technology use was a strong support to her change. She had, in her first five years of teaching, gradually shifted her role to that of a facilitator:

I've changed dramatically...this is my fifth year...[now I am] giving kids a greater degree of control over their learning and you are kind of backing up and being a facilitator. Whenever I put myself in that situation I could see the motivation level going up and then the other problems that come along with teaching begin to diminish...[This is because I am becoming] more comfortable myself as being a facilitator and guiding the students along the way rather than directing them through the process of learning, over a period of time in terms of me letting go. (Teacher 31.1)

As an example of her new approach, she described a recent math lesson. While her students worked on computer activities of an exploratory, trial and error nature, she watched them process the information. This allowed her to gain information about their understanding and what they needed to learn. While she couldn't remember the name of the program she had used, she was fluent in describing how her students had used it. When asked how much of her change in goals and philosophy was attributable to computers, she answered,

I think I was on the road [to change]. But I think that the use of the computers, to some extent, facilitated making the transformation. That's an on-going process. The more exposure I have to computers, the more that I learn about different types of software, they [computers] have greater impact on making this change. (Teacher 31.1)

Her description of the computer facilitating, but not driving, the changes she made exemplifies the general attitude of teachers in this study. For her, using computers in support of her instruction took work; she did not view their use as pre-made solution. She described how she and the computer coordinator worked together to figure out how work in the computer lab might supplement what they are doing in class: "It is not like there is a written curriculum for the computer. We kind of put it together as we go along based on the needs of the students. Like I said, we try and connect it as much as possible to what is happening in the classroom." She concluded, "The computer definitely connects with the new philosophy that I've come to grips with."

Veteran teachers, too, looked back over their careers and recognized changes they had made. Although in general, the changes made and lessons learned were described much less vividly. Instead, they were seen as more slight and gradual improvements in established practice. For example, a teacher at a private K12 school in Minnesota in looking back over his career said,

When I started out I was insecure, and, as such, I wanted to dominate the classroom. I still believe that the teacher should be organized in the classroom, but I think that he can organize his classroom in such a way that there is a lot more student participation. The easiest way to control a class is simply to lecture and run through [the material]. In many ways the kids think that is a great education...But they are very, very, passive and they are not active...I've created activities and made the kids much more active rather than simply repeating the things that they are told. (Teacher 22.2)

Indicating that this change was the result of gradual learning more so than any critical incident, he went on to describe how computers had helped him. He told of recently using a computer simulation very successfully to teach about immigration in his social studies class. He felt the software had made a more realistic and fun simulation for the students to interact around and focus on as well as helping them to see the complexity and the grayness in the issue.

Some teachers were especially articulate in ascribing the change they made to their thinking and learning, not the computer's capabilities. A teacher at a K-8 school in New York said that when she started teaching, first she really loved imparting information to her students, but then added, "I am definitely trying to move toward having them discover as much of it as they can. That is hard." Computers, she went on to say, have had nothing to do with that change. Rather, she attributed this change in her general philosophy to her practical experience, her work with other teachers, and her increased insight into seeing how a child thinks. She then talked about the pressure put on schools to have computers. She felt that the value of computers was overrated:

It has been seen in a balanced way. It seems to be the gospel. If you get it from a computer screen or from television, it's gospel. Everyone thinks we should stick them in the schools because that will make us more competitive somehow, make children more competitive.... it is the big thing right now, but I think it will die down...It will become another tool that teachers will use...It is a matter of what you want to do. I've been on a computer since I was their [the students'] age and younger. It is not that I am uncomfortable with computers. I am wary of them being [promoted in the classroom] "just because." (Teacher 35.3)

While these remarks seem to de-emphasize the importance of technology, as the teacher continued her interview, she discussed the importance of computer and information literacy skills. She also related a story of how one particular student's use of computers affected that student in dramatic ways and that this had helped her realize the usefulness of employing different learning modalities for different students: "It has helped to achieve goals. Especially for kids who need that, who feel more comfortable writing on the computer than they do by writing it by hand. In the presentation of what they know, [and] what they've learned, it has opened up new ways for them to show it."

