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ABSTRACT

A program for infusing technology into the high school curriculum was initiated with grant funds at the Western Pennsylvania School for the Deaf in 1993-94. The first year of the program focused on establishing an Interactive Technology Lab, assessing teachers' readiness for the integration of technology into the curriculum and the effects of this technology on teacher and student attitudes and student achievement. Attitudinal and achievement changes were assessed in two sophomore biology classes and one senior chemistry class. Interactive video and electronic networking were the technological areas highlighted as particularly useful for deaf students, whose English language skills may be weak. Evaluation results were generally positive in terms of measured student and teacher outcomes and extremely positive in terms of the development of and capacity for delivering the technology-infused curriculum. The most important result may have been student enthusiasm for the technology. Eight tables present evaluation findings. (Contains 13 references.) (SLD)

Integrating Technology into the Curriculum First Year Evaluation

by

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INTRODUCTION

Technology has become a pervasive part of everyday life, affecting how we transact business, communicate, and perform our jobs. While the introduction of technology into schools has sometimes been justified based upon these "real-world" developments, stakeholders in the educational system sometimes want to know what effects the incorporation of technology into schools has on student outcomes. Even though much of the literature has been said to demonstrate an equivalency or advantage of technology-delivered instruction compared to teacher-directed, lecture methods (Bialo & Sivin, 1990), many of the effect size advantages for technology have been shown to be significantly reduced when the same teacher delivered instruction for both the experimental and control groups (Clark, 1985). That is, it appears that it is not technology per se that has resulted in improved student outcomes, but rather how the technology was used and integrated into instructional processes. Other studies have shown that the development of the curriculum by students, using technologies such as interactive laser disc, CD-ROM, and hypermedia, has resulted in improved student outcomes (Lehrer, Erickson, & Connell, 1992; Spoehr, 1992).

The gateway for integrating technology into the curriculum at the Western Pennsylvania School for the Deaf was a 1986 policy decision by the Board of Trustees to establish "Teacher Initiated Grants". These grants provided funding and release time for teachers who proposed projects that held promise for improving teaching and learning. The decision to offer these grants was based on the belief that teachers could contribute to improved teaching and learning by doing their own research. As an extension of this policy, one particular teacher, Barbara Goodman, decided to apply for external funds in 1992 and was awarded a one year Tapestry Grant from the Toyota Foundation. This teacher believed that the integration of multimedia into the science curriculum offered great potential for improved student outcomes. The purpose of the grant was to remaster existing commercial laser disc materials for use by deaf and hard-of-hearing students and to develop new software, based in HyperCard, for use in high school chemistry and physics classes. This teacher also began to engage in "action research" (although she wasn't aware that this was the accepted name for it!), by reflecting on how this technology promoted learning. Building upon the accomplishments of this initial project, the Department of Innovation and Evaluation, developed a three-year proposal to extend the integration of multimedia into the curriculum that included the development of an interactive technology lab and was based on the overarching need to provide teachers with adequate time to explore, learn, develop, and integrate multimedia into the curriculum. Initial funding in the amount of $15,000 was obtained from the Pittsburgh based PNC Foundation. Although these funds were far from adequate in terms of obtaining equipment and sufficient teacher-released time, they provided us with our first evidence that outside entities saw value in this project. We were also able to use this initial commitment as evidence of credibility to other potential funders.

In June, 1993, we presented a proposal to the Buhl Foundation that was based on the premise that technology is a tool that would help to improve teaching and learning if it was *integrated* into the high school curriculum. The proposal requested $190,000 over a three-year period for integrating multimedia into the science, English, and social studies curriculum and utilized a spiraling implementation model from one year to the next so as to ensure

continuity and a growing base of expertise within the school. While we did not obtain the full amount of our request, we were awarded $131,000 to support the project over two years with a possibility for funds during the third year. This support, together with the dedicated work of our teachers, enabled us to begin a program for infusing technology into the high school curriculum in school year 1993-94.

PURPOSE AND GOALS

The purpose of this study is to describe and evaluate the achievements of the first year of a three-year project for integrating interactive technology into the high school curriculum at the Western Pennsylvania School for the Deaf. This first year extended from October 1, 1993-September 30, 1994.

