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AUTHOR Bernauer, James A.
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ABSTRACT

This paper describes how technology has been successfully integrated into a school's curriculum, the leadership decisions leading to this success, and the impact that technology has had on students and the school organization. Although the Western Pennsylvania School for the Deaf provides specialized services, findings from this study may be applied to other K-12 schools that desire to use technology as a tool for improving teaching and learning. Discussion includes the organizational structure of the school; the award of "teacher-initiative grants" of which a substantial amount was used to purchase computer technologies; further technology initiatives and the need for organizational partnering; benefits of technology; and the technology implementation plan. A summary of accomplishments in science and language arts, as well as teacher and student responses to the technology are provided. The conclusions of this project are as follows: (1) technology integration can not only offer a way to improve teaching and learning, but can also affect changes in teacher roles, curriculum planning, and decision making; (2) technology will continue to be integrated into the curriculum; (3) student outcomes need to be evaluated; (4) there are financial and other kinds of benefits received by partnering with other organizations; and (5) institutions that train educational leaders need to promote technology. Eight tables show results of teacher and student assessments. (Contains 38 references.) (AEF)

TECHNOLOGY AND LEADERSHIP

by

James A. Bernauer

Western Pennsylvania School for the Deaf
and Duquesne University

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James A. Bernauer
Phone: 412-244-4250
E-mail: BERNAUER@GENESIS.DUQ.EDU

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Introduction

This paper describes how technology has been successfully integrated into a school's curriculum, the leadership decisions leading to this success, and the impact that technology has had on teachers, students, and the school organization. Although this school serves deaf and hard-of-hearing students by providing specialized services (notably instruction using a combination of speech and sign language), activities and findings described in this study may be generalizable to other K-12 schools that desire to use technology as a tool for improving teaching and learning.

The Western Pennsylvania School for the Deaf is located on a seventeen acre campus in a suburb of Pittsburgh and was the first day school for the deaf in the United States. There are 213 pre-12 students from twenty-nine counties in western Pennsylvania enrolled. Approximately 50% of these students are day students and 50% are residential students. The major purpose of the school is to graduate students with the requisite knowledge, skills, and attitudes to be productive members of a society that includes both deaf and hearing persons. While the range of intelligence approximates that at most K-12 schools, deafness presents a formidable challenge to educators in terms of developing the language-based skills of reading and writing. Research indicates a median reading achievement level for deaf students in their final year of secondary school of a fourth grade equivalent (Allen, 1986; Trybus & Karchmer, 1977), a level which often remains the same when these students become adults (Hammermeister, 1971). The major reason for this statistic is that deaf persons, especially those who are born deaf, miss large parts of the spoken language through which most people interact and which is also the basis for written language and the whole reading process. As Berlo (1966) found, every day, the average American "spends about 70% of his active hours communicating verbally -- listening, speaking and writing". Significant reduction in this English language input, caused by hearing loss, can severely delay educational progress, especially in reading and written language, even for those students whose basic intelligence is fully within the normal range.

While the difficulty of the educational challenge with deaf students is formidable, similar challenges exist in the general school population especially in urban schools where there are large percentages of low income students. For example, an assessment system entitled "Testing for Essential Learning and Literacy Skills" (TELLS) was developed in the Commonwealth of Pennsylvania as an "early warning system" to identify students with reading and math problems early in their school years. Data from 1989 indicated that while only 6% of schools outside of Pittsburgh and Philadelphia serving fifth graders had mean scores in reading below the accepted "cut" score, 64% of schools in Pittsburgh and 92% in Philadelphia had mean scores *below* the cut score. The scores for math are just as discouraging with 57% of schools serving fifth graders in Pittsburgh and 86% in Philadelphia having means below the cut score -- only 3% of schools in the rest of the state were below the cut score. (Pennsylvania Department of Education, 1990). A more recent assessment system for reading and math (Pennsylvania System of School Assessment) was administered in March 1995 and shows similar low levels of achievement for students in schools from these two large urban school districts. On the national level, the National Education Goals Panel reported that at the half way point to the proposed Goals 2000 target, that the share of proficient readers among high school graduates dropped from 36% in 1990 to 34% in 1995. (National Education Goals Panel, 1995). Trends from NAEP from the early 1970s to 1992 indicate a continuing low level of proficiency in more challenging content (300 and 350 levels) not only in the area of reading, but also writing, mathematics, and science (Educational Testing Service, 1994). Clearly, the need to identify interventions that may improve outcomes is a national priority.

Organizational Structure

The Western Pennsylvania School for the Deaf (WPSD) has been designated as an "approved private school" by the Pennsylvania Department of Education. As such, it receives full reimbursement for all instructional and campus support positions including the Principal, Superintendent, teachers, supervisors, maintenance crews, cafeteria and dorm personnel. Tuition, as well as room and board, are free of charge to students. While there is no immediate reimbursement from the state for major capital expenditures (such as renovations), these items can be depreciated over a ten year period. Areas deemed non-instructional (such as public relations) do not receive state support. As a private school, the school is permitted to raise funds for programs and projects that the Department of Education will not reimburse. In addition, the school has its own private endowment and aggressively engages in grant writing and fundraising. The school Board, unlike that of public school Boards, is elected by existing Board members usually at the recommendation or prior approval of the Superintendent. One of the apparent results of this arrangement is that the political conflicts surrounding Board elections is notably absent and the relationship between the Superintendent and the Board has historically been quite cordial. This situation probably accounts for the fact that there have been only eight Superintendents in 125 years with the previous two Superintendents having terms of 23 and 24 years respectively. This tenure differs dramatically from the three to five year tenure reported for Superintendents at public schools.