The many teachers who, on the one hand, saw themselves as driving the changes they had made and, on the other hand, acknowledged that computers and network technologies had made many of these new opportunities possible, did not seem to see this as a contradiction. Instead, as this next teacher from Minnesota explains, they saw decisions to change and the support computers can provide for those changes as evolving together:

I still believe in teaching the basics. I still believe in individual attention. However, over the years, I have certainly come to do a lot more group things and pairings and that kind of thing.... I don't think I've changed much in three years.... I think I'm too old. I've taught too long. I mean you want the child to succeed, and you want to do what it takes to get them there. I think what they [computers] have done is that they have allowed us to use a new source for information which was not there before. So, the Internet or the encyclopedias which we didn't have before. Which came first, the chicken or the egg? I think they are more an add-on. They came in so you utilize them. As the technology comes forward you access it. (Teacher 21.3)

In other words, this teacher recognized the job she had to do and chose the latest tools with which to do it. She continued, attributing changes she had made to "my own education: hearing things, reading things, observing other teachers and seeing successes."

Like the other teachers in this study, the reasons this teacher gave for the changes she had made did not derive from any one source as the right way to teach. Rather, for all of them, their ideas about best teaching practices were a combination of the possibilities they were exposed to, the expectations placed upon them, and the sense they as individuals made of all of it. For most of these teachers the computer helped them to do a job they felt needed to be done. Their computer use stemmed from decisions about how to teach, not from hardware or software capacity.

Formal learning experiences.

Three of the 32 constructivist teachers indicated that their impetus for teaching with computers came from a formal learning experience. Although mentioned in conjunction with learning from experience and reflection upon experience, this impetus is distinct from the previous reason in that, while the changes were ultimately made as a result of the teacher's decision, the catalyst for the change was external to the teacher---information presented in a formal learning experience.

One of these teachers, an elementary teacher from California, described college course work as influential on her instructional approach. During her master's degree program she learned how computers could keep students "involved and interested." She continued to learn about additional programs through her yearly involvement with a local university's summer institute. She made it clear that it was not just the computer in general that she found helpful in her teaching practice but specific programs that she deemed the right kind.

Another of these three teachers, a Minnesota junior high science teacher, described how he gained his expertise in project-based science pedagogy during his college course work.

I spent a couple weeks on a project at Boston U learning to use computers and teaching science and that strengthened my thinking that I was doing the right thing [by teaching in this style]...Computers were a big part of that course. You learned how to do new science and use the computer as a tool. That is where I got the idea for the interactive log [on the computer] with the kids...My belief is a little stronger that science should be more hands-on based. The technology can help to make that more of a rigorous way [of doing hands-on science] than without it [the technology]. (Teacher 23.3)

Because this science teacher had been given an experience where the computer assisted an instructional style that he believed in and because this style was further reinforced at his school setting, teaching science with computers in a project-based style seemed a sound decision.

What these teachers' responses suggest is that carefully crafted learning experiences can help teachers construct knowledge and thus serve as a catalyst for further growth. It also illustrates that the new practice must fit in with other elements of context and culture in the teacher's workplace.

Schoolwide expectations and instructional emphases.

Teachers are generally regarded as independently practicing professionals. They make the day to day decisions about specific instruction and assessments to use in their classrooms. To be sure, they work under prescriptions provided by district curriculum plans, and they are limited by textbooks and other resources to which they have access. But they are subject to relatively infrequent observation or other assessments. So when teachers report the influence of a schoolwide emphasis on how they teach--particularly when the teachers were influenced toward constructivist practices---it warrants special examination.

Among the 10 teachers who were most oriented toward constructivist practices six of them indicated that the instructional climate in their school influenced their change toward more student-centered practices. Two schools, both in New York state, stood out in particular because five of these six teachers taught at them. At one school all three teachers and at the other school two of the three teachers specifically mentioned the schoolwide leaning toward constructivist approaches to teaching and learning as a major reason they employed such practices.

At one of these schools, a teacher described the manner in which the school's expectations and emphases influenced her internal decision-making processes. She had transferred from a school that focused on preparing students for the New York State Regents high school graduation exam. She explained how her new school reoriented her science teaching toward helping students see the connections among science concepts. Essentially, this school gave her permission to teach in a way in which she was philosophically in sync.

Since I've come here, everything has changed. But not necessarily my philosophy, just what I am able to do. I wasn't as comfortable with the hands-on [approach to science] before...now I am and I really see benefit in it. At first I didn't realize how useful it was and now I do...When you are teaching in a Regents-oriented school, you still kind of have that goal whether you want to or not. You do want them to pass the Regents [exam]. That has completely changed...With the [school's emphasis on hands-on] science, you want them to really understand it and put it in to use...That's what I really look for, the connections. (Teacher 33.1)

This science teacher did employ computers in her classroom; she described that she valued access to them in terms of the schoolwide emphasis on exhibitions, a performance assessment approach. "[The impact of computers has been]... for their exhibitions. It is important that they type them. That has affected that. I've used the computer myself for teaching, using the Internet and everything. So that's made a difference. The computer has helped me reach my goals." (Teacher 33.1) For her, the value of the computer was cast in the same terms as her changed approach to teaching science. She wanted to align with the schoolwide emphasis on students working in-depth with information and then showing, through application, their understanding of it.