This first year of the project focused on establishing an Interactive Technology Lab (ITL), assessing teachers' readiness for the integration of technology into the curriculum, and a preliminary assessment of the effects of this technology on teacher and student attitudes and student achievement. Two sophomore biology classes and one senior chemistry class were selected as subjects in order to assess these attitudinal and achievement changes. In some ways, this first year was seen as a pilot year, since it was felt that there was much that needed to be learned in terms of design, instrumentation, and the nature of the emerging technology itself. The goal however, was to begin building expertise both in technology and in subject matter applications among teachers and students. It was also considered to be critically important to foster awareness and increasing participation by all teachers in the use of technology in order to maximize the promise that the benefits of this project would be continued beyond the initial three-year period by becoming a part of the school culture.

Among the many advantages of interactive technology is that it provides visual and highly motivating material, which can be especially effective with students who are deaf. In addition to providing clearer access to information, it was also believed that interactive technology could support student mastery of challenging content as well as higher order thinking skills such as application and synthesis *provided* that it was part of overall instructional processes that were designed to achieve these ends.

The overall goals of the project over the three year period were:

(1) to establish an Interactive Technology Lab (ITL) that would serve as the hub for development, student learning, and dissemination to the rest of the school.

(2) to develop and apply interactive technology materials and procedures within the WPSD High School, for instruction and learning in three major content areas over a three year period -- spiraling the implementation from one year to the next, to ensure continuity and a growing base of expertise. The content areas were:

- Science and English (Year I)
- English and Social Studies (Year II)
- Social Studies (Year III)

(3) to integrate this technology, with its related materials and procedures, fully into the curriculum development process at the secondary school level;

(4) to provide substantial released time for training opportunities in the technology and production process for three lead teachers (in Science, English, and Social Studies), and training for all other high school teachers;

(5) to evaluate teacher characteristics and concerns regarding technology and changes that occur during the project;

(6) to evaluate the effects of technology on student achievement and attitudes.

NEEDS AND EDUCATIONAL SIGNIFICANCE

(1) Characteristics of the Technology:

Why concentrate on interactive video and electronic networking? A s explained in the Smithsonian National Demonstration Laboratory Bulletin (1990), "Interactive video combines the versatility of a computer with the imagery of video to enable the user to control the learning environment". Laser disc and CD-ROM (Compact Disc-Read Only Memory) technology provide high quality graphics with either still frame 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 are especially compelling. Video technology offers these students an opportunity to learn via their primary mode of learning, while the interactive features support an inquiry-based, active method for learning.

Some studies investigating human learning has supported the hypothesis that interactive technology promotes a higher level of student learning than traditional teaching methods (Fletcher, 1993). Possible reasons for this difference include:

- students are more fully engaged and more active learners with interactive technology than with traditional classroom methods,
- interactive technology enables learners to progress at their own pace;
- interactive technology enables students to capitalize upon their own strengths or learning styles rather than forcing them to conform to one set pedagogical approach.

Laser discs, 8" or 12" in diameter, may contain up to 54,000 still frames or 30 minutes of full motion video (usually in brief movie clips) on each side. They allow immediate access to any of these images and allow the user complete control of whatever portion he/she wants to view at any time. When combined with an external computer and hypermedia such as "HyperStudio", these discs are extremely versatile, flexible and interactive. Rather than restricting student access to information in a linear format --from beginning to end, without any stops -- many laser discs are non-linear (Hypertext format), allowing the user to move at her own pace and according to her own learning style.

CD-ROM technology, although more restricted in motion and interactivity, can provide immediate access to stores of visual information -- graphically enhanced multimedia encyclopedias, dictionaries, and other resources -- with up to 270,000 pages of text on disc, 5" in diameter.

(2) Technology and Characteristics of Population:

Studies have documented a national median reading achievement level of only a 4th grade equivalent for deaf students in their final year of secondary school (Allen, 1986; Trybus and Karchmer, 1977), a level which often remains the same when these students become adults (Hammermeister, 1971).

The primary reason for this low level of achievement 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. Every day, the average American "spends about 70% of his active hours communicating verbally -- listening, speaking and writing" (Berlo, 1966). Significant reduction in this English language input, caused by hearing loss, can severely delay educational progress, especially in reading and written language, even for the many students whose basic intelligence is fully within the normal range.

Most deaf students acquire information most easily through visual means -- through the language of sign, through illustration, gesture and, significantly for this project, through video presentations. Although books are also visual, and therefore ultimately an excellent source of information for deaf persons, they are written in a language based on audition. Therefore, without many years of learning the English language, its vocabulary, syntax, and meaning, the deaf child will find many books highly frustrating and will begin to avoid their use. Cornett, Knight, and Williams (1979) label 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 described earlier, the potential advantages of interactive technology for deaf students were documented informally at WPSD using laser disc applications in physics. Specifically, the teacher involved in these science projects noted that her students:

1) exhibited a greater interest in learning science
2) had more interest in computers
3) demonstrated substantial gains in science achievement

A few other teachers, particularly in the math and English departments, were also involved with pilot classroom computer projects using Hypermedia technology and various graphics packages which allow the teacher or student to author curricula. These experiences also provided anecdotal evidence supporting the notion that interactive technology improved learning and motivation; however, because of time and cost restraints teachers were unable

to assess actual impacts on students. In fact, without additional funding for the rather costly technology, for the released time needed to develop and adapt materials, and for the training time required for a more inclusive number of teachers, the benefits observed from these pilot projects would more than likely have been short-lived and of little value for school-level improvement.

ACTION PLAN AND ACTIVITIES

One of the problems with technological advances in general education has been a lack of success in integrating technology into the curriculum, with the result that technology often is unused, underused, or is seen by teachers and students as irrelevant to teaching and learning. Several cases have been reported in the literature where software was purchased by a school and was then subsequently used on a limited basis -- "where teachers did not integrate into the curriculum and where learners did not make the promised gains" (Turner, 1993, p.5). Therefore, this current project was designed to avoid such problems and to provide for the optimum integration of technology with the curriculum.

The implementation plan was developed in conjunction with those teachers who had expressed interest in this technology and who were willing to commit to a three-year development effort. In addition, school administrators and support personnel had given their full support to this project. Because a very small pilot in science and math had already taken place, two of our teachers had already acquired a rather substantial level of expertise, which provided the school with a basis for future development efforts. The project was based on a three-year implementation plan for the purpose of integrating technology into the high school curriculum as follows:

In Year I (1993-94) of the project, the major planned activities were to:

(1) establish a "development team", lead by the lead-science teacher responsible for the implementation of the project;

(2) establish an Interactive Technology Lab (ITL), a special area in which activities focused both upon the development of interactive technology applications;

(3) develop applications specifically for high school science instruction;

(4) train other science teachers in the use of interactive technology

(5) train a lead-English teacher in the use of interactive technology since this teacher would assume the lead development role in Year II.

(6) involve students in the interactive development efforts, both for immediate feedback and for their own advanced learning opportunities.

The "Development Team" for Year I was comprised of the following professional personnel, each of whom contributed to the implementation of the project on a regular but part-time basis (approximately half-time for the teachers and 5-10 hours a week for the Project Coordinator):

1 Science Teacher (Consulting Teacher)
1 English Teacher
1 Project Coordinator

Teacher schedules were adjusted and released time provided so that team members had the opportunity to work together during the day in order to develop technology applications and plan for their integration into the curriculum. A full-time substitute teacher was hired for the first year of the project so that there was adequate time available for development and training and that released teacher-time would not compromise student learning. While this posed a difficult scheduling problem for the Principal, she recognized that released time was the key resource for promoting success of the project.

The "Interactive Technology Lab" (ITL) was established by the third month of the project -- both for the technology-related exploration, adaptation, application, and production activities; and for individualized student exploration and use. The lab was set up in a centrally located corner room measuring 17' X 26' (442 square feet) and is very close to the Principal's office as well as the classroom of the Lead Science Teacher. Because it is a corner room, windows provide adequate light and it was repainted and a new rug was installed to further improve the learning environment. In addition, new electric lines had to be installed to support the workstations.

During Year I, six Interactive Technology Workstations (ITWs) were purchased and placed in the lab. Each ITW is a complete unit for technology development and learning, and is comprised of a laser disc player, a MAC computer, a TV monitor, appropriate software, and video equipment for developing in-house multimedia. One of these workstations (MAC-Quadra 840) is more powerful than the student workstations (MAC-660 AVs) and is reserved specifically for teacher development of multimedia applications. For example, "remastering" of laser discs enabled us to take optimum advantage of existing software, much of which has excellent content material and graphics, but which is presented at a language level which makes this material inaccessible for many deaf students.

