Powering Up: Supporting Constructivist Teaching with Technology

Eileen M. Coppola
Center for Education
Rice University
6100 Main Street
P.O. Box 1892, MS-147
Houston, TX 77252
ecoppola@rice.edu

Keywords: constructivism, professional development, school organization, teacher learning, administration

Presented at the National Educational Computing Conference, June 28, 2005, Philadelphia, Pennsylvania.

Virtually everyone agrees that computers offer amazing new possibilities: they are powerful tools that make our work more efficient, perhaps richer or more comprehensive, often more fun. As each year passes, computer technology becomes smaller, cheaper, more mobile, more colorful, more user-friendly, and more powerful. Sometimes new technologies offer possibilities we'd never considered, changing the very content and output of our work.

Yet, the use of computers in for K-12 education, after so many years, still lags far behind its uses in other areas, and sadly behind the visionary possibilities for it. Despite the development of ever more powerful technologies in smaller and smaller packages; despite the ubiquity of the Internet and email, advancements in graphics software and the development of excellent educational tools and simulations; despite the fact that the desktop computer first arrived in schools over 20 years ago, educational leaders find it very difficult to figure out how to take a vision of computer use in schools and make it a reality. Where computers are used, they are often used to give tests or as an electronic textbook. They may be used for Internet searches, but the fact of using a computer for research does not imply the student has learned much about doing research. Word processors may be used as typewriters but not in ways that leverage them for the revision process. It is far easier to use computers superficially than it is to genuinely intertwine them with curriculum and pedagogy. Taking full advantage of the possible uses of computers is mostly a problem of capacity: the capacity of the teachers to use them for teaching, and the capacity of the school and district to support those teachers and their students in classrooms.

This continues to be a very complex and slippery problem. We would be hard-pressed to find a principal or superintendent who would not like to see computers better used in his or her school or district. A critical question then, is how teachers will learn to use the computers for teaching, and how schools and districts can help them learn to do it.

I offer a set of caveats and recommendations for leaders who wish to understand the dynamics of computer use that supports high quality teaching. These are based on a year-long case study of teachers' learning and the organizational dynamics of a school where computers are used well. Within this large, public high school, which I call "Woodland High School" (WHS), I focused my research on five teachers of different subjects who had thoroughly integrated computers into their student-centered, project or lab-based, largely constructivist teaching styles. First, I explored how they learned to do the teaching they did, then analyzed what it was within their school organization and policy environment that allowed them to do it.

These teachers were successful in having students create complex web pages to represent knowledge in the Classics: Greek history, literature, and language. They used simulations to teach market economics and Newtonian physics. They helped students learn to write by setting up a writing lab that made good, but not exclusive use of computers. They taught how computers can be used as tools in a business, for everything from marketing to payroll accounting. They were not teachers who were asked to mindlessly take software off a shelf and use it. Instead, they developed powerful and appropriate uses for technology based on their knowledge of their subject, their students, and appropriate pedagogical approaches.

From my own experience as a K-12 teacher, technology coordinator, administrator, and student of policy's impact on teaching, I have identified several scenarios – negative scenarios – which often impede school's best efforts to get good technology use going. Following that, and based directly on my research, I pose recommendations for leaders who are serious about creating organizational and policy environments in which teachers can learn to use technology for strong teaching.

Pitfalls: The Traps Schools Fall Into When Implementing Technology for Instruction

When the drive to get technology into instruction is too strong, several types of results can frustrate the successful marriage of quality teaching to new technologies. I label these: "cosmetic use," " the technological imperative," "romantic visions," and the "competition drain". These are common pitfalls: if you can identify a school as falling into one or more of these traps, it is unlikely that good computer use will grow and thrive there.

Cosmetic Use

Cosmetic use occurs when schools and teachers feel so pressured to use technology that they respond by looking like they are using technology. The show is not difficult to stage. The physical infrastructure of a computer lab or classroom is developed and students can be observed sitting at computers, even though there may be little or no actual instructional value in the work they are doing. Schools may develop whole networks, labs, and classroom computers that will be used infrequently except for a few teachers and students in a few class sessions. It is possible for schools, departments, and classrooms to put hardware and software firmly in place, yet use it in very limited and superficial ways. The pressures from communities, school boards, grant-making agencies, or administrators to use computers may be sufficiently strong that teachers make sure their students are sitting in front of the computers even when they know very little about what the students should be doing at the computers.

This type of thing often happens when administrators determine technological configurations from the top, an example of how policy mandates may not always translate into good practice. Requiring that all computers be placed one or two per classroom, or that all computers be placed in labs is a common strategy pursued by administrators who want to envision and plan for school wide or district wide use. The administrators are usually themselves under

pressure to make sure computers are used in teaching, so they come up with the best solution they know. In fact, neither the placement of the machines nor their use can be successfully mandated from the top. Teachers need to decide for themselves how computers should be placed, so that they can use them in a way that makes sense given the flow of instruction.