While the structure of WPSD corresponds somewhat to the typical "loosely coupled" school organization (Glassman, 1973; March and Olsen, 1975), the fact that the Superintendent resides in the same building as the rest of the school staff and that the "central office" and school-level staff are inextricably linked, differs from that of most public school systems. The Superintendent has established an alternating meeting schedule where one week his "administrative team" (principal, business manager, development officer, assistant superintendent, and adult education director) meet followed the next week by a meeting with a larger group of staff including the supervisors of the preschool, elementary, and high school and other support positions such as counseling in addition to the administrative team. This highly integrated central office/school arrangement predictably results in a much flatter reporting structure than exists in school districts that are larger and more geographically dispersed. However, until recently, direct instructional concerns or innovations were rarely discussed at these meetings; rather, issues such as school events and policy issues usually were of central concern.

Phase I Empowerment

A seminal policy, from the perspective of technology innovation, was implemented by the Superintendent and the Board in school year 1989-90 when they introduced "teacher-initiative grants". The purpose of these grants, according to the former Superintendent, was to provide support to teachers whose proposals "held promise for improving teaching and learning" (W. Craig, personal communication, December 12, 1995). The idea for these grants was adapted from a similar grant program that had been offered for a few years by the Pennsylvania Department of Education to all schools but was subsequently discontinued.

Nine grants involving fourteen teachers were awarded during this first academic year by an evaluation committee comprised of supervisors and administrators. These grants ranged from $1-$3 thousand and a substantial amount of these funds were used to purchase computers, peripheral equipment, and software. The decision to offer these grants was pivotal because it produced what I call "Phase One Teacher Empowerment" by encouraging teachers to explore new ideas for improving teaching and learning. From a systems perspective, this decision also demonstrated an action by leaders *on* the system that authorized and legitimized the efforts of teachers *in* the system to professionalize their craft. (Rhodes, 1990). This initiative is also consistent with a fundamental principle for school change that places individuals (especially teachers) as the necessary center of successful change efforts (Hall and Hord , 1987):

Technology Initiatives and the Need for Partnering

One of the consequences of Phase I empowerment was that the grant process was taken one step further in 1992 by a science teacher who decided to seek external funds to integrate interactive-multimedia technology into her science classes. This teacher was successful in obtaining a small grant from the Toyota Foundation and she purchased hypercard software and a MAC computer for her classroom. As she began to develop science applications, she "noted an increased interest in science among her students, increased motivation to learn new things, and higher achievement" (B. Goodman, personal communication, March, 1994).

Based on this anecdotal evidence, the Principal requested that the Superintendent support efforts to garner funds for technology expansion due to the cost of the required hardware and software. The Superintendent agreed to this request and a three year grant request was written to extend the integration of multimedia throughout the high school. The grant proposal was written by this author in close collaboration with the Principal and three teachers representing the science, language arts, and social studies departments. The proposal was presented to the Pittsburgh-based Buhl Foundation in June 1993 and requested $190,000 over a three-year period to integrate interactive-multimedia technology into the science, language arts , and social studies curriculum (math was not initially included in the proposal because of the lack of adequate software available at that time). The proposal was based on a "spiraling" subject area implementation model in order to promote collegial learning where technology was to be integrated into science during school year 1993-94, language arts in 1994-95, and social studies in 1995-96.

The grant was approved by the Buhl Foundation and funds awarded beginning September, 1993.

Why Technology?

While the literature provides some evidence that interactive technology promotes an equivalent or higher level of student learning than traditional teaching methods (Bialo & Sivin, 1990; Fletcher, 1993; Lehrer, Erickson, & Connell, 1992; Spoehr, 1992), many of the effect size advantages were shown to be significantly reduced when the same teacher delivered instruction for both the experimental and control groups (Clark, 1985). This latter finding implies that it may not be technology per se that promotes improved student outcomes, but rather how the technology was integrated into instruction. On the other hand, the kind of instruction that technology can support such as cooperative learning, individualized instruction, mastery learning, cues and feedback, and reinforcement are instructional methods whose achievement-related effect sizes have been shown to be larger than 0.33 and hence have practical significance for educational improvement (Walberg, 1984).

Notwithstanding this conflicting evidence, teachers and administrators began to think of interactive multimedia technology as a promising way to exploit the visual learning modalities of deaf students in order to promote better achievement. Because of the nature of their disability, most deaf students acquire information most easily through visual means -- through the language of sign and illustration. Although books are also visual, and therefore ultimately an excellent source of information, they are written in a language based on audition. Consequently, without many years of learning the English language, and its vocabulary, syntax, and meaning, the deaf child will find many books highly frustrating and will begin to avoid their use. Cornett (1979) labels reading as the most important "window of the world" for deaf persons -- "the only avenue through which they can have full access to information" -- so that "a deaf person desperately needs to be a veritable bookworm" (p.43). Unfortunately, because reading proves so difficult, a large percentage of deaf persons become "nonreaders", creating a "Catch 22" situation in which they avoid the very books they need in order to improve their reading skills.

As explained in the National Demonstration Laboratory Bulletin (1990), interactive technology combines the versatility of a computer with video to promote student control of the learning environment. Optical discs, including both videodisc and CD-ROM (Compact Disc-Read Only Memory) technology provide high quality graphics with either still frames or motion, and are capable of storing vast quantities of information in a compressed space. For students who are deaf, and who therefore must rely primarily upon vision to obtain information, the advantages of technology which is both highly visual and interactive seemed especially compelling to teachers. Video-based technology seemed to offer students an opportunity to use their dominant mode of learning; while the interactive features offered the potential for promoting higher-order thinking skills.

Some of the objectives advanced in the grant proposal for integrating technology into the curriculum were that students would:

- become more fully engaged in learning compared to traditional instructional methods;
- be able to progress at their own pace;

• capitalize upon their own strengths and learning styles rather than forcing them to conform to one pedagogical approach.