Another teacher from the same grade 7-10 school described how he now did instructional planning quite differently because of the school emphasis on student outcomes; he mapped instruction backwards from them. He discussed why he had to adopt this new approach to planning instruction: "At other schools, I had a mandated [math] curriculum. I didn't have to think about it [planning outcomes]; I had the outcomes already prepared for me. Then I just had to teach to that. So, my planning approach changed when I came here... it has been a learned process." (Teacher 33.3) This teacher believed his back-mapping approach to instruction was the most significant change he had made in all his years of teaching:

I used to teach in a traditional school for many, many years with teacher-centered lessons, teacher-dominated lessons---a very structured way with students sitting in rows. Six years ago I came to this school where all learning is project-based and the idea of the teacher being a coach is a much more important thing than the giver of knowledge,[the teachers as] the facilitator. It is hard. What you believe in theory, your own experience for many, many years, it is hard to change. And I have. In many respects it is like starting over. (Teacher 33.3)

For this teacher the catalyst for change was coming to this particular school. Clearly, the professional climate, created by his peers and the administration and shared by him, was influential.

The influence of this environment on the internal changes to his practice led to his use of computers in his math class. Some of his best experiences came having students graph programs to illustrate and support the ideas expressed in their project papers and use spreadsheets to calculate figures such as catenary curves. When asked if computers had changed how he taught, he replied,

It doesn't change the approach to teaching but it certainly enhances the experience... I think if you have a more traditional teacher and you utilize the computers in the class you might not automatically be more project oriented. I think we are already more project oriented here. As I see it, it enhances the experiences of students... I see computers as tools to be utilized and the [schoolwide curriculum] goals are the same as tools. We want students to think critically and to that extent the computers can help. They can facilitate not so much the thinking process as the implementation of the ideas. I see them as helping to achieve goals that we already have set for ourselves. No matter what the discipline here I think the ability to think for themselves critically is the most important thing. (Teacher 33.3)

Through a reference to his previous school site this teacher gave another example of how the school environment serves as a catalyst for using computers in a particular way.

There was one point in the early '80s when I did a tremendous amount of programming because the school I was in got a bunch of labs with PCs, and they said, "You are going to teach in there." I said "What software have you got?" and they didn't have any. So I and another friend did a lot of programming in BASIC. (Teacher 33.3)

While computers were available in both his former and his present school he used them in two very different ways. Both approaches were the result of his context; each school had made different software available to him and provided quite different expectations of how he should utilize it. His experiences are an example of the influence professional climate can have on a teacher's instructional practice.

At the other New York school where several substantially constructivist teachers mentioned a schoolwide instructional emphasis as influential on their making changes, a middle school teacher described how he came to incorporate cooperative learning techniques.

The major changes [in my career] were when I came here... But there were still some earlier in my career in that I saw a need to have students interact... That foundation, not solidly developed, was built upon in that the teaching styles here, in most instances, afford that kind of learning environment. Most of the staff members as well as the director were instrumental in getting me to move ahead full-fledged into a cooperative learning environment... Early on [in my career] I was much more focused on factual, rote type of learning. I expected the students to learn a body of knowledge, I really didn't care very much about the interactive process under which they got learning ... now I think there is knowledge that has to be gotten, but I think that [in addition] ... there is a wide range of social, interpersonal learning [as well]. (Teacher 32.1)

This teacher's willingness to incorporate cooperative learning into his pedagogy was directly influenced by its emphasis in his school setting. This emphasis also influenced approach to using technology.

The use of computers [allows] the idea that research and presentations can be done, cooperative learning can be expanded upon. When it comes to creating something like the multimedia [projects]... it is using the computers [that is]... allowing them to interact... to

contact others...to produce a piece where different students would be inputting different components for that final product. (Teacher 32.1)

He describes here the uses of computers as the more recent and minor change that supported his major change of incorporating cooperative learning techniques. For this teacher, the schoolwide culture set the tone for how technology was useful to him.