The Technological Imperative

In some schools, work on instructional technology becomes dominated by well-meaning people who are fascinated more by the technology than by the teaching. When this happens, the cart is leading the horse. An urgent sense arises in the school that as new technologies become available, educators should take advantage of them. So, when email becomes easy and accessible, everyone needs pen-pals from distant countries. As computers with strong graphics capabilities are introduced into schools, it seems that everyone should be doing PowerPoint presentations or editing videos. Conversations among adults hooked on the technological imperative tend to orient around new finds of trendy, cutting-edge hardware or software. The implication is that since it's new and amazing, it should be in classrooms. It seems as if new technological developments should be embraced, but, in fact such new developments are only as valuable in classrooms as their educational use is well-founded. The technology cannot drive instructional use: the instructional need must find the technology.

Romantic Visions

Romantic visions drive technology use when leaders entertain overly hopeful, very abstract notions of its possibilities. Some people believe computers can replace teachers, be more efficient than teachers, increase class size, decrease cost, and motivate students. I have always wondered how this would be possible. For example, a scientist friend who served on his local school board argued that by investing in computer technology, schools would be more efficient because technology had made business more efficient. This is a weak analogy, because children are much more complex as "raw material" than plastics or metal. At another time, a man from an education ministry in South America

approached me to ask whether installing computers in schools throughout the country would enable them to increase their class size from 40 to 70. The idea behind this was that the computers would do what no teacher could: motivate and guide the learning of 70 young individuals in a single classroom.

Competition for Access Drains Energy from Instruction

Finally, when access to computers is a struggle, the internal politics of the school come to the fore as faculty compete for scarce resources. The politics of competing for scarce resources will dominate, leaving little room for the careful, thoughtful work necessary to instructional design.

Since computers are expensive and computer use is valued in schools, gaining access to the computers can easily become a source of competition and micropolitical conflict. Where computer use is highly valued by administration, those who do it well gain status in the organization. Others can resent that status, engendering conflict among faculty. Subgroups often form which consist of users versus nonusers, creating an intergroup dynamic laced with competing values and assumptions. These dynamics may drain energy from the primary task of the school: to develop high quality instruction that leads to powerful learning for children.

The question, then is not simply whether computers are being used in classrooms, but how they are being used and to what ends. In my experience, pursuit of cosmetic use, the technological imperative, romantic visions, or the domination of politics often consume time, energy, and resources with few instructional results.

Findings from the Study of Woodland High School: The Dynamics of Learning and Organizational Support

From research and experience, I have found that the best way to help teachers learn about computers is to place the problem of pedagogy front and center, then support teachers as they explore ways that technology might strengthen their teaching. At Woodland High School, the teachers who developed robust, sophisticated methods for using computers were the ones who were continually trying to improve their teaching, and who sought resources to do so. These resources included new technologies, because they received support in obtaining and using the technology within their classrooms. Within limits set by course curricula and standards, these teachers did the difficult intellectual work of finding technological tools that work for them, trying them out in their classrooms, revising and polishing those lessons, and trying again. Through years of continual learning and revision, their teaching with technology came to be very powerful. However, the teachers were only motivated to do this difficult learning because they were allowed the flexibility to choose computer uses that made sense to them, as professionals, in the context of their classrooms – and in the context of their own prior knowledge. They found technologies that allowed them to solve problems they were wrestling with anyway: how do I help kids learn to revise their writing many, many times? How do I help students understand multidisciplinary links between language, literature, and history in the study of a society? How do I get students to address their misconceptions about the physical world to gain the often counterintuitive understanding of physical science? How can I simulate the free market, so that students gain a deep understanding of its dynamics?

The teachers' learning proceeded through a system of capacity building that combined a culture of professional responsibility with multiple, flexible opportunities for learning. Teachers were provided the time and money to attend professional

conferences of their choosing and encouraged to engage in professional networks which, at the high school level, were generally oriented to their particular teaching field. Norms and expectations that teachers would improve, which often required innovation on their part, were part of the culture of this school. The culture grew up over time, but for a teacher working daily in this school, it was clear that to win the respect of administrators, colleagues, and ultimately, the surrounding community, one needed to be serious about teaching. And being serious meant improving in response to the requests and needs of students and parents.

The teachers' learning about technology, then, was self-motivated and self-directed, and well-supported. The process led to quality teaching because it was authentic learning for teachers. Instead of merely looking like they were using technology, they engaged in the difficult process of intertwining new tools with their existing knowledge of pedagogy, subject matter, and curriculum – a truly constructivist process.