Implementation

One of the problems associated with technological advances has been a lack of success in integrating technology into the curriculum which often results in it being unused and the perception by teachers and students that it is irrelevant to teaching and learning. Turner (1993) relates cases where software was purchased by schools but where teachers "did not integrate into the curriculum and where learners did not make the promised gains" (p.5). The Office of Technology Assessment (1995) states that while there are lots of computers in schools (5.8 million or about one for every nine students), that this technology will be wasted unless efforts are greatly increased to train and support teachers since they lack both the knowledge and time necessary to integrate technology into the curriculum. Based on such findings, the budget for this grant was heavy on funds for teacher substitutes so that time was available daily for collegial exploration of the new technology, staff training, and for developing a sense of ownership among teachers. There were one or two periods of daily common planning time among the lead teachers in science, language arts, social studies, and math during the three years of the project.

The implementation plan was designed primarily by those teachers who had expressed interest in using technology to improve instruction and who were willing to commit to a three-year development effort. Implementation followed a spiraling model where the focus during the 1993-94 school year was science, 1994-95 was language arts, and 1995-96 was social studies. During the first year, the science teacher acted as the lead teacher helping the language arts teacher to develop needed competencies and coordinated the purchase of equipment. Beginning in the second year, the language arts teacher assumed the lead role and assisted the social studies teacher who then became the lead teacher during the third year of the project. These three teachers then jointly developed training sessions for other teachers in the high school that were designed to equip teachers with the knowledge and skills to use multimedia technology in their own classrooms.

Results and Phase II Teacher Empowerment

There were several positive results that occurred over the three-year implementation period:

First, the Interactive Technology Lab (ITL) is now used routinely by teachers and students and is equipped with eight student stationary workstations, one moveable workstation, one PowerBook laptop computer, and a teacher development workstation. Each student workstation consists of a Quadra 660 AV platform or a PowerMac, Pioneer LD-V2400 videodisc player, and a twenty inch Zenith TV with a text and captioning chip. The development workstation is a Quadra 840 AV and is used by teachers to develop new multimedia applications that will be integrated with instruction. Because graphics and other multimedia require a large amount of disc space, the lab also is equipped with a

SyQuest Drive and removable cartridges that provide 88 meg of storage. Also in the ITL is a Microtek Scanmaker color scanner and a Hewlitt Packard Deskwriter 550C color inkjet printer. In addition, each lead technology teacher in science, language arts, social studies, and math has a workstation in their classrooms. Two additional teachers were also awarded workstations as a result of teacher initiative grants during school year 1994-95. Since the ITL is on the first floor, there is also a moveable workstation on the second floor for classroom use. All workstations are connected via an ethernet connection and teachers routinely access files in the ITL from their classrooms.

A second positive result was that technology integration into the high school curriculum was quite complete in the areas of science and language arts by December, 1995. A summary of accomplishments and activities follows. [1]

<u>Teacher-Developed Science Hypermedia</u>

Specific projects completed by the lead teacher and her students relate to objectives in the following areas: Classification of Matter; Structure of Matter; The Chemistry of Medicine; Forensic Chemistry; Classification of Living Things; and The Human Body Systems. Additional projects completed in cooperation with other science teachers related to objectives in the areas of Rocks and Minerals; Earthquakes; The Oceans; and the Physics of Sports. These projects included:

• "Remastered" Hypercard stacks that connect to the <u>Physics of Sports</u> laser disc. Work included the rewriting of lesson material in the stacks and the addition of a) glossary stack for student access; b) math practice stack of mathematics principles; and c) Video-Script stack for student reference with non-captioned laser disc clips.

•Hyperstudio stacks that introduce the concept of multimedia and its various components. The stack provides examples of all multimedia components including: button, text, and graphics design and layout; scanning; video capture and digitization; graphic manipulation; laser disc connection and importation and; QuickTime movie development.

• Hyperstudio stacks to be used by other classroom teachers. For example, the topic of "oceans" was used to create a multimedia review stack to support work in the classroom using the textbook <u>Globe Earth Science</u>. Scanned pictures from the text, imported still frames, and movies provide graphic material while text and diagrams help to explain the topics in more depth. Laser disc control is built into the stacks which also provide the teacher with a videodisc lesson plan that can be used during the regular teaching period.

• Multimedia HyperStudio stack to introduce visitors and parents to multimedia and its capabilities.

• The Globe Earth Science Stacks ("The Oceans") was completed and used with ninth grade students.

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[1] Results for 1993-94 are taken from Bernauer, J. (1995) Integrating technology into the curriculum: First year evaluation. Paper Presented at the AERA Annual Meeting, San Francisco, CA.

Student-Developed Hypermedia in Biology (10th Grade)
Students learned the fundamentals of multimedia development through demonstration and development using interactive laser disc, CD-ROM access, scanning, video capture and digitization (including QuickTime movie development), photographic digitization, telecommunications, and hypermedia production. After the technical hurdles were cleared, it was observed that the students began to focus on the planning aspect of their projects. They also demonstrated increased awareness of the design techniques needed for their projects -- critiquing each others' work may have helped in this area. Individual and small-group projects that coordinated objectives of the science curriculum with multimedia production, were used to facilitate cooperative learning. Textbook reference and a variety of technological resources were used by students to research their science topics and plan ways to actively present the material.

• The first lesson developed by Biology students focused on the topic of "Life Activities". Each student was given a life activity (reproduction, movement, etc.) to research and, after basic instruction in Hyperstudio, the students composed one card containing text, graphics, and buttons to access a laser disc frame or movie.

• The second multimedia lesson developed by students involved the study of the "Classification of Living Things". Students worked in pairs to research their topic (animals, plants, protists, or monerans) and planned a multi-card Hyperstudio stack containing text, graphics, laser disc control, and CD-ROM imports of photos and movies.