The development of interactive technology applications within the science area was the major content focus for Year I. The development team worked with the high school science teachers to generate these applications and to assure that they reflected the most important curricular goals in their classes. The consulting science teacher, because of her prior experience with technology, served as the lead development teacher. In addition, the designated English teacher -- who also had experience with authoring programs in hypermedia, was taught to create a greater variety of interactive media so that she could act as the consulting teacher for the development of applications in English during Year II (1994-95). Initially, it was thought that the largest percentage of teacher-time would be spent "re-mastering" laser discs to make them more consistent with the language needs of deaf students; however, it was found that because of the high level of enthusiasm among students, "development" was shared more with students. For example, teachers and students developed "Quick-Time" movies (digital movie briefs transferred from a video camcorder to the computer screen) that showed the students themselves conducting actual lab experiments -- determining velocity, energy expended, or pollution quotients. In the interactive laser disc pilot projects already conducted at the school, several remastered and newly created physics

materials had already been generated and were integrated successfully into the curriculum. However, time and equipment constraints prevented the development of similar materials in chemistry and biology; therefore, these areas became the focus for the first year of this project.

To assist in producing media that corresponded to the specifications of teachers, it was also thought that "computer specialists" would be needed to provide technical assistance. Again because of the enthusiasm and released-time for teachers for professional development, it was found that these teachers could accomplish most tasks themselves or locate outside expertise for specific questions. It became apparent that there was need for teachers to become "trouble-shooters" since too much time was lost looking for another person to solve relatively simple problems.

The training and involvement of all WPSD science teachers was a key factor in the implementation of Year I goals. Therefore, a very important role of the development team was to meet with and train these teachers -- to assure that the interactive applications in science did indeed fit into the established curricular goals and that they could be implemented by each of the teachers in his or her own classroom. These science teachers were encouraged to explore the technology and were provided with the opportunity to develop expertise in developing interactive-technology applications. The training of the English teacher designated to be Lead Teacher in Year II was concentrated not only on use of the materials but also in developing the technological expertise needed to remaster existing programs and to author new programs using the expanded and interactive technology. During this first year, this teacher also acquired a working knowledge of the processes and problems involved with leading this technology effort in Year II.

Students were included in the design so that they would be given the opportunity to gain valuable technical experience with multimedia applications as well as key content exposure; they also had the unique opportunity to develop and practice the higher-order thinking skills required for designing new materials and programs. It was anticipated that five students would be selected to be part of the development team and therefore to be involved in the production of interactive applications; however, it was found that most students could develop their own applications with guided instruction. In addition, students from each of the science classes were involved in using the materials that were developed, and had the opportunity to provide valuable feedback regarding the effectiveness and interactivity of these materials. This arrangement gave every student in these classes an opportunity to be a part of this project and to use higher-order thinking skills to plan and design applications.

Throughout Year I and in the subsequent years, the Project Coordinator was responsible for keeping the project on schedule, for coordinating activities among the other development team members, and evaluating and reporting on project progress to the funder. To ensure that the project would continue to become integrated with the overall school curriculum and instructional goals, the Project Coordinator kept the principal informed of all activities and met regularly with the teacher-developers.

Although we have not completed Years II or III, a brief description is included to provide a sense of the overall continuity of the project.

In Year II (1994-95) development efforts are to shift primarily to high school English instruction, with some beginning development work in the area of social studies. The development team will be comprised of the following members:

1 Science Teacher (Consulting Teacher)
1 English Teacher (Lead Teacher)
1 Social Studies Teacher
1 Project Coordinator

The major goals of the project and the overall implementation will remain very similar to those described in detail above -- modified by the experience of Year I. The major activities for Year II will be:

(1) obtain additional interactive technology workstations for the Lab in order to provide greater opportunity for student use;

(2) develop interactive activities specifically for high school English instruction;

(3) train the other English teachers in the use of interactive technology and train a designated Social-Studies teacher in technology-related development in preparation or Social Studies in Year III of the plan;

In Year II, the Lead Science Teacher will continue to act as a consultant, although in a reduced capacity, while the Lead English Teacher will assume the primary role in development of the interactive English materials. These materials will include a wide range of language arts content areas, including grammar, vocabulary development, basic reading skills, research writing, career skills, creative writing, and literature of all genre. Training will begin during Year II for the person who will serve as the Lead Teacher in Social Studies for Year III. A considerable amount of time will be allocated for preparing materials and tutorials for these teachers and for workshops outside of the school as part of dissemination efforts. The Project Coordinator will continue to draw together the various components and content areas involved in this process and will maintain regular contacts with the Principal to assure that the technology activities remain integrated with the educational process.