What about teachers who did not use technology in their classrooms? They are often classified as the "resisters," but, in fact, their reticence seemed reasonable. Some of them simply did not see how computers could help them do what they do any better; they did not see the value of computers for their teaching. I do not find it helpful to characterize such teachers as resisters. If an English teacher is considered excellent, well-respected within her community, is it vital that she use technology, too? If a history teacher is struggling with how to teach students to use the Internet for historical research, and remains unconvinced that it is more productive than books, perhaps he has a point. If the teacher is a good one, I found, he or she can easily defend the decision not to embrace computer use. If the teacher is not good, no computer will change that; the source of the improvement will come from new learning and motivation.

Other teachers who did not use computers had had negative experiences with access or support. When access to

computers does not fit with the flow of the class, they are especially difficult to incorporate. This most often happens when teachers are provided access to "labs" at a particular time. Does it make sense in terms of their curriculum? Does it make sense for all the students to be working on computers at that time? In other workplaces, aren't computers a tool ready to be used as needed? They also have experienced the frustration of needing support-on-demand in the classroom, and not having it. Such an experience is frustrating and humiliating for a teacher, who is clearly struggling with the new technology anyway. Problems may be encountered during a lesson, or even just before a lesson, as computers or networks crash and cannot be fixed prior to class meeting. In that case, an entire lesson plan has to be quickly revised. Teachers who have experienced uneven access and support often, quite sensibly, give up.

Recommendations

Out of this study, then, comes some advice for leaders on how to support teachers' work and continued learning about technology:

•Make technological and material support a predictable constant.

For the teachers using technology successfully at WHS, access to computers and stability of the technological infrastructure was a dependable feature of daily life. This meant that they had access to a satisfactory quantity of computers during class time (as defined by the teacher), that the computers worked almost all the time or were repaired quickly, that the networks for storage or internet access were stable, and that troubleshooting help was readily available. Though the system may not have been perfect, its essential stability meant that teachers could plan their lessons and, on most occasions, complete them without tripping over technological failure. It meant that they do not spend undue energy dealing with access and breakdowns, and it means that they did not have lesson after lesson fail to meet their and their students' expectations because of network outages or machine failure.

Having access and stability as a constant fuels teachers' commitment to developing uses for computers. It frees them to focus on the instructional aspects of the work, rather than jockeying for access, or readjusting plans because of breakdowns. Technological instability saps teachers' energy from the most important work at hand: creating high quality instruction. As professionals, their expertise is best employed when they are free to teach.

One of the great strengths of the organizational system at WHS when it came to promoting technology was that the infrastructure was so solid and consistently maintained that it was

accepted as a given. In a way, it faded into the background; it was usually not a primary concern. This allowed the teachers to focus on teaching.

The technology personnel treated teachers and students as their clients, working at their behest to support instructional needs. The goal of a school wishing to promote classroom computer use should be to provide technical support as a service to teachers and students so that teachers can focus their energy on what's important and what they do best.

•Accept that learning to integrate computers takes lot of time, and that the best uses will be locally created.

Teachers at WHS who used computers most successfully began using the machines during the 1980s. High quality instruction that takes advantage of computers as tools takes considerable time to engineer and refine. University professors who develop curricula and software that they transport to schools have certainly applied a lot of time and expertise to the instructional design. Adopting such a program, in partnership with university support may take less time than developing it within the school, but still the teacher must learn to use the program in his or her own classroom, and the program itself will require adjustments as it sees use with real students.

Faculty will require considerable time to learn hardware and software –– whether that software is curriculum-specific or a more general application. For example, a Social Studies teacher who would like to employ spreadsheets for data analysis in a sociology project has to learn basic hardware operation, the main concepts of a spreadsheet, the specific application available to the school, master advanced functions such as charting and graphing, figure out how the spreadsheet might fit into a project, develop the project, then structure lessons for students so they can learn to use the program well enough to analyze their research data. It's a lot of work and, without a large block of time in the school year to accomplish it, the most likely scenario is that a teacher will learn the necessary skills and develop a unit slowly over the course of several

years. This is what I observed in all five case studies of accomplished technology users at WHS.

•Understand that the best technology use will be rooted in sound pedagogy. Keep pedagogy front and center.

Technology added to a pedagogical approach that is unsound cannot produce good instruction. Computer-based technology –- or any other kind of technology –- cannot in and of itself improve instructional practice. If technology is added on to poor practice, the teaching will continue to be of poor quality. Some educators seem to believe that purchasing expensive software packages will supersede a teacher's incapacity in the classroom, or will introduce new, powerful instructional paradigms. This study clearly shows that teachers take curriculum resources such as software and create uses for them. Those uses tend to be extensions of the teachers' existing theory of teaching and learning. Each of the teachers in this study found possible uses for computers, and brought them into the classroom through a complex and creative process of rebuilding curriculum. The teacher is always the driving agent when it comes to quality technology use. In this study, the pedagogical theory held by the teacher drove his or her use of technology. Although in some instances, powerful technology-based curriculum or other experiences on the road to learning about the technology affected the teacher's thinking, it was always the teacher's agency that determined the quality of classroom use.

•Urge teachers to use classroom technology through expectations of high quality instruction, not requirements that they use technology.

From a teacher who is a dedicated professional, the commitment to bring an innovation into the classroom is of tremendous value to the organization. With that commitment comes the kind of intellectual focus, energy, and motivation to succeed that cannot be mandated. In this study, teachers committed to using computers once they were convinced they

would be a valuable tool for teaching. Good professionals will only adopt technology when they see a pedagogical reason for doing so. Once Woodland faculty were won over by its teaching value, they willingly undertook the extra effort required to learn about the technology and create uses for it.

Providing valuable technological and professional development on teachers who are not won to its purposes can mean wasting it. The norm of autonomy at WHS meant that teachers did not feel they had to pretend to adopt computers, but in many schools, an attitude towards innovation that stresses compliance may lead teachers to spend energy looking like they are using the computers, when in fact they are just going through the motions. True commitment means teachers will be focused on learning and creating high quality instruction. Seeming committed on the surface is not enough.

•Open the system. Accept expertise.

When it comes to technology, considerable expertise is likely to be found outside the school. A significant advantage held by Woodland's organization its "open systems" approach, which allowed many outside influences to seep through the organization's barriers. In practice, this meant that faculty and administration participated in a Teachers can make use of a wide array of professional activities from diverse sources, including universities, professional networks, participation on state and national level committees, conferences, workshops, and even part-time assignments. At WHS, this open approach was routine: information on opportunities was circulated, and taking advantage of the opportunities made easy because time and funding were provided. The administration did not attempt to determine the source of teachers' ideas and learning; instead, it supported learning from a very wide range of sources chosen by the teachers themselves. This attitude led to a very rich pool of ideas among the faculty.

•Finally, keep in mind that the best teachers are intellectuals.

To say that teachers at WHS were treated as professionals would be only part of the story. It is every bit as important to note that their intellectual life was lively, part of the day-to-day fabric of the workplace. These faculty were people who took their subject disciplines seriously, kept abreast of new developments, had opinions about them, and thought hard about their work in the classroom.

Material and cultural support for intellectual pursuits – serious learning-- among teachers fosters empowerment and creativity: the best of what they can give in the classroom. These are teachers who feel empowered to grow by developing innovative instructional approaches. They feel free to try them and revise them many times. Through the respect they receive for their own capabilities and learning, they grow into strong teachers, knowledgeable about their subject matter, how to teach it well, and where and how technology can add power to their work in the classroom.

References

Abelmann, C., Elmore, R., Even, J., Kenyon, S., & Marshall, J. (1999). When accountability knocks, will anyone answer? (RR-42). Philadelphia, PA: CPRE Research Report Series, University of Pennyslvania, Graduate School of Education.

Anderson, J. R. (1985). Cognitive psychology and its implications. New York: W.H. Freeman and Company.

Anderson, R. E., & Becker, H. J. (2001). School investments in instructional technology (8). Irvine, CA: Center for Research on Information Technology and Organizations, University of California, Irvine.

Ball, D. L., & Cohen, D. K. (1995). Developing practice, developing practitioners: Toward a practice-based theory of professional education (Paper prepared for the Commission). New York, NY: National Commission on Teaching and America's Future.

Becker, H. J. (1994). Analysis and trends of school use of new information technologies (Contractor Report). Washington, DC: Office of Technology Assessment.

Becker, H. J. (2000). Findings from the teaching, learning, and computing survey: Is Larry Cuban right? Paper presented at the School Technology Leadership Conference of the Council of Chief State School Officers, Washington, DC.

Becker, H. J., Ravitz, J., & Wong, Y. (1999). Teacher and teacher-directed student use of computers and software. Irvine, CA: Center for Research in Information Technology and Organizations.

Becker, H. J., & Riel, M. M. (1999, September, 1999). Teacher professionalism and the emergence of constructivist-compatible pedagogies. Paper presented at the American Educational Research Association, Montreal, Canada.

Bloom, B. S. (1956). Taxonomy of educational objectives: The classification of educational goals, by a committee of college and university examiners (1st ed.). New York: D. McKay.

Bolman, L. G., & Deal, T. E. (1991). Reframing organizations: Artistry, choice, and leadership. San Francisco: Jossey-Bass Publishers.

Borko, H., & Putnam, R. T. (1996). Learning to teach. In D. C. Berliner & R. C. Calfee (Eds.), Handbook of Educational Psychology (pp. 673-708). New York: Simon & Schuster Macmillan.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). How people learn: Brain, mind, experience, and school. Washington, DC: National Academy Press.

Brown, J. S., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-42.

Bruner, J. (1966). Toward a theory of instruction. Cambridge, MA: Harvard University Press.

Calderhead, J. (1996). Teachers: Beliefs and knowledge. In D. C. Berliner & R. C. Calfee (Eds.), Handbook of Educational Psychology (pp. 709-725). New York: Simon & Schuster Macmillan.

Census, U.S. (2002). Statistical Abstract of the U.S.: 2001. Computers For Student Instruction In Elementary And Secondary Schools: 2000-2001. Washington, E.C.: Congressional Information Service.

Cinnamond, J. H., & Zimphher, N. L. (1990). Reflectivity as a function of community. In R. T. Clift & R. W. Houston & M. C. Pugach (Eds.), Encouraging Reflective Practice in Education: An Analysis of Issues and Programs (pp. 57-72). New York: Teachers College Press.

Clark, C. M. (1986). Ten years of conceptual development in research on teacher thinking. In M. Ben-Peretz & R. Bromme & R. Halkes (Eds.), Advances of Research on Teacher Thinking. Lisse, Netherlands: Swets and Zeitlinger.

Cohen, D. K. (1987). Educational technology, policy, and practice. Educational Evaluation and Policy Analysis, 9(2), 153-170.

Cohen, D. K., McLaughlin, M. W., & Talbert, J. E. (Eds.). (1993). Teaching for understanding: Challenges for policy and practice. San Francisco: Jossey-Bass Publishers.

Cole, M., & Scribner, S. (1974). Culture & thought: A psychological introduction. New York, NY: John Wiley & Sons.

Collins, A. (1990). The role of computer technology in restructuring schools. In K. Sheingold & M. S. Tucker (Eds.), Restructuring for Learning with Technology. New York: Center for Technology in Education.

Cuban, L. (1986). Teachers and machines: The classroom use of technology since 1920. New York: Teachers College Press.

Cuban, L. (2001). Oversold and underused: Computers in the classroom. Cambridge, MA: Harvard University Press.

D'Andrade, R. (1995). The development of cognitive anthropology. New York: Cambridge University Press.

Darling-Hammond, L. (1995). Changing conceptions of teaching and teacher development. Teacher Education Quarterly, Fall, 1995, 9-26.

Darling-Hammond, L. (1997a). Doing what matters most: Investing in quality teaching. New York, NY: National Commission on Teaching and America's Future.

Darling-Hammond, L. (1997b). The right to learn: A blueprint for creating schools that work. San Francisco: Jossey-Bass Publishers.

Darling-Hammond, L., & McLaughlin, M. W. (1996). Policies that support professional development in an era of reform. In M. W. McLaughlin & I. Oberman (Eds.), Teacher Learning: New Policies, New Practices. New York: Teachers College Press.

David, J. (1990). Restructuring and technology: Partners in change. In K. Sheingold & M. S. Tucker (Eds.), Restructuring for Learning with Technology. New York: Center for Technology in Education.

Deal, T. E., & Peterson, K. D. (1999). Shaping school culture: The heart of leadership. San Francisco: Jossey-Bass Publishers.

Dede, C. J. (1990). Imaging technology's role in restructuring for learning. In K. Sheingold & M. S. Tucker (Eds.), Restructuring for Learning with Technology. New York: Center for Technology in Education.

Duffy, T. M., & Jonassen, D. H. (1992). Constructivism: New implications for instructional technology. In T. M. Duffy & D. H. Jonassen (Eds.), Constructivism and the Technology of Instruction: A Conversation (pp. 1-16). Hlllsdale, NJ: Lawrence Erlbaum.

Elmore, R., & Burney, D. (1997). Investing in teacher learning: Staff development and instructional improvement in Community School District #2, New York City (Report prepared for the Commission). New York, NY: National Commission on Teaching & America's Future.

Elmore, R. F. (1995). Teaching, learning, and school organization: Principles of practice and the regularities of schooling. Educational Administration Quarterly, 31(3), 355-374.

Elmore, R. F., & McLaughlin, M. W. (1988). Steady work: Policy, practice, and the reform of American education. Santa Monica, CA: The Rand Corporation.

Elmore, R. F., Peterson, P. L., & McCarthey, S. J. (1996). Restructuring in the classroom: Teaching, learning & school organization. San Francisco: Jossey-Bass Publishers.

Fullan, M. (1993). Change forces: Probing the depths of educational reform. Bristol, PA: Falmer Press.

Fullan, M. (1995). The school as a learning organization: Distant dreams. Theory into Practice, 34(4), 230-235.

Gardner, H. (1985). The mind's new science: A history of the cognitive revolution. New York: Basic Books.

Gardner, H. (1991). The unschooled mind. New York: Basic Books.

Geertz, C. (1973). Thick description: Toward an interpretive theory of culture, The Interpretation of Cultures (pp. 3-30). New York: Basic Books.

Glaser, R. (1984). The role of knowledge. American Psychologist, 39(2), 93-104.

Glennan, T. K., & Melmed, A. (1996). Fostering the use of educational technology: Elements of a national strategy. Santa Monica, CA: RAND, Critical Technologies Institute.

Goodlad, J. I. (1984). A place called school: Prospects for the future. New York: McGraw Hill.

Gordon, D. T. (Ed.). (2001). The digital classroom: How technology is changing the way we teach and learn. Cambridge, MA: Harvard Education Letter.

Grimmett, P. P., & Erickson, G. L. (Eds.). (1988). Reflection in teacher education. New York: Teachers College Press.

Grimmett, P. P., MacKinnon, A. M., Erickson, G. L., & Riecken, T. J. (1990). Reflective practice in teacher education. In R. T. Clift & R. W. Houston & M. C. Pugach (Eds.), Encouraging Reflective Practice in Education: An Analysis of Issues and Programs (pp. 20-38). New York: Teachers College Press.

Grossman, P. L. (1990). The making of a teacher: Teacher knowledge & teacher education. New York: Teachers College Press.

Hargreaves, A. (1993). Individualism and individuality: Interpreting teacher culture. In J. W. Little & M. W. McLaughlin (Eds.), Teachers' Work: Individuals, Colleagues, and Contexts. New York: Teachers College Press.

Holmes, H. W. (1937). Shall teachers be scholars? Cambridge, MA: Harvard University.

Honey, M., Culp, K. M., & Spielvogel, R. (1999). Critical issue: Using technology to improve student achievement (Vol. http://www.ncrel.org/sdrs/areas/issus/methods/technlgy/te800.htm): Pathways to School Improvement.

Huberman, M. (1989). The professional life cycle of teachers. Teachers College Record, 91(1), 31-57.

Huberman, M. (1993). The lives of teachers. New York: Teachers College Press.

Huberman, M. A., & Miles, M. B. (1984). Innovation up close: How school improvement works. New York: Plenum Press.

Johnson, S. M. (1990). The primacy and potential of high school departments. In M. W. McLaughlin & J. E. Talbert &

N. Bascia (Eds.), The Contexts of Teaching in Secondary School: Teachers' Realities. New York: Teachers College Press.

Jonassen, D. H. (1996). Computers in the classroom: Mindtools for critical thinking. Englewood Cliffs, NJ: Prentice-Hall.

Lampert, M. (1993). Teachers' thinking about students' thinking about geometry: The effects of new teaching tools. In J. L. Schwartz & M. Yerushalmy & B. Wilson (Eds.), The Geometric Supposer: What is it a Case of? (pp. 143-178). Hillsdale, NJ: Lawrence Erlbaum Associates.

LeBaron, J. F., & Collier, C. (Eds.). (2001). Technology in its place: Successful technology infusion in schools. San Francisco: Jossey-Bass.

Lieberman, A. (Ed.). (1988). Building a professional culture in schools. New York: Teachers College Press.

Lieberman, A. (1996). Practices that support teacher development: Transforming conceptions of professional learning. In M. W. McLaughlin & I. Oberman (Eds.), Teacher Learning: New Policies, New Practices. New York: Teachers College Press.

Little, J. W. (1981, April 13-17, 1991). The power of organizational setting: School norms and staff development. Paper presented at the American Educational Research Association, Los Angeles, CA.

Little, J. W. (1982). Norms of collegiality and experimentation: Workplace conditions of school success. American Educational Research Journal, 19(3), 325-340.

Little, J. W. (1993). Teachers' professional development in a climate of educational reform. Educational Evaluation and Policy Analysis, 15(2), 129-151.

Lortie, D. C. (1975). Schoolteacher: A sociological study. Chicago: University of Chicago Press.

Martin, J. (1992). Cultures in organizations: Three perspectives. New York: Oxford University Press.

McLaughlin, M. W., & Oberman, I. (Eds.). (1996). Teacher learning: New policies, new practices. New York: Teachers College Press.

McLaughlin, M. W., Talbert, J. E., & Bascia, N. (Eds.). (1990). The contexts of teaching in secondary schools. New York: Teachers College Press.

Means, B. (Ed.). (1991). Technology and education reform. San Francisco: Jossey-Bass Publishers.

Means, B., & Olson, K. (1995). Technology's role in educational reform: Findings from a national study of innovating schools: SRI International.

Means, B., Penuel, W. R., & Padilla, C. (2001). The connected school: Technology and learning in high school. San Francisco: Jossey-Bass.

Mintzberg, H. (1979). The structuring of organizations. Englewood Cliffs, NJ: Prentice-Hall.

Morgan, G. (1997). Images of organization (Second ed.). Thousand Oaks, CA: Sage Publications.

Nelson, B. S., & Hammerman, J. K. (1996). Reconceptualizing teaching: Moving toward the creation of intellectual communities of students, teachers, and teacher educators. In M. W. McLaughlin & I. Oberman (Eds.), Teacher Learning: New Policies, New Practices. New York: Teachers College Press.

Newman, D. (1991). Technology as support for school structure and school restructuring (Technical Report 14). New York: Bank Street Center for Technology in Education.

Newmann, F. M., & Wehlage, G. G. (1995). Successful school restructuring. Madison, WI: Center on Organization and Restructuring of Schools, University of Wisconsin, Madison.

Olson, D. R., & Bruner, J. S. (1996). Folk psychology and folk pedagogy. In D. R. Olson & N. Torrance (Eds.), The Handbook of Education and Human Development: New Models of Learning, Teaching and Schooling. Cambridge, MA: Blackwell.

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York: Basic Books.

Perkins, D. N., Schwartz, J. L., West, M. M., & Wiske, M. S. (Eds.). (1995). Software goes to school: Teaching for understanding with new technologies. New York: Oxford University Press.

Pope, M. (1993). Anticipating teacher thinking. In C. Day & J. Calderhead & P. Denicolo (Eds.), Research on Teacher Thinking: Understanding Professional Development (pp. 19-33). Bristol, PA: Falmer Press.

Pope, M. L., & Denicolo, P. (1986). Intuitive theories -- a researcher's dilemma. British Educational Journal, 12(2), 153-165.

Powell, A. G., Farrar, E., & Cohen, D. K. (1985). The shopping mall high school: Winners and losers in the educational market place. Boston, MA: Houghton Mifflin.

Resnick, L. (1987). Education and learning to think. Washington, DC: National Academy Press.

Rogers, E. M. (1995). Diffusion of innovations (4th ed.). New York: Free Press.

Rosenholtz, S. J. (1991). Teachers' workplace: The social organization of schools. New York: Teachers College Press.

Rossi, I., & O'Higgins, E. (1980). The development of theories of culture. In I. Rossi (Ed.), People in Culture (pp. 31-78). New York: Praeger.

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). Teaching with technology: Creating student-centered classrooms. New York: Teachers College Press.

Sarason, S. (1990). The predictable failure of educational reform. San Francisco: Jossey-Bass Publishers.

Sarason, S. (1996). Revisiting "The culture of the school and the problem of change". New York: Teachers College Press.

Scardamalia, M., Bereiter, C., Brett, C., Burtis, P. J., Calhoun, C., & Lea, N. (1992). Educational applications of a networked communal database. Interactive Learning Environments, 2, 45-71.

Scardamalia, M., Bereiter, C., & Lamon, M. (1994). The CSILE Project: Trying to bring the classroom into World 3. In K. McGilly (Ed.), Classroom Lessons: Integrating Cognitive Theory and Classroom Practice (pp. 201-228). Cambridge, MA: MIT Press.

Scardamalia, M., Bereiter, C., McLean, R. S., Swallow, J., & Woodruff, E. (1989). Computer-supported intentional learning environments. Journal of Educational Computing Research, 5, 51-68.

Schein, E. H. (1992). Organizational culture and leadership. Jossey-Bass Publishers.

Schön, D. A. (1983). The reflective practitioner: How professionals think in action. New York: Basic Books.

Schön, D. A. (1987). Educating the reflective practitioner: Toward a new design for teaching and learning in the professions. San Francisco: Jossey-Bass.

Schön, D. A. (1988). Coaching reflective teaching. In P. P. Grimmett & G. L. Erickson (Eds.), Reflection in Teacher Education (pp. 19-30). New York: Teachers College Press.

School, W. H. (2002-2003). Annual Report of Woodland High School.

Schwartz, J. L. (1995). Shuttling between the particular and the general: Reflections of the role of conjecture ahd hypothesis in the generation of knowledge in science and mathematics. In D. N. Perkins & J. L. Schwartz & M. M. West & M. S. Wiske (Eds.), Software Goes to School: Teaching for Understanding with New Technologies (pp. 93-105). New York: Oxford University Press.

Scott, W. R., & Cohen, R. C. (1995). Work units in organizations: Ransacking the literature. In L. S. Siskin & J. W. Little (Eds.), The Subjects in Question: Departmental Organization and the High School (pp. 48-67). New York: Teachers College Press.

Scribner, S. (1986). Thinking in action: Some characteristics of practical thought. In R. J. Sternberg & R. K. Wagner (Eds.), Practical Intelligence: Nature and origins of Competence in the Everyday World (pp. 13-30). New York: Cambridge University Press.

Senge, P. M. (1990). The fifth discipline: The art and practice of the learning organization. New York: Currency Doubleday.

Sergiovanni, T. (2000). The lifeworld of leadership. San Fransico: Jossey-Bass.

Sheingold, K. (1990). Restructuring for learning with technology: The potential for synergy. In K. Sheingold & M. S. Tucker (Eds.), Restructuring for Learning with Technology. New York: Center for Technology in Education.

Sheingold, K., & Tucker, M. S. (Eds.). (1990). Restructuring for Learning with Technology. New York: Center for Technology in Education.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(1), 1-22.

Siskin, L. S. (1994). Realms of knowledge: Academic departments in secondary schools. London: The Falmer Press.

Siskin, L. S., & Little, J. W. (Eds.). (1995). The subjects in question: Departmental organization and the high school. New York: Teachers College Press.

Sizer, T. R. (1985). Horace's compromise: The dilemma of the American high school. Boston: Houghton Mifflin.

Smircich, L. (1983). Concepts of culture and organizational analysis. Administrative Science Quarterly, 28, 339-358.

Snyder, T., & Palmer, J. (1986). In search of the most amazing thing: Children, education, & computers. Reading, MA: Addison-Wesley.

Spillane, J. P., & Jennings, N. E. (1995, April, 1995). Constructing a challenging pedagogy for all students; Contrasting the rhetoric of reform with practice and the rehetoric of practitioners. Paper presented at the American Educational Research Association, New York, NY.

Stake, R. E. (1995). The art of case study research. Thousand Oaks, CA: Sage Publications.

Swidler, A. (2001). Talk of love: How culture matters. Chicago: University of Chicago Press.

Talbert, J. (1995). Boundaries of teachers' professional communities in U.S. high schools: Power and precariousness of the subject department. In L. S. Siskin & J. W. Little (Eds.), The Subjects in Question: Departmental Organization and the High School (pp. 68-94). New York: Teachers College Press.

Toronto, U. o. (2003). Knowledge Forum. http://csile.oise.utoronto.ca/.

Trumbull, D. (1989). Computer-generated challenges to school culture: One teacher's story. Journal of Curriculum Studies, 2, 457-469.

Tyack, D., & Cuban, L. (1997). Tinkering toward utopia: A century of public school reform. Cambridge, MA: Harvard University Press.

U.S. Congress, O. o. T. A. (1988). Power On! New Tools for Teaching and Learning. Washington, DC: Office of Technology Assessment.

U.S. Congress, O. o. T. A. (1995). Teachers and Technology: Making the Connection. Washington, DC: Office of Technology Assessment.

U.S. Government, B. o. t. C. (2000). U.S. Census. http://www.census.gov/main/www/cen2000.html.

University, T. (2003). Perseus Project. http://www.perseus.tufts.edu/.

Weick, K. E. (1995). Sensemaking in organizations. Thousand Oaks, CA: Sage.

Wenglinsky, H. (1998). Does it compute? The relationship between educational technology and student achievement in mathematics. Educational Testing Service.

Westheimer, J. (1998). Among schoolteachers: Community, autonomy and ideology in teachers' work. New York: Teachers College Press.

Wiske, M. S. (Ed.). (1998). Teaching for understanding: A practical framework. San Francisco: Jossey Bass.

Wiske, M. S., & Houde, R. (1993). From recitation to construction: Teachers change with new technologies. In J. L. Schwartz & M. Yerushalmy & B. Wilson (Eds.), The Geometric Supposer: What is it a Case of? (pp. 193-216). Hillsdale, NJ: Lawrence Erlbaum Associates.

Wiske, M. S., Niguidula, D., & Shepard, J. W. (1988). Collaborative research goes to school: Guided inquiry with computers in classrooms (Technical Report TR88-3). Cambridge, MA: Educational Technology Center, Harvard Graduate School of Education.

Yin, R. K. (1994). Case study research: Design and methods (Second ed.). Thousand Oaks, CA: Sage Publications.