• The third multimedia project was more controlled requiring that students follow card-by-card instructions to complete a Hyperstudio stack related to the endocrine system. Students summarized information from their text and developed specific cards, laser disc control of movies and still-frames, and clip art manipulation.

• Multimedia dissection units where students learned how to import QuickTime movies and still-frame photos onto the computer.

• A "Multimedia Current Science Research Presentation" using Hyperstudio. Students gathered print information relating to a current science topic, and searched through CD-ROM's and videodiscs to find related visuals.

Student-Developed Hypermedia in Chemistry (12th Grade)
• Students first learned the basics of multimedia development including scanning, laser disc control, CD-ROM access, video capture and digitization, photographic digitization, and QuickTime movie development.

• Students worked in pairs to produce a Hyperstudio project related to the topic of classification of matter (elements, compounds, and mixtures). Students were free to combine any elements of multimedia development into the stack and create a stack of any length.

• A more structured project relating to the structure of matter was the focus of another project. Students followed card-by-card instructions to complete a fifteen card stack using scanned art and summarized text from their textbooks. Laser disc contro' and importation of laser disc frames to the computer screen were also used.

• As part of an independent study project on the topic of forensics, one student created a Hyperstudio stack utilizing scanned pictures of stuuents' fingerprints. The stack featured a game in which students had to analyze a suspects' fingerprint and match to one of the students.

• As part of the study in Forensics, one student discovered a telecommunications project through Classroom Prodigy featuring a game in which students had to recreate the face of a criminal as if they were a witness to a crime.

• The 12th grade Chemistry class completed "Multimedia Current Science Research Presentations" as described above for biology..

• The 12th grade Chemistry class also created multimedia lab reports using videotaped footage and still-frame images of themselves completing in order to complete required laboratory assignments. Students were instructed to incorporate all of the multimedia skills they learned throughout the year in order to create interesting and informative HyperStudio stacks.

<u>Teacher-Developed Language Arts Hypermedia</u>

• Modification of the "Literature In Navigation" Hyper Card stack to enhance student understanding of various aspects of literary theme in the novels *The Grapes Of Wrath* and *The Great Gatsby*. Teacher-developed essays were typed into the stacks and programmed so that the students could view specific scenes from the movie that dramatized various aspects of the novel. Students were then able to work independently to analyze literary techniques, characterization, and plot development to further enhance their understanding and appreciation of these literary classics.

• A HyperStudio stack to access the *Speechreading* laser disc produced at the National Technical Institute of the Deaf (NTID) for the purpose of independent speechreading practice and assessment.

<u>Student-Developed Hypermedia in Language Arts (12th Grade)</u>

Specific academic objectives for twelfth grade language arts that were met through the use of technology include: writing a personal essay (informative writing), writing a resume (application vocabulary, career assessment), writing a research paper (gathering resources, note taking, outlining, factual writing), giving an oral presentation (researching, organizing, and public speaking skills). Reading objectives include identifying and analyzing literary techniques (point of view, characterization, writing style, theme) in classic literary works. Other student projects included:

• Multimedia resumes in a Hyper Studio stack format, autobiographical text, scanned photographs, graphics, and Quick Time movies to demonstrate various aspects of their personal lives and educational and occupational experiences.

• Development and presentation of a multimedia speech on a decade in 20th Century American history. Students were taught to use advanced word processing features to write and revise outlines, take and organize notes, and write comprehensive paragraphs. They then developed Hyper Studio stacks containing scanned graphics and text to highlight aspects of their speeches. The stacks were connected to laser discs so that the students could use additional still slides and movies to further support their presentations. These speeches were presented to an audience of their peers and teachers.

• Production of a HyperStudio stack in a language experience format displaying a field trip to the Pittsburgh Zoo. The QuickTake camera was taken on the trip, and students took pictures of various animals. Students also wrote brief field notes and descriptive paragraphs about each animal upon returning to school. These paragraphs were then typed into the stack and, together with the digitized photos, were used to create a multimedia review of the experience.

Teacher Results

Tables 1 and 2 describe the characteristics of 18 teachers in the high school at the beginning of this project (September, 1993), in terms of general and technology-related characteristics.

Table 1. Teacher General Characteristics[1]

Characteristic	Number of Teachers			
Age	**20-29** 0	**30-39** 8	**40-49** 7	**50+** 3
Years Teaching	**1-5** 0	**6-10** 0	**11-20** 9	**20+** 9
Education	**Bachelors** 3	**Some Grad.** 4	**Masters** 11	**Doctorate** 0

[1]n=18

Table 2. Teacher Technology-Related Characteristics[1]

Characteristic	Number of Teachers (%)			
Skill	**Non-User** 1(5%)	**Novice** 5 (28%)	**Average** 7 (39%)	**Very Skilled** 5 (28%)
Usage	**Never** 2 (11%)	**Infrequently** 2 (11%)	**Weekly** 3 (17%)	**Daily** 11 (61%)
Use Where	**Never** 2 (11%)	**School Only** 5 (28%)	**Home Only** 0 (0%)	**School&Home** 11 (61%)
Training	**None** 0 (0%)	**1-3 Hours** 4 (22%)	**4-12 Hours** 5 (28%)	**13+ Hours** 9 (50%)
Use For[2]	**Nothing** 1 (3%)	**Instruction** 16 (41%)	**Remediation** 10 (26%)	**Personal** 12 (30%)

[1] n=18

[2] Teachers were asked to list as many uses as applied.