In Year III (1995-96) the overall goals and activities will remain similar to those of Years I and II, except that the content focus will be Social Studies. The members of the development team will include:

1 Science Teacher (Consulting Teacher)
1 Social Studies Teacher (Lead Teacher)
1 English Teacher
1 Project Coordinator

The major activities for Year III will be:

(1) to obtain or upgrade interactive workstations to provide expanded opportunity for student use, consonant with the expanded availability of materials;

(2) to develop interactive applications specifically for high school Social Studies instruction;

(3) to train the other Social Studies teachers in use of interactive technology

EVALUATION PLAN AND INSTRUMENTATION

This first year of the project was considered the most critical in terms of the project's ultimate success, since the activities conducted were intended to establish the capacity for future development efforts. Hence, evaluation of this year's activities focused primarily upon the process of establishing the Interactive Technology Lab, and training teachers and other development team members. Formative rather than summative assessment was stressed to ensure that the project was progressing satisfactorily, to assess teachers' attitudes toward the project components, and to determine whether any changes needed to be made.

However, while the emphasis in Year I was on capacity-building, it was also considered important to develop methods to assess the effect of technology on student attitudes and achievement. Instruments were adapted from the Texas Center for Educational Technology to measure the change in attitudes of both students and teachers toward technology. Student science assessments were also conducted both pre and post implementation (September and May).

The evaluation plan for Year I was based on attainment of the following outcomes:

(1) to establish an Interactive Technology Lab (ITL) within the school;

(2) to develop and apply interactive technology materials for science;

(3) to integrate this technology into the school curriculum;

(4) to provide training in the technology and production process for a core group of teachers;

(5) to evaluate the effects of technology on student learning and on teacher and student attitudes.

Table 1 describes the objectives of the project and the design and instruments that were used to assess the attainment of these objectives.

Table 1. Objectives, Design, and Instrumentation

OBJECTIVE	DESIGN	INSTRUMENTS
1. Technology Lab	Description	Journals/Logs
2. Develop Multimedia	Description	Journals/Field Notes
3. Integrate Multimedia into Instruction	Description	Journals/Lesson Plans/Field Notes
4. Train Teachers	Description	Journals/Field Notes
5. Teacher Attitudes	Pre/Post	TCET Survey[1]
6. Student Attitudes	Pre/Post	TCET Survey[1]
7 12th Grade Chemistry	Historical Contrast Pre/Post	Teacher-Made Test SAT
8. 10th Grade Biology	Comparative Groups	Teacher-Made Test

[1] Instruments were adapted from the Texas Center for Educational Technology

Objectives 1-4 were concerned with creating the capacity to deliver multimedia instruction in science -- assessment of these objectives was done through rich description. Teachers were asked to keep journals and field notes to aid in reflection about important processes and outcomes and also as a record of activity and achievement that could be used to generate the six-month reports that were required by the funding agency

Objectives 5-8 were concerned with assessing effects on students and teachers and it was for these areas that compromises had to be made. While random assignment of students and teachers to control and experimental groups provide the best way to assure internal validity (Campbell and Stanley, 1963), the reality of schooling usually prevents this kind of "true" experimental design. Neither teachers nor students could be randomly assigned to groups since this arrangement conflicted with prior educational placement decisions that were made based upon the criteria of maximizing teacher effectiveness and student learning. Therefore, the design used "intact classrooms" rather than random assignment. Another problem is the small number of students and teachers in the study. This, of course, is directly related to the comparatively smaller classes that are found in classes for deaf students compared to district schools.

The assessment of the effects of technology in chemistry required an additional design compromise since there was no control group available. In order to provide some basis for evaluation, a teacher-made test was used to assess gains and SATs were used as an additional measure. The TCET attitudinal survey instruments were modified somewhat to improve their readability for deaf students; the instruments were not modified for teacher use. While the quality of this study from a strict internal validity perspective is not extremely strong, it was the best that could be done under the circumstances. Since weaknesses in design, such as those described here, were unavoidable, our intention was to learn from Year I so that a better evaluation system could be put in place in subsequent years.

From the perspective of "external validity", generalization to other populations and for other "treatments" that are not an exact match to that described here, is also problematic. This uncertainty is attributable not only to the uniqueness found in a particular organization such as ours, but also to the complexity of the intervention. It may be the case, however, that some of the

lessons learned in this action research study, may be found to be useful to others who are thinking about integrating technology into the curriculum.

RESULTS

Results are presented here in relation to the objectives listed in Table 1 and cover the first year of the project--October 1, 1993 to September 30, 1994.

Objective 1--Create a Technology Lab:
As described previously, it was decided that the best location for the lab would be one that was centrally located to the classrooms of the lead science teacher and English teacher as well as to the principal's office. The first thing that had to be done was to run new electric lines and install adequate outlets as well as create more pleasant surroundings. The room was freshly painted and cracks in walls and ceilings were repaired. A new carpet was also installed.

By the end of Year I of this project, there were six Interactive Technology Units (ITU) for student use in the lab. Each ITU consisted of an Apple Quadra 660 AV computer, a Zenith TV that was used as a monitor, and a Pioneer laser disc player. Originally, each of these units were placed on long tables. Subsequently, movable AV workstations were purchased to house each unit. In addition, one ITU was acquired that consisted of a Quadra 840 computer. This unit was reserved for teacher development of multimedia in science and to some extent in English. There was also a "traveling" ITU available on each of the two school floors of the high school for use in classrooms and an ITU in the classrooms of the three lead teachers in Science, English, and Social Studies. All of these units were networked with an ETHERNET connection to facilitate the transfer of files and to support the future installation of video conferencing.

The following equipment is also contained in the Interactive Technology Lab: A Microtek color scanner for importing graphics into authoring programs such as HyperStudio, a Micronet removable cartridge drive for storing and transporting large image files, and an Apple QuickTake camera for digital photography. Overall, by September 30, 1994, the Interactive Technology Lab was fairly well established. However, the fact that students still had to double-up on computers and that storage capacity on the computers could not handle the large graphic files from clip art, CD-ROM, and Quicktime movies, made it apparent that additional improvements would have to be made in Year II.

In the technology-related interactive classrooms and lab, not only do students learn to use the laser disc and CD-ROM options discussed above, but they have benefited through new telecommunications capacity, using computer and modem connections. As part of this project, students and teachers have learned to access computer networks (such as INTERNET, PRODIGY, and America Online), and are now able to communicate with students across the country, both deaf and hearing, to discuss new ideas and research findings. INTERNET access has been greatly facilitated through a cooperative arrangement with Duquesne University.

Objective 2--Develop Multimedia:
By the end of Year 1, teachers developed the following materials:

A. Science

Teacher-Developed Hypermedia
1. "Remastered" Hypercard stacks that connect to the Physics of Sports 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.

2. Hyperstudio stack that introduces 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.

3. 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 Globe Earth Science. 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 videodisk lesson plan which can be used during the regular teaching period.

4. Remastering of the Physics of Sports Hypercard stacks was completed and will be tested with students later in the project.

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

6. The Globe Earth Science Stacks ("The Oceans") was completed and used with students in the 9th grade to review for tests. The students enjoyed working on the stacks and the teacher commented that "the students' test grades were above average for that class".

Student-Developed Hypermedia-Biology
1. 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.

2. 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.

3. The third multimedia project was a more controlled project in which students had to follow card-by-card instructions to complete a Hyperstudio stack about the endocrine system. Students summarized information from their

text and developed specific cards, laser disc control of movies and still-frames as well as clip art manipulation.

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

5. 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 videodisks to find related visuals.

Student-Developed Hypermedia-Chemistry

1. Students first learned the basics of multimedia development including scanning, Level 3 laser disc control, CD-ROM access, video capture and digitization, photographic digitization, and QuickTime movie development.

2. Using skills learned, students were paired 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.

3) A more structured project relating to the structure of matter was the focus of the third project. Students followed card-by-card instructions to complete a 15 card stack using scanned art and summarized text from their textbooks. Laser disc control and importation of laser disc frames to the computer screen were also used. This structure ensured that each student utilized all of the skills previously learned.

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

5)Again, 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.

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

7. The 12th grade Chemistry class also created multimedia lab reports using videotaped footage and still-frame captured images of themselves completing required laboratory assignments. They incorporated all of the multimedia skills they learned through the year into creative and informative HyperStudio stacks.

B. Language Arts

Teacher-Developed:

1. 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.

2. 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.

3. In conjunction with a unit on career planning, the students developed multimedia resumes in a Hyper Studio stack format. The students typed autobiographical text and then added scanned photographs, graphics and Quick Time movies to demonstrate various aspects of their personal lives and of their educational and occupational experiences.

4. To fulfill research and public speaking course requirements, the students developed and presented a multimedia speech on a decade in 20th Century American history. The students were taught to use advanced word processing features to write and revise outlines, take and organize notes, and write comprehensive paragraphs within the word processing framework. 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, teachers and various administrators.

5. Students produced 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 wrote 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.