It is notable that six of the ten teachers with the strongest constructivist orientations described schoolwide shared goals as the most influential factor on recent major changes in their practice. It is also important to note that they valued computer use that specifically supported the schoolwide goals. As in the previous sections, these teachers explicitly described the technology as helping them only to make changes they already wanted to make. For this group, the catalyst for their instructional changes was the professional culture of their school. As a first year teacher at one of these two New York schools said, "The reason I wanted to teach in...[this] school so badly was because of my student teaching experience here last year. I felt like our philosophies were totally in sync...I can't imagine that my philosophy will change—especially surrounded by people who share my philosophies." (Teacher 32.3)

Non Constructivist Teachers

However, out of the 47 teachers interviewed, 15 were categorized as non-constructivist. These teachers also indicated they had made changes in their instructional practices over the last few years. The reasons they offered for doing so were the same reasons offered by the teachers more oriented toward constructivist practices.

Six of these teachers indicated that they had learned from their experiences and their reflection upon them. They had made changes such as a greater emphasis on teaching students how to work together and teaching them independent research skills. Three other teachers of the 15 indicated that, as a result of their students' lower readiness to learn, they had made changes such as making lessons simpler or more focused, or instituting an accountability system for homework. Another 3 of the 15 made a change because of something learned in a formal learning experience. For example, one teacher implemented a new approach to teaching reading as a result of a college class she had taken. Two others indicated simply they had made "not much" change to their instructional practices over the last few years. One teacher did not answer this question.

Summary

What did this study tell us about computers as catalysts for these changes? Across the board, teachers made it clear that the computer was not an automatic catalyst toward more constructivist practices. Instead, they offered a variety of reasons for changing practice. A pattern stood out past the midpoint in the rank ordering of teachers by overall constructivist scores and towards the constructivist end of the continuum (the midpoint included the fifteen teachers categorized as non-constructivist as well as seven weak constructivist teachers). The only catalysts offered by teachers past this mid-point were reflection upon experience and schoolwide initiatives or programs as catalysts of change.

Because teacher reflection is often associated with promoting change, it is important to note that reflection on experience was not exclusive to either extreme of the non-constructivist to constructivist continuum. It was not a de facto catalyst for constructivist practices. Reflection can apparently influence teachers to change their practice in a variety of directions. For teachers who indicated that they adopted

a more constructivist teaching style because of experience and reflection upon that experience, we can only infer that their reflection was perhaps somehow influenced towards valuing more constructivist practices. This inference is somewhat supported by the fact that the most constructivist-oriented teachers in this study explicitly stated that the schoolwide initiative or program which triggered the changes they made had been crafted to promote a constructivist view of learning.

Conclusion and Recommendations

The participating teachers' agency was evident as they discussed the changes to classroom practice they made over the last several years. They saw themselves as having made decisions about how best to teach. Their experiences, local circumstances, and needs influenced the changes they decided to make and the approaches they decided to take. They made it clear that their changes in instructional approach were the result of thoughtful reasoning. We could describe this thought process as their construction of knowledge about what "works" and doesn't work in the classroom. These data suggest that experiences in the classroom, reflection on those experiences, and the professional culture of a school influence this knowledge construction process.

Viewing the current practices of teachers as socially constructed knowledge, and noting that any new practices would be influenced by social environment and culture, prior experiences, and schema, raises many questions about the nature of a catalyst and the limits of its influence. While this study does not address all those questions, it does suggest strongly that there is a need to revise the image of computer as a catalyst for changed instructional practice. A simplistic view of computer as catalyst of instructional change is misleading because it disregards what we have learned about teacher development and the change process. Specifically, it underestimates the impact teachers' beliefs have on how they teach, it simplifies the process of how teachers develop and learn professional knowledge, and it diverts the examination of how social norms and structures might support or contradict a proposed change.

Instead, to understand the role computers play in changes to instructional practice, we should draw upon what is already established in the study of teacher development and school change. We should frame teachers as agents of change, in need of a supportive context. If we view teachers as agents of change (and thus the main catalysts for change) we will recognize that using computers in the classroom in a constructivist manner is a teacher's decision. To make this decision teachers will draw upon their knowledge and expertise of what works in the classroom. In order for that knowledge to include the use of computers, teachers must have opportunities with computers, modeling of how they work in instruction, and opportunities to reflect on their, and the computer's, role in the learning process. In other words, they must be allowed to construct knowledge about educational technology. In this case, the school context plays a key role: It is in the workplace that the models should be situated, the opportunities for learning provided, and the positive reinforcement and support nurtured.

A supportive context with rich professional development experiences and a professional culture that encourages reflection and trying new approaches will produce the learning necessary for technology use to become a part of a teacher's decision making. This does not diminish teachers' basic need for access to technology, technical support, training, and time to learn. It merely frames these needs in the larger context of factors conducive to a teacher's learning to teach effectively with technology.

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