While 2/3 of these predominantly veteran teachers consider themselves as average or skilled with computers, the other 1/3 have had very little experience with technology. In terms of usage, the distribution is also skewed since 61% of teachers report that they use computers daily, while the remaining teachers use technology only once a week or less. This finding is of interest, since the reported frequency of use is an indicator of the extent to which technology is being used as a *tool*, for teaching and learning rather than for solely for "enrichment". The fact that only 41% of teachers use technology for instruction is a more direct measure of the extent of the integration of technology into the curriculum.

Table 3 identifies teacher concerns regarding how technology might negatively affect their roles as professionals, the inadequacy of their current skill level with technology, and how the introduction of technology might negatively affect their instruction. Data describing these three concerns were obtained from grouping items that related to each characteristic on the "Survey of Concerns Questionnaire" that was adapted from the Texas Center for Educational Technology and developing pre and post mean scores. Mean scores were obtained by averaging responses on a five point scale where a score of 1 was defined as "No Concern" ; a score of 3 as "Concerned" and 5 as "Very Concerned" for each of 17 teachers from whom data were obtained. Pre-test scores were obtained in November, 1993 and post-test scores were obtained in May, 1994. Indices of change include a percentage change from pre-test to post-test and the calculated dependent t statistic and associated probability levels.

Table 3. Teachers' Concerns Regarding Technology[1]

Concerns	Pretest	Post Test	% Change	t	p
Professional Impact	2.3	2.2	-5%	0.63	0.54
Teachers' Skill Level	2.0	1.9	-5%	.30	0.77
Instructional Impact	2.6	2.4	-8%	1.20	0.24

[1]n=17

Table 3 shows that there was a decline in concerns regarding the possible negative effects of technology in all three categories. However, the magnitude of the change was not significant from a statistical perspective. These results, however, do provide some evidence that teachers' concerns regarding the integration of technology into the curriculum declined somewhat during the first year of the project. In addition, the fact that there were relatively low levels of concern shown on the pretest (while restricting the amount of change that could be demonstrated and hence the probability of "significant" results) is quite encouraging since it is an indicator of willingness to accept the introduction of technology into the curriculum.

Student Results

There were a total of 86 students in the high school during school year 1993-94. Ten students were involved with this project in 10th grade biology and six in 12th grade chemistry. The purpose of this objective was to evaluate the entering behavior of these participating students in relation to technology and to assess changes in attitudes and achievement.

Table 4 describes two classes of sophomore biology students (n=10) and one class of senior chemistry students (n=6) in terms of their skill level and usage of technology as of September, 1993.

Table 4. Student Technology-Related Characteristics[1]

Characteristic	Number of Students (%)			
Skill	Non-User 0 (0%)	Novice 4 (25%)	Average 8 (50%)	Very Skilled 4 (25%)
Usage	Never 0 (0%)	Infrequently 5 (31%)	Weekly 0 (0%)	Daily 11 (69%)
Use Where	Never 0 (0%)	School Only 10 (62%)	Home Only 0 (0%)	School&Home 6 (38%)

[1]n=16; 10 sophomores (two classes) and 6 seniors (one class)

As can be seen from Table 4, 75% of these students consider themselves as "average" or "very skilled" in the use of technology compared to 66% of teachers (Table 2). These student self-assessments were confirmed by the lead science teacher. Although Table 4 does not show disaggregated data for sophomores and seniors, it was found that of the six students in the senior chemistry class, two or 33% classify themselves as average while the remaining four students or 67% consider themselves very skilled. In addition, while 69% of these two classes report daily use of technology compared to 61% of teachers, all six members of the senior class reported that they use technology daily.

To assess changes in student attitudes for the sophomore biology classes, a non-equivalent control group design was used. That is, while a control group was used, neither students nor teachers were randomly assigned to classes. Table 5 describes the results of a pre/post questionnaire that was administered in November 1993 and May, 1994. An independent t test was used to evaluate the difference in gain scores between the experimental class (participated in technology program) and the control group (did not participate in the technology program).

Table 5. 10th Grade Biology-Attitudinal Changes[1]

	Average Gain Scores (s.d..)			
Characteristic	Experimental	Control	t	p
1. Desire to Learn	.33(.41)	-.16(.24)	2.4	.05
2. Enjoy Science	0	0	-	-
3. Enjoy Cooperative Learning	.33(.82)	.38(.48)	-.10	.92
4. Feel Boredom	0(1.8)	-.75(1.5)	.72	.50
5. Enjoy Computer Work	.17(.41)	0(.82)	.38	.73

[1]n=10: Experimental=6; Control=4

The results indicate that the only significant difference between the control and experimental sophomore classes occurred in students' expressed motivation to learn. However, it should be noted that for characteristic 2 ("Enjoy Science") and characteristic 5 ("Enjoy Computer Work"), five of the six students in the experimental group already assessed themselves at the highest rating of "5" on the pretest so that no gain was possible. Parenthetically, it should also be noted that because of the small sample size of this study, finding statistically significant results is problematic due to the effect of sample size on the size of the "error" component; in effect, "statistically significant" results are not only a function of "true" differences, but also of the number of subjects used in a study.

Table 6 reports changes in attitudes for senior chemistry students during school year 1993-94. Since there was no control group available, a dependent t test was used to assess changes.

Table 6. 12th Grade Chemistry-Attitudinal Changes[1]

Characteristic	Pretest	Post Test	% Change	t	p
Desire to Learn	4.6	4.7	2%	1.6	0.18
Enjoy Science	4.3	4.6	7%	1.0	0.37
Enjoy Cooperative Learning	4.7	4.9	4%	1.0	0.37
Feel Boredom	3.4	2.5	-36%	-1.0	0.37
Enjoy Computer	5.0	5.0	0	-	-

[1]n=6

While no statistically significant differences were found (see note above on the effect of sample size), there was a large percentage decrease (36%) in the degree of boredom reported by these senior students with school. In addition, although not statistically significant, every percent change is in the direction expected based on the hypothesis that the integration of technology into the curriculum will have beneficial results on student attitudes. An underlying measurement issue is what exactly a small percentage change signifies on a five point scale. For example, although there was "only" a 7% increase in the reported enjoyment of science, what is not readily interpretable, is what this small increase may actually mean in terms of future student interest and motivation to pursue science.

To assess changes in achievement for the sophomore biology classes, a non-equivalent control group design was used. Table 7 describes the results of a teacher-made test that was administered in November 1993 and May, 1994. An independent t test was used to evaluate the difference in gain scores between the experimental class (participated in technology program) and the control group (did not participate in the technology program).

Table 7. 10th Grade Biology-Achievement[1]

	Average Gain Scores (s.d.)			
Assessment	Experimental	Control	t	p
25-item test	2.2(4.0)	1.8(1.8)	0.20	0.85

[1]N=11: Experimental=6; Control=5; 25 item test

While there was a larger average gain score for the experimental group (2.2) compared to the control group (1.8), there was a greater degree of variability within the experimental group (4.0) than in the control group (1.8); consequently, the calculated t was not found to be statistically significant. However, these results can be viewed as encouraging in the sense that they are in the expected direction.

Since no control group was available for the 12th grade chemistry class. a dependent t test was used to assess pretest/posttest changes both on a 40 item teacher-made test and on the SAT scores for science. This group was exposed to technology during the entire school term.

Table 8. 12th Grade Chemistry-Achievement[1]

Assessment	Pretest	Post Test	% Change	t	p
25-Item Teacher Test	22	27	23%	5.5	.005
SAT Science[2]	673	692	3%	3.6	.023

[1] n=5: 40 item test.

[2] SAT Science Scale Scores were obtained in 1993 and 1994

Even though both assessments showed statistically significant gains, no firm statements can be made regarding the effectiveness of technology-integrated instruction due to a lack of a control group and the attendant threats to internal validity (Campbell and Stanley, 1963). However, from a practical school-based perspective, these findings serve as positive indicators of student improvement.

Unexpected Results

While the results above flowed from the design of the study, there was another category of results that were unanticipated.

First, the quasi-experimental control group design that relied on a control and experimental group during 1993-94 barely survived this first year. This situation was due to the enthusiasm generated by the technology and the consequent desire of other students and teachers to become involved with technology. In a "messy" school environment, it was not only difficult to maintain the artificial control/experimental dichotomy, administrators quickly realized and agreed that it would be inequitable to withhold a "treatment" that was academically motivating to both students and teachers. However, from a research perspective, even though the design was not a true experimental one, it at least partially controlled for alternative threats to internal validity -- this control was lost relatively quickly.

A second unanticipated result was that some teachers began to feel uncomfortable in the classroom because they found themselves, as one teacher described it, as "standing around" rather than being the focus of instructional activity in the classroom. This new role for teachers emerged as *students* began to assume responsibility for working on projects that spanned several class sessions. For example, when social studies began to be integrated with technology in school year 1995-96, the teacher developed a task list for group work to design a multimedia project for W.W.II and a newsletter called *History Times* that was subscribed to by staff and faculty. At the end of each class, students noted on the task list where they stopped and then used this list at the beginning of the next period to begin work again independent of teacher directions or direct instruction.

I observed an especially poignant example of this new role of teachers as facilitators rather than as instructors in a ninth grade science classroom. The following activities were occurring:

• One group of students was downloading recent earthquake sites from the World Wide Web;
• A second group of students used another computer to write-up a report using the downloaded earthquake data and placed pins on a map where the earthquakes occurred;
• A third group of students fashioned ocean bottom terrain from clay to demonstrate some effects of earthquakes.

The teacher in this classroom acted like an orchestra conductor coordinating the activities and giving direction to the various individuals in the groups. In both the social studies and the science classes, a common ingredient was that project activities had to be developed by the teacher well in advance of the actual classes. Teacher classroom time was now spent assisting students who were actually *doing* the work rather than delivering instruction to them.

A third unexpected result has been an increased awareness among teachers and the principal for the need to extend class periods from their current fifty minutes and to initiate some type of block scheduling. While the advantages of longer class periods have long been thought beneficial for classes requiring materials such as vocational education, technology projects present a similar need and opportunity and will probably result in the school instituting block scheduling beginning with the 1996-97 school year. Projects that made this need clear were evident in both science and language arts including a module on motion for physics that incorporated digitized video recordings of balls being thrown on the soccer field and multimedia student resumes that incorporated text, graphics, video, and sound.

A fourth unexpected result was the creation of a school-wide technology committee that has been charged by the Superintendent to make recommendations for technology purchases, plans for future networking, and selecting future recipients of teacher-initiated grants. This committee is comprised primarily of teachers and some administrators (including the Principal) and is recognized as the group that will chart the future technology plans for the school. Prior to the formation of this committee, technology decisions were made by the Superintendent in conjunction with the Business Office and the Media Director.

A fifth unexpected result was that the school became recognized as a leader in technology integration beginning with the second year of the project (1994-95) This recognition came about primarily from the desire of the funder to disseminate results. Teachers responded to this request by presenting their work at regional and state education conferences. As a consequence of this recognition, the Carnegie Science Center of Pittsburgh asked that teachers develop multimedia workshops to be offered to teachers throughout the western Pennsylvania area. Approximately 200 teachers have now been trained by means of these workshops and various inservice presentations to school districts. In addition, as a result of teachers presenting their work at the Pennsylvania School Boards Association Meeting in 1995, several superintendents in different parts of the state requested that teachers make onsite visits to their schools -- funding arrangements still need to be worked-out to accomplish this wider level of dissemination.

As a consequence of both these expected and unexpected results, there has occurred what I call "Phase II Teacher Empowerment" where teachers have internalized the role of developer of curriculum as well as decision maker for technology integration. I believe that these roles have developed primarily as a consequence of the opportunity created by the Board's initial decision to offer Teacher Initiative Grants that led to "Phase I Teacher Empowerment" and the subsequent culture for teacher initiatives that gradually developed over a three-year period as teachers explored new ways to merge technology with teaching and learning. Perhaps as a result of the need to submit regular reports to funders, teachers have also become more aware of the need to collect evidence to support their claims of improved teaching and learning and there now seems to be a growing awareness among teachers of the need to do their own curricular research that uses more authentic methods of assessment rather than to rely solely on standardized norm-referenced tests.

Conclusions

The tentative conclusions of this project are as follows:

First, technology integration appears to not only offer a way to improve teaching and learning, but can also act as a lever for more systemic school change by affecting the role of teachers in the classroom, curriculum planning, and decision making. These changes are consistent with the view that education is a system, where a change in one part of the system (technology) can have positive effects on other parts of the system. Senge (1990) refers to this as the "trim tabs" in a system that can be used to send positive ripple effects throughout an organization. Clements and Swaminathan (1995) argue that teachers should guide students' use of technology and allow them to explore how they can individually and collaboratively design specific projects. It seems that the "standing around phenomenon" represents such a paradigm shift where teachers spend a great deal of time developing outlines for projects that are based on curricular goals and then use classroom time to promote student learning by *doing* rather than by passively receiving information. As a consequence, a school culture seems to be developing that is designed more for learning than for teaching (Peck and Dorricott, 1994) and raises the question whether it might be time to begin to refer to teachers as coaches and whether this perceptual change might help to promote the kind of "teaching" that will result in desired student outcomes.

A second conclusion was articulated by the Principal when she posed and answered the following question -- "would we continue to integrate technology into the curriculum if there were no discernible achievement gains?" Answer: "Yes"! The Principal reached this conclusion after stating: "First, we are covering the same amount of material using technology as we did without it; second, achievement is at least as good now as it was before; and third, we know that our students have achieved technological expertise and now routinely use technology as a pencil" (E. Moore, personal communication, January 19, 1996). This assessment is consistent with the Secretary's Commission on Achieving Necessary Skills in its SCANS report (1991) where recommended competencies for graduates include mastering the abilities to organize resources, work with others, locate, evaluate, and use information, understand complex work systems, and work with a variety of technologies. Daggett (1995) argues that schools must recognize that the world today is both highly technical and information-based and that students need to leave school with both the knowledge and practical skills that they can apply in a global society. Integrating technology into the curriculum seems to offer a way to promote both the competencies identified in the SCANS report and the knowledge and practical skills identified by Dagget.

A third conclusion relates to the need to identify and assess important student outcomes. Notwithstanding the Principal's conclusion that technology integration should continue even without discernible achievement benefits, the Superintendent decided in February, 1996 to evaluate how the school was doing in relation to other schools for the deaf and to regular public schools and to try and tease out any effects that could be attributed to the use of technology. This decision was based on the need to decide how to allocate scarce resources to most effectively promote improved student achievement. A consultant was hired to perform this study which is scheduled to begin later in the year. While the Principal agreed that it is important to gather baseline data, she has questioned the use of standardized tests as the primary outcome measure and has argued that the British model of inspection may offer a more realistic basis for evaluating school quality. At the time of this writing, a final decision has not been reached. In my capacity as Development Director and Grant Manager, I asked teachers in the fall of 1995 to identify products that they believe would provide evidence of student achievement of the most important goals for student learning in the areas of science, math, language arts, and social studies. As Herman (1993) suggests, when evaluating the impacts of technology, rather than lumping together all of the various teacher uses of technology and trying to evaluate overall school effects, schools should seek to evaluate the impacts of technology on valued outcomes such as attitudes and skills in writing, reading, and math as well as content-specific knowledge and understanding in the content areas. Herman also suggests that teachers assume the role of researchers which is consistent with the need to put teachers at the center of change (Hall and Hord, 1987). The specific reason for my request to teachers was to be able to incorporate these products in a report due to our major funder who was extremely supportive of efforts to use alternative assessment methods to capture student achievement in a meaningful and convincing manner. The report was due on March 15, 1996 and covers the period September, 1995 through February, 1996. Although teachers were quite willing to have students develop products for assessment purposes, it was apparent that they need more training in how to use product assessment as an evaluative tool.

A fourth conclusion is that there are distinct financial and other kind of benefits received by partnering with other organizations for technology integration. There is simply no way that this project could have been successful without the funds provided for equipment and teacher-released time. In addition, the need to report to a funder provided a mechanism for external accountability and dissemination where the funder had as much at stake in terms of success as the school. As of this writing, another large foundation has expressed interest in working with the school for the purpose of determining to what degree the lessons learned with this technology project could be applied to other schools. This foundation is especially interested in the organizational and leadership aspects that fostered technology-integration success. Empirical questions include the degree to which the public/private structure of this school, Teacher-Initiative Grants, and the relatively flat organizational structure, could be adapted to public schools.

A question that all school leaders must ask is to what degree programs and research findings are generalizable and replicable in their own schools. This present study was conducted at a school that serves deaf children and is characterized by a public/private arrangement and small class size and these unique characteristics are assuredly not trivial factors. Some leaders may, in fact, conclude that it is impossible to replicate programs from such a school. Others, however, may conclude that, while these differences are significant compared to the typical public school, the critical factor may be the decisions by school leaders to encourage and support the efforts and ideas of teachers for improving teaching and learning. In this study, teachers have come to own their ideas and this ownership and consequent empowerment are consistent with what many agree is needed to effect school improvement.

Finally, it seems that there can be no turning back in terms of technology and that institutions that train educational leaders need to promote the attitudes, knowledge, and skills to help incorporate technology into curricula. The Proposed NCATE Curriculum Guidelines (National Policy Board for Educational Administration, 1995) list under Area II (Instructional Leadership), the need for institutions to train leaders to use technology for curriculum and instruction as well as for school management, and to be able to make informed decisions regarding hardware and software. In addition, many of the emerging national content standards including math, science, geography, history, social studies, language arts, and civics incorporate technology into their standards (Donovan and Sneider, 1994).

Research and Assessment Directions

From a research perspective, the design for the first year was positivist and designed to generate objective numerical data for project evaluation. In retrospect, these data were not very useful from either an accountability perspective nor from an instructional improvement perspective. Based on recent meetings that I attended, it appears that an assessment plan is emerging that ill utilize standardized tests to obtain baseline comparative data and more authentic assessment methods to generate product and process data. Although the Superintendent and the Principal are co-directing this plan, my observation is that the Superintendent seems to be more concerned about the accountability aspect and the Principal more concerned about trying to create a portrait of the school that is more qualitative. The Principal's position is consistent with Biddle and Anderson's observation (1986) that qualitative research can be useful for generating new insights regarding what should be considered important outcomes before engaging in hypothesis testing and strict quantitative research. It may well be that the final assessment system will incorporate a two-track strategy (Bernauer and Cress, in press) that recognizes the need for one type of assessment data to promote school improvement and another type to provide an audit of school performance for accountability purposes.

Methods of assessment (such as performances) are an "alternative" to paper and pencil selected response items and can provide a more complete picture of student skills and products using scoring rubrics but require both creativity to design and informed judgment to evaluate. While many teachers are aware of such assessments, it seems that few have been able to actually integrate these assessments with instruction or to use them for accountability purposes. The integration of interactive technologies with curricular objectives offers the opportunity to utilize these techniques. Teachers at the Western Pennsylvania School for the Deaf are beginning to develop a variety of assessment methods that will enable students to critically self-assess the strengths and weaknesses of their own projects. Teachers plan to continue to develop these assessment strategies and use them as major evaluation tools beginning in school year 1996-97.

A danger that I came to recognize from doing in-house research is the need to construct case studies versus "case stories" (Biddle and Anderson, 1986) because the objective of research should *not* be "to confirm the investigator's commitment but to investigate a problem" (p. 238). I have found that the only effective way to combat this tendency to find one's own preferences in the data, is to involve persons external to the school system who do not have a vested interest in findings -- not always a pleasant experience, but necessary.

The Continuing Role of Leadership

After posing ten questions for educational leaders to ask themselves regarding technology in schools, Friedman (1994, p. 90) poses this final question and answer:

Question: "When will I have a computer and modem on my own desk so that I can access information, exchange e-mail with teachers and parents and serve as a role model for others in my system?"

Answer: Integration of technology is not a mechanistic act but part of a cultural revolution. In order for that culture to thrive it must be nurtured by all concerned-especially those serving as leaders"

Sustaining innovative approaches for teaching and learning require that leaders continue to provide support and encouragement to teachers. This aspect of school leadership has been described by Rhodes (1990) when he says that "Leaders must provide the connection to purpose, and to other interdependent functions that maintain systemic, systematic support" (p.33). Sarason (1972) maintains that leaders need to feel that they "own" a theory that will provide them with a perspective for identifying and manipulating critical theories in order to achieve those goals that are central to their conception of success. Underscoring the fact that continued support and guidance from the Principal and Superintendent are required to continue technology integration in this project is evidenced from comments from the lead science teacher. When asked if anything new was happening technology-wise in science with her science teachers, she answered "no" -- almost as an afterthought, she said that "she needs to work with them". (B. Goodman, personal communication, January 10, 1996). The pressing time demands from trying to do too much in schools require that leaders help to give focus and direction to teachers and teacher-leaders who feel stretched trying to "cover the material". Even though the school culture is changing at WPSD, it has become apparent that leaders cannot assume that the right things are continuing to occur; rather, the situation demands an ongoing inspection and commitment to provide time and staff development opportunities for teachers in order to help them to identify and promote the most important student outcomes.

Guskey (1994) when describing the critical components of effective staff development says:

> It has to be research-based, or there has to be some research evidence behind it...it needs to be implemented in a context that is supportive, where there are opportunities for teachers to work collaboratively and where there is an atmosphere that's open for experimentation. There needs to be regular follow-up and continuous support -- opportunities for teachers to share, to work collaboratively, and to be free from oppressive demands that prevent them from experimenting. There has to be some latitude recognizing that when teachers do something new, things may not go very well at first. (p. 26)

As Fullan (1990) argues, to be effective, staff development must become an integral part of an overall strategy that places the continuous professionalzation of teachers as a top priority. The literature from the 1980s supports the notion of teachers must be at the center of change. For example, Lieberman (1988) noted that the "second wave" of reform was focused not on curriculum and instruction but on teachers and the Academy for Educational Development (1985), after reviewing past efforts at school reform, concluded that:

> Without serious, sustained attention to the further development of teachers on the job, changes in curriculum and organization-indeed, even in the objectives of schools-will fall far short of hopes for achieving excellence. Excellence in public schooling and in teacher development can be achieved only if teacher development becomes school-focused. (p. 49)

While our experiences thus far with integrating technology into the curriculum and attempting to make cultural changes in the school have met with some measure of success, this success must still be described as tenuous. It is still necessary for school leaders to continue to provide a focus on integrating technology with important curricular goals and organizational purpose by providing the opportunity for the continuous professionalization and consequent empowerment of teachers -- without this continuing leadership role, future success is problematic.

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