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"One Hundred Percent Efficiency:" The Use of Technology in Science Education Since 1900

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“One Hundred Percent Efficiency” The Use of Technology in Science Education Since 1900

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01. Introduction (Return to Index)

If there is a single word that is commonly associated with educational technology, it is "promise." .... Advocates of particular educational technologies such as educational radio, motion pictures, television, video cassettes, video discs, and computers have lauded the potential of their particular favorites as promising a revolution in education. (Levin and Meister 1985, p.1)

In the statement above, Levin and Meister began their examination of the disappointments associated with technologies over the decades. They found many areas in which to affix blame as to why technology had not accomplished its promised goals of revolutionizing teaching. Rather than focus on the sometimes giddy and often inflated promises of what technology was supposed to bring to teaching, this study focused on successful classroom practices using technology in science education. They were not promises; rather, they represented efforts by teachers to make use of new and innovative tools to help students learn.

The need for such a study is self-evident. The symbiotic nature of science education and technology have led to many individuals using technological tools to improve teaching and learning. Placing these tools into a broader historical context will help future educators look more objectively at the use of technology in the classroom, by offering perspective on its antecedents.Interest in using technology to “improve” teaching is as great now as it has ever been. National initiatives supporting the infusion of technology in instruction include federal legislation such as Goals 2000 and Secretary of Education Richard Riley’s (1997) goal that students should be entitled “to have their classroom connected to the Internet by the year 2000 and to be technologically literate.” (On-line) To this end, school districts sponsored “net days” and provided funds for technology and teacher training in its use.

Effective teachers use a variety of tools. Technology has given teachers the ability to adjust the relationship between time and space for students and themselves in support of the potential for highly engaged learning. As defined by Reynolds and Barba (1997), technology is electronic devices and products as well as the products created though the use of these devices. With these tools, teachers were given the means to both automate and innovate their classroom practices. Whether seeking to achieve Thomas Edison’s goal of one hundred percent efficiency in instruction or simply to develop a more sophisticated set of thinking skills, teachers found innovative uses for technology throughout the century.

Support for the use of technology emerged from all levels, including professional organizations such as the National Science Teacher’s Association (NSTA). The NSTA in 1998 stated:

NSTA recognizes and encourages the development of sustained links between the informal institutions and schools. Informal education generally refers to programs and experiences developed outside of the classroom by institutions and organizations that include...media [such as] film, broadcast, and electronic. (p. 54)

The use of technology ranged from the informal as described above–students watching television programs such as Bill Nye the Science Guy orNOVA, to highly structured approaches such as Optical Data’s Windows on Science videodisc series. In between were software programs that allowed and encouraged exploration by students, using the World Wide Web as a source of information and as a means of communication, and using software to create a presentation of their experimental results.

Connecting the use of these tools with the past and current ideas of scientific literacy provided the overall structure for this study as to what science education was all about. Scientific literacy represented a concept that evolved over the decades. In essence, it represented the purpose to which science teaching was to be dedicated. Over the decades it moved from primarily a content focus (National Society for the Study of Education, 1932)to a broader set of ideas which included also the thinking skills and goals for learning science in a way that would positively impact society for all its members (American Association for the Advancement of Science, 1993; