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ABSTRACT

While the computer chip is revolutionizing society as a whole, its effects on education remain limited. This paper identifies and describes how exemplary elementary school teachers in Southwestern Ohio use technology in the classroom, and provides a model for the development of tomorrow's classrooms. Qualitative and quantitative data collection was conducted over a 6-month period in 1996-97. In Phase 1, 42 school district technology coordinators identified exemplary uses of technology in elementary classrooms, and named exemplary technology-using teachers. In Phase 2, 59 teachers identified as exemplary technology-users were surveyed, with questions based on information gathered in Phase 1. Seven general areas emerged as being most important to the technology coordinators: the Internet, instructional design, research, student use of multimedia authoring programs to create presentations, basic skills instruction and reinforcement, problem solving, and writing and desktop publishing. The teachers were in considerable agreement with the coordinators, and with each other, about technology uses. Of the technology coordinators surveyed in Phase 1, 45% did not identify any exemplary teachers. Findings from this study support the idea that technology has real potential for changing instruction. The picture of the exemplary classroom that can be developed from this study may serve as a model for the experts and the practitioner alike. (Contains 17 references.) (SWC)

The Coordinators and the Teachers:

A Description of Exemplary Use of Technology in Elementary Classrooms

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Purpose

While the computer chip is revolutionizing our society as a whole, its effects on education remain limited. The conservative nature of the place called school results in attempts to use the new technology to retain, or to make more efficient, old goals and status quo social organization. This is in conflict with the desire of many leaders to use technology as the wedge to fundamentally change the nature of teaching and learning.

Presently we are asking teachers to change to something different, without presenting a clear picture of what this classroom of the future should look like. The purpose of this study was to provide a clearer image of tomorrow's classrooms. By identifying and describing how exemplary elementary school teachers use technology, a model for tomorrow's classrooms can be developed.

Theoretical Framework

A cultural constructivist approach was taken in this study. Scott, Cole, and Engel (1992) developed that term, adding to Piaget's notion of children as constructors of their own development through their actions, the need for an equally active and usually more powerful adult in the interaction. As the "director of learning," exemplary teachers design, prescribe, and evaluate the most effective learning experiences for each student. The instructional characteristics

commonly attributed to the influence of constructivist theories are used in analyzing technology applications used in exemplary classrooms.

In addition, the authors used Taylor's (1980) useful classification scheme of computer usage in which he viewed the computer as tutor, tool, or tutee. As a tutor, the computer acts as a teaching machine instructing or providing drill and practice. Instruction can be individualized; feedback becomes immediate. As a tool, the computer allows the student to produce something. Examples of "tools" are a word processor, data base, spreadsheet, telecommunications device, graphics design tool, or presentation tool. Tutee, Taylor's third classification, occurs when the computer is programmed by the student by the use of a programming language such as BASIC, Logo, or Pascal.

Review of the Literature

Early research consisted primarily of whether the use of computers improved student achievement (Becker, 1992). In a large national survey, Becker (1993) found that students at the elementary level use computers overwhelmingly in an exercise mode (Taylor's tutor) doing drills and playing various educational games, rather than in a productivity mode (Taylor's tool). In the subsequent Office of Technology Assessment report (OTA,1995), the most common use of computers in elementary schools was for basic skills practice. This differs from the major use of the computer by people outside education who use it as a tool, and it is in striking contrast with Papert's (1980) and Pea's (1985) vision of developing enhanced intelligence. Early innovative use of computers in schools focused on implementing Seymour Papert's (1980) Logo programming language and proposed philosophy of teaching (Taylor's tutee model). A significant debate in the research area emerged when Clark (1983) argued that "the best current evidence is that media are

mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 445). Kozma (1991) led the intellectual forces that expressed disagreement; he offered a new framework in which the learner "actively collaborates with the medium to construct knowledge. It stands in vivid contrast to [a framework in which] learning occurs as a result of instruction being 'delivered' by some (or any) medium" (p. 179).

Studies that focus on exemplary use of technology are limited. In a study conducted by the Bank Street College of Education(Hadley & Sheingold, 1993; Sheingold & Hadley, 1990), researchers identified teachers who had reputations as expert computer users. They found that these "expert" teachers used productivity software to provide intellectually exciting educational experiences for students. Productivity software included "tool" software such as word processors, data base programs, drawing programs, or spreadsheets.

In another look at what factors result in teachers using computers effectively, Becker (1994) used national survey data to identify exemplary computer-using teachers. He wanted to learn how exemplary teachers came to use computers differently than other teachers. He used a set of criteria similar to those used in the Bank Street study to nominate exemplary teachers; he then examined the national probability survey data to learn what fraction of teachers fulfill the criteria. A set of standards was selected which taken together "suggest a classroom environment in which computers were both prominent in the experience of students and employed in order that students grow intellectually and not merely develop isolated skills" (p. 294).

In the study reported here, the researchers began with some very critical questions. Do the experts and the practitioners agree about how technology is being used in classrooms and about what is most important? How is technology used in the classrooms of our most successful

computer-using teachers? Which applications do students use most often? Which applications do teachers believe are most important? Were there discrepancies between what teachers believed to be most important and what students actually do? How do teachers perceive technology's role in instructional design? Information about technology staff development was also obtained. How much staff development have the exemplary teachers had in the area of technology? What form of staff development has been most significant? The answers to these questions provide information that can be used to create a model for tomorrow's classrooms

Methods

This descriptive study identifies and describes how exemplary elementary school teachers in Southwestern Ohio are currently using technology in their classrooms. The research was conducted over a six month period in 1996-97. Qualitative and quantitative data collection strategies were used in this two phase study. The membership list of the regional technology support agency, SOITA (Southwestern Ohio Instructional Technology Association), provided the general parameters. The member districts included small rural districts, suburban districts, and urban districts. Varied socio-economic conditions were present.

In the first phase, 57 technology coordinators from Southwestern Ohio school districts were sent a questionnaire in which they were asked, in an open-ended question, to identify up to five exemplary uses of technology in elementary classrooms. They were also asked to name up to five exemplary technology-using teachers. Forty-two responses were received yielding almost a 74% return rate. The districts included a reasonably diverse demographic mix, though only two coordinators identified the students in their district as coming from predominantly wealthy

families. Sixty-four percent of the districts were predominantly middle class and 31% were predominantly poor.

The information that was gained from the Phase 1 survey was then used to develop the survey for Phase 2. The open-ended survey responses were entered verbatim into a word processing document. One hundred and sixty-one exemplary uses of technology in elementary classrooms were identified. The data were then organized according to common ideas including student presentation, research, Internet, desktop publishing, basic skills, keyboarding, inclusion, problem solving, computer programming, tools, and instructional design. Organized data from the technology coordinators' survey were then collapsed to create a list of 39 distinct exemplary uses of technology. These became the core questions on the questionnaire for the second phase of the study. The exact words of the original key informants were retained as much as possible. Additional questions were added about obstacles which may prevent the teacher from employing a technology use and about staff development. Questions to gather demographic data were added as well. The resulting survey was field tested by three exemplary technology using teachers.

The Phase 2 survey was then sent to the seventy-six teachers identified by the coordinators served as exemplary users. These teachers were asked to validate the description of exemplary technology use that emerged from the data collected from the coordinators. Content validity was embedded within the instrument (Isaac & Michael, 1981) through this process. Teachers were asked about the frequency of student participation in various uses of technology identified in the survey, and they were also asked how important they believed each form of technology use to be. One survey was returned by the post office; three were returned and not filled out with notes indicating that they were not elementary teachers. Fifty-nine were completed and returned, resulting in almost an 82% return rate. The teachers came from school districts of varying sizes;

50% of the represented districts have 4,000 students or fewer. Half were from suburban districts and the other half were evenly divided between urban and rural districts. Sixty-seven percent of the respondents indicated that their students come from middle income families, with 33% of the teachers indicating that their students come from poor families. None of the teachers indicated that their students come predominately from wealthy families.

The data from the Phase 2 survey were entered into a database/spreadsheet computer program. Next, descriptive statistics (means and standard deviations) were found for the core questions which asked teachers to rate thirty-nine technology uses according to frequency of use in their classroom and the importance of the use. This information was put into a table for analysis. Data patterns emerged. Tables displaying the meaning drawn from the displayed data were developed.

Results

Seven general areas emerged as being most important to the coordinators, as evidenced by the frequency with which coordinators cited these uses. These areas were Internet, instructional design, research, student use of multimedia authoring programs such as HyperStudio to create presentations, basic skills instruction and reinforcement, problem solving, and writing and desktop publishing.

The teachers were in considerable agreement with the coordinators about technology uses. The trustworthiness of the instrument was established by the lack of significant additional uses of technology cited by teachers. When asked, "Is there any other important use of the technology that you use frequently in your classroom which has not been listed in this questionnaire? Please list," only a very limited number of responses was provided.

The teachers were also in considerable agreement with each other. This can be seen in the low overall variability of responses from the teachers about the frequency and importance of technology uses. Only 4 items of the thirty-nine had a standard deviation of 2 or higher. This is further evidence of the relative trustworthiness of the data.

In general, teachers thought that the items as suggested by the coordinators were all quite important. The uses deemed most important by the teachers are shown in Table 1.

Table 1

Most Important Technology Uses: Mean Ratings by Teachers (N=59)

Items	x [a]	SD
To motivate students	5.77	.68
To change from traditional classroom	5.72	.62
CD-ROMS for research	5.68	.70
Computers in writing process	5.59	.88
Variety of resources used	5.56	.95
Desktop publishing software	5.54	.87
Integrate subject matter	5.48	.90
Internet to do research	5.39	.83
Enhance communications w/parents	5.37	.99
Tailor curriculum to individual student needs	5.36	.89
Writing across the curriculum	5.32	1.12

[a] Importance: 6 = highly important, 5 =moderately important, 4 =somewhat important, 3 =somewhat unimportant, 2 =moderately unimportant, 1 = not at all important

Like the coordinators, the teachers agreed that research, writing, and instructional design uses were among the most important uses for technology in the elementary classroom. Some differences between teachers and coordinators are apparent, however, in the degree of importance the respective groups attach to several of the uses most frequently cited by the coordinators. Multimedia authoring programs, basic skills, and problem solving, were not rated in the top ten uses by teachers. The difference between the teachers' and coordinators' ratings of importance is one of degree. Teachers agreed that those uses were at least somewhat important. Importance ratings for these items ranged from a basic skills item, "use of ILS software," which received the lowest mean importance rating of the group (4.3), to the item "real world problem solving in math and science," which had a mean importance rating of 4.93.

Considering all of the 39 uses on the questionnaire that the teachers were asked to rate for frequency and importance, even the technology uses with the lowest mean importance ratings were rated as fairly important by the teachers (see Table 2).

Table 2

Least Important Technology Uses: Mean Ratings by Teachers (N=59)

Items	$\bar{x}$ [a]	SD
Logo, Lego Logo, or Lego Dacta	3.57	1.57
Distance learning /video conferencing	3.90	1.60
Probes as lab tool	3.91	1.53

[a] Importance: 6 = highly important, 5 =moderately important, 4 =somewhat important, 3 =somewhat unimportant, 2 =moderately unimportant, 1 = not at all important

Many uses were judged important, but what technology did the teachers really use in their classrooms? The most frequent technology uses are related (Table 3). That is, the three uses with frequency ratings of more than once a week all speak to how technology can improve instructional design.

A relationship can also be seen in the items with the next highest frequency ratings. The three items in the survey pertaining to student writing (computers in the writing process, writing across the curriculum, and desktop publishing) make up three of the four most frequent uses in the classrooms of the surveyed teachers.

Table 3
Most Frequent Technology Uses: Mean Ratings by Teachers (N=59)

Items	$\bar{x}$ [a]	SD
Teachers use technology...		
To change from traditional classroom	5.35	1.13
To motivate students	5.19	1.26
To be more creative in designing assignments	5.10	1.25
Students use technology...		
Computers in writing process	4.67	1.59
CD-ROMS to do research & investigate subject matter	4.50	1.59
Variety of resources (books, CDs etc.) used	4.32	1.73
Computers to write across the curriculum	4.16	1.59
Desktop publishing software	4.07	1.79

[a] Frequency 6 = daily, 5 = once a week, 4 = once a month, 3 = fewer than once a month, 2 = fewer than 5 times per year, 1 = never

Of the technology uses most frequently cited by the coordinators, how frequently are these uses occurring in the classrooms of the exemplary teachers? The area of most agreement between coordinators and teachers was in instructional design (see Table 4).

Table 4

Frequency of Use of Areas Most Cited by Coordinators: Mean Ratings by Teachers (N= 59)

Item	$\bar{x}$ [a]	SD
Research		
CD-ROMS for research	4.50	1.59
Variety of resources used	4.32	1.73
Computerized library card catalog	2.81	2.01
Internet		
To communicate w/other schools	2.03	1.74
To do research	1.97	1.59
World Wide Web	1.83	1.49
To e-mail students in other parts of world	1.58	1.38
Create World Wide Web pages	1.51	1.89
To conduct research w/ other schools	1.24	.80
Multimedia authoring programs	2.67	1.77
Instructional Design		
Change from traditional classroom	5.35	1.13
Motivate students	5.19	1.26

(Table continues)

Item	$\bar{x}$ [a]	SD
More creative in designing assignments	5.10	1.25
Tailor curriculum to individual needs	4.93	1.45
Integrated subject matter	4.72	1.45
Students work collaboratively	3.82	1.83
Criterion-referenced assessment/ portfolios	3.02	1.79
Basic Skills		
Drill & practice programs	3.77	1.97
ILS software	2.48	2.12
ILS for intervention	2.37	1.88
Writing		
Writing process	4.67	1.59
Across the curriculum	4.16	1.59
Desktop publishing	4.07	1.79
Problem Solving		
Problem solving software	3.07	1.82
Real world problem solving math/science	2.34	1.85

[a] Frequency 6 = daily, 5 = once a week, 4 = once a month, 3 = fewer than once a month, 2 = fewer than 5 times per year, 1 = never

Considering all of the uses listed on the questionnaire, 6 of 10 of the least frequent technology uses involved the use of the Internet (Table 5).

Table 5

Least Frequent Technology Uses: Mean Ratings by Teachers (N=59)

Items	$\bar{x}$ [a]	SD
Distance learning/video conferencing	1.23	.69
Internet to conduct research w/other schools	1.24	.80
Logo, Lego Logo, or Lego Dacta	1.47	1.14
Probes as lab tool	1.48	1.28
Create World Wide Web pages	1.51	1.89
Internet to e-mail students in other parts of world	1.58	1.38
Homework hotline	1.81	1.81
World Wide Web	1.83	1.49
Internet to do research	1.97	1.59
Internet to communicate w/other schools	2.03	1.74

[a] Frequency 6 = daily, 5 = once a week, 4 = once a month, 3 = fewer than once a month, 2 = fewer than 5 times per year, 1 = never

Interesting data emerged from the questions dealing with staff development. Teachers indicated that they had participated in a variety of technology staff development opportunities (Table 6), but clearly the most important dynamic appears to be on the importance of "learning on your own." Technology skills seem to be skills that many exemplary teachers gain informally through a personal search rather than formally, through a "guided' learning process. Ninety-five percent of the teachers indicated that some of their technology skills had been learned on their own. In

addition, "learning on my own (reading, videos, individual help)" was identified by 60% of the teachers as the "most significant source of learning" as compared to the formal staff development opportunities listed in Table 6.

Table 6

Percent of Teachers Reporting Participation in Staff Development Opportunities (N=59)

Learned on own	95%
District or building level workshops	84%
SOITA workshops	63%
Conferences	57%
University credit	50%
Private vendors	43%

Exemplary teachers spend a lot of time learning about technology - 75% percent of them reported that they had spent more than 5 days within the last school year learning to use technology. This is consistent with the previously stated general lack of concern by teachers over insufficient staff development as an obstacle to implementation. Exemplary technology teachers tend to be self-guided learners.

Discussion and Implications

Surprisingly, 45% of the coordinators did not identify any exemplary teachers. Three coordinators wrote on the survey that their districts did not yet have any exemplary users. It is not clear why the other coordinators did not identify teachers. Perhaps their districts also did not yet have any exemplary technology-using teachers. Or, perhaps, they were unaware of who these

teachers were. This did result in a smaller group of teachers who were surveyed in phase 2 than had been planned. The researchers do not believe that the results of the study were substantially affected however. The responses from the teachers who were surveyed were quite consistent, as evidenced by the relatively low standard deviations, and the demographic mix of teachers remained stable..

In this study, many important components of educational reform were named by technology coordinators when they listed the most important ways that technology is used in elementary classrooms. In the area that became grouped as "instructional design," coordinators stressed such things as the importance of collaboration, integration of subject areas, individualized and interactive learning, and communication with parents. In a sense, they were expressing a belief that technology, as utilized by our strongest teachers, is beginning to change the very structure of our classrooms. The exemplary teachers verified this fact. They cited "motivating students and keeping students interested and experiencing success" and "changing from traditional classrooms to using a wider variety of teaching techniques" as the top two most important uses of technology. Even stronger evidence is found in the three most frequent uses of technology. Teachers stated that their most frequent use of technology is to change the "look" of the traditional classroom. The next two most frequent uses of technology were motivating students and being "more creative in designing assignments for students." Teachers also reported using technology quite frequently to "tailor the curriculum to students' individual needs," "enhance my communications with parents," and "integrate subject matter such as math and language arts." This is good news indeed for educational reformers. The potential for technology to support change appears to be real.

Another encouraging finding is the high level of agreement between the experts/formal leaders (technology coordinators) and the practitioners (exemplary teachers). This high level of agreement is good news. If there had been substantial differences in the basic beliefs of the experts/leaders and the implementers, this would be a matter of concern. This would have indicated the need for improved dialogue between the two groups and pointed toward the need for very different types of staff development. In addition, the expert teachers are very likely to be part of the informal leadership structure of their school districts: they are likely looked to as a model and a source of advice by their fellow teachers. They may well be providing formal and informal staff development for others, chairing building technology committees, etc. Should their beliefs about the importance of various technology uses be in variance with the beliefs of the formal technology leadership, this would be quite problematic. If the formal leadership promoted using computers for research and writing, while the informal leadership argued that drill and practice was more important, the teaching staff would be confused about what they ought to try in their classrooms. The likelihood of the average teacher being motivated to use technology to change their classroom is more likely when both administration and valued colleagues agree.

Discrepancies do appear when looking at the frequency that some of these activities (e.g., Internet uses or student use of multimedia software), identified by both coordinators and teachers as most important, actually take place in the classrooms. The strongest areas of agreement are instructional design, student research, and writing. These activities happen every month or at least once a week. The frequency of use of technology for writing and research is supported in the literature. For example, at the Peakview School (Wilson et al., 1994), exemplary teachers used technology extensively for research and writing activities. Less frequent in use, despite shared

belief in importance by coordinators and teachers in this study, were Internet applications, problem solving, basic skills practice, and student use of multimedia authoring programs.

The infrequency of Internet application use despite strong belief in its importance by both coordinators and teachers is quite easily explained: lack of access. Almost half of the teachers listed lack of Internet access as the most significant obstacle preventing implementation of important uses. Only about one-fourth of the teachers have Internet access in their classrooms and more than one-half lack access any place in their school. If this survey were to be repeated in a year's time, the results might be quite different.

The relatively low frequency of using technology for basic skills practice found in this study is quite surprising. Previous studies (Becker, 1993; OTA, 1995) found that at the elementary level students use computers overwhelmingly for doing drills and playing various educational games.In the classrooms of the exemplary technology-using teachers in this study, this finding is reversed. That is, the students in their classrooms use technology predominantly for productivity, not basic skills.

This may be a critical distinction between exemplary users and the average users. In the study of expert computer users done by the Bank Street College of Education, researchers found that exemplary teachers overwhelmingly used productivity software to provide intellectually exciting educational experiences for students (Hadley & Sheingold, 1993; Sheingold & Hadley, 1990).

The final area of discrepancy between coordinators and teachers' beliefs of importance and the frequency of student use is multimedia authoring. Technology conference presentations and reading the popular educational technology periodicals partially document that the use of multimedia authoring programs such as HyperStudio is very important (D'Ignazio & Davis, 1997,

Downs & Clark, 1997, LeCrone, 1997). The formal experts (technology coordinators) certainly think this is the case -- it was among the most frequently cited technology uses on their survey. While the teachers agreed about it being important, their students use it only about every other month. This study did not offer any information about why this is true.

Could this be a Logo-type phenomenon? Many of the early innovative uses of computers in schools were attempts to implement Papert's Logo programming language and proposed philosophy of teaching (Papert, 1980). The exemplary teachers in this survey not only rated Logo as being of the lowest importance of any of the 39 technology uses listed in the survey; a number of them noted that they did not even know what it was. Fashions change. Logo's original promise did not pan out. Will this be true of student produced multimedia?

Teaching practices which are consistent with constructivist thought involve helping learners internalize or reshape new information in order to "make it their own." A significant finding of this study is that exemplary technology-using teachers are using technology in their classrooms in ways that are overwhelmingly constructivist. That is, the technology uses that students used most frequently in the teachers' classrooms were research, writing, and desktop publishing. Students are using technology as a tool to explore new information and produce new products. They are actively engaged in learning. Each one of these applications provides students opportunities to actively process new information, to transform it, and "to make it their own."

The technology uses that technology coordinators and exemplary teachers alike deemed most important (Internet, student research, writing, and desktop publishing) exhibit these characteristics. For example, student use of a variety of resources, including CD-ROMS, for research certainly involves highly visual formats and rich learning environments. Student research may involve problem-oriented learning activities, collaborative work, learning through

exploration, and authentic assessment. The other most important applications, according to the coordinators, were student use of multimedia authoring programs, problem solving, and basic skills instruction and reinforcement. The use of multimedia authoring programs and problem solving are clearly learning activities which are constructivist. Basic skills instruction and reinforcement is the only important use of technology found in this study which does not.

Another context which can be used to examine the results of this study is to use Taylor's (1980) classification scheme for computer usage.The data of this study fall heavily in the tool classification (Internet, instructional design, student research, writing and desktop publishing, student use of multimedia authoring programs, and problem solving). As a tutor, the computer acts as a teaching machine instructing or providing drill and practice. Only basic skills instruction and reinforcement fits into the tutor category. Tutee usage occurs when the computer is programmed by the student through the use of a programming language. "Logo, Lego Logo, and Lego Dacta" is the only application identified by the coordinators which can be classified as tutee. As previously noted, Logo was rated by teachers as the least important of all the applications listed in the questionnaire. This is a real change in the general view about what is important for computer use. In the early years of computing in schools, learning how to program a computer was considered highly important. Many schools introduced students to the BASIC programming language. Teaching BASIC was not mentioned by one coordinator or teacher in this questionnaire.

Educational Significance

The most encouraging finding of this study was support for the idea that technology has real potential for changing instruction. Technology coordinators expressed a belief that

technology, as utilized by our strongest teachers, is beginning to change the very structure of our classrooms. The exemplary teachers verified this. The picture of the exemplary classroom which can be developed from this study may serve as a model for the experts and the practitioner alike.

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