<u>Print Materials:</u>
A variety of print materials were developed to serve as instruction, referral and evaluation sheets for the multimedia development projects:

- Level 1 and Level 3 Laser disc Control
- Bar Code Creation tutorial
- Creation of Laser disc Slideshows
- Importation of laser disc frames and movies to computer
- Hyperstudio Tutorial
  QuickTime Movie Development
- Scanning Instructions
- Telecommunication Tutorials for America on-line, Classroom Prodigy and the INTERNET
- Multimedia Product Evaluation Forms for teacher, self- and peer-evaluations
- Multimedia Presentation Evaluation Forms for teacher, self- and peer-evaluations
- Instructions for accessing multimedia materials for information search, graphics and movie acquisition and video disc frame
- Instructions for computer assisted research writing

- A multimedia performance test to assess the students' proficiency in using the equipment in the development of a variety of multimedia tasks

Objective 3: Integration of Technology into the Curriculum
Science: The development of multimedia materials was fully integrated into the top-level chemistry, physics, and biology classes. Students learned the fundamentals of multimedia development through demonstration and actual creation of the components of multimedia technology: 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 coordinating, 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. Students will continue to be given the opportunity to improve their technological, planning, and development skills within the context of curricular objectives. 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 relate to objectives in the following areas: Rocks and Minerals; Earthquakes; The Oceans; and the Physics of Sports.

Language Arts: Specific academic objectives for twelfth grade Language Arts that were met through the use of this 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, etc..) in classic literary works.

Objective 4: Training of Teachers
It was recognized from the outset of the project that its success rested on the continuous development of teachers' expertise in technology and that this could happen only if common daily time was provided for collegial work. The lead science teacher, who had the most expertise with technology, was responsible for training the Language Arts teacher who would become the lead teacher in Year II (1994-95). Basic use of the Macintosh computer and multimedia components were initially discussed and practiced together and training in the use of Level 1 and Level 3 laser disc control was completed as were the basics of telecommunications. However, it was soon discovered that because of the untapped potential with multimedia, that cooperative training was soon occurring. Important "finds" were subsequently made by each teacher with regard to hardware and software capabilities that were then shared. Because of this synergy, that was made possible by common shared time, development occurred at a much faster rate than initially anticipated. Mastering video capture, QuickTime movie development, scanning and Hyperstudio development

was a cooperative venture in which both teachers worked together to resolve the many hardware and software incompatibilities that were discovered. This cooperative atmosphere created an excellent learning environment for both teachers and many of the problems were easier to solve with two "heads" working together.

Science

All of the teachers in the high school Science Department were trained to some extent in the use and development of multimedia production and its integration into the curriculum. One science teacher was trained in the use of Level 1 and Level 3 laser disc control. Although this teacher has not been trained to create his own multimedia productions, he has been trained to use materials already developed or remastered by the Lead Teacher. This teacher also uses the laser disc "Life Science" index to create Level 1 laser disc presentations allowing three of his biology classes to view visual representations of some complex scientific concepts. Additionally, this teacher uses The Physics at Work laser disc at Level 3 utilizing the computer lessons previously remastered.

A second science teacher primarily uses Level 1 presentation of laser disc control within his science classes adding a visual link to the mathematics information presented through lecture. However, this teacher has also developed expertise in telecommunications usage in the use of the scanner. He has taught himself how to use video capture and photographic digitization equipment for presentation of materials through the use of Hyperstudio for the Apple IIGS computer and is currently learning how to transfer work from his IIGS computer to his new Macintosh AV computer.

A third teacher has been trained in Level 1 and Level 3 use of laser disc materials for Science and Social Studies and is currently preparing to use materials developed by the lead teacher to a greater extent. She will be able to present visual lectures coordinated with her textbook lessons and her students will be able to independently complete hypermedia lessons relating to her lectures. She additionally hopes to create multimedia tests in which the students must view laser disc and CD-ROM images and write essays about those images.

English

Six additional English teachers were trained in the following areas: CD-ROM and laser disc access, HyperStudio stack development, and telecommunications use. In addition, the teachers were trained to use the scanner, and to import live video and still digitized photos. In addition, the Speech Teacher in the Upper School was trained to use the Speechreading stack that was developed previously.

Objective 5: Teacher Characteristics and Attitudes

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.

As can be seen, there is a veteran and highly-educated staff in the high school. While 2/3 of these 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 role as a professional, 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%	0.30	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.

Objective 6: Student Characteristics, Attitudes, and Achievement

Characteristics

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.

Attitudes

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.

Achievement

10th Grade Biology

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 all of 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.

CONCLUSIONS AND DISCUSSION

The results of this study were generally positive in terms of measured student and teacher outcomes and extremely positive in terms of the development of the capacity for delivering technology-infused instruction. Perhaps the most important result was the enthusiasm shown by students in the "experimental" classes as well as the rest of the student body. While the initial design was considered adequate because of the segregation of experimental from control subjects, it soon became readily apparent that students in the high school were not neutral about the introduction of technology; rather, there was a general spillover to the body general simply because of the enthusiasm to use the new technology. Although not documented in the results, we were very surprised how quickly students became proficient in using technology as a tool for learning rather than as technology for its own sake. However, as an observer of the implementation process, I believe these achievements can be attributed to the planning and growing expertise of the teachers.

While the establishment of the capacity for integrating technology into the curriculum was our immediate goal, we realize that the continuous improvement of teaching and learning must serve as the true barometer of success. In addition, while assessing student outcomes using selected-response formats is an easier and generally acceptable assessment strategy, it does not support the teaching or learning of higher-order content and mental processes as well as does essay or performance formats. Consequently, as we continue with implementation, we intend to explore the use of alternative assessment methods as well as to identify more appropriate outcomes for evaluating the effects of integrated-technology. Outcomes to be assessed may include:

- Student mastery of challenging content and higher-order thinking skills
- Collaborative action research
- Collaborative teaching
- Constructivist teaching approaches and problem solving.
- Collaborative learning
- Teaching and learning "across the curriculum"
- Heterogeneous groupings
- Teacher-student interactivity
- Block period scheduling

There are several limitations to this study that need to be noted. First, because of the lack of random assignment of stud nts to classes, assurance of pre-treatment group equivalency is problematic for the sophomore classes. An even more severe threat to internal validity exists with respect to findings with the chemistry classes because of a lack of a control group. However, since the purpose of this study was to evaluate the implementation and results of a technology project in a school for the deaf, the "reality of schooling" was an overarching factor in the research! Since this study can be considered as "action research" , it was guided more by the values and goals of teachers rather than strictly by theoretical concerns. Therefore, while generalizability may be sufficient because of the real-life integration of technology into the curriculum, the existence of many "uncontrolled" factors such as teacher instructional methods requires a more "contextualized" research approach. In this first-year study, while student outcomes were indeed important, the actual establishment of a multimedia lab and multimedia materials, were of primary

concern. The development of instructional processes, while also of central concern, was seen more as an emerging result of both the development of technology and the collegial learning of teachers as they were given the opportunity to integrate technology into the curriculum.

Although not assessed formally in this study, informal observation and discussion with teachers revealed that teachers found themselves "standing around" in the classroom as opposed to their former role of directing instruction. This finding is important because it signifies a re conceptualization of the role of teachers in a constructivist and problem-oriented classroom. The fact that it was not thought of as a formal assessment item, may reflect the fact that the definition of research is still dominated by psycho-statistical design considerations rather than as a reflective approach for discovering what is actually important in the teaching-learning process.

Initially, teachers thought that they would do extensive development of their own programs for students to use by adapting the language to fit the needs of individual students. However, rather than spend time *showing* students what to do with "remastered" programs, teachers spent much of their time designing projects and tutorials to promote learning by *doing*. The belief underlying the use of these instructional processes was that goals for student mastery of content, the development of higher-order thinking processes, as well as skill in using technology as a tool, would be more effectively attained through a more constructivist approach. The phenomenon of "standing around" does not imply that teachers had less work to do; rather, teachers reported that most of their work occurred in the planning stage and not in the delivery of a completed curriculum. The use of multimedia integrated with instruction, required that teachers spend a great deal of time "setting the stage" so that students would have problems to solve that required their using print materials, live performances, as well as electronic media. Inquiry-based learning was incorporated with technology to a greater degree than what was observed in teachers' classes who still rely on being center-stage during the actual delivery of instruction.

An indication of the achievements and growing expertise of our teachers is that they have delivered professional development workshops for inservice credit to area teachers in cooperation with the Carnegie Science Center of Pittsburgh and have done on-site training at some of the more prestigious "hearing" schools in the Pittsburgh area. Presentations have been made at the National Science Teachers Association National Convention, National Education Computing Conference, Pennsylvania Association of Educational Communications and Technology Conference, and the National Symposium on Educational Applications of Technology for Persons with Sensory Disabilities.

Our goal is to continue to empower our teachers to deliver challenging content integrated with technology through appropriate scheduling modifications and ongoing professional development opportunities. Giving them assistance in evaluating their own work and how it can be improved using action research is probably the most important service that those outside of the classroom can render to promote the integration of technology into the curriculum and the continuous improvement of teaching and learning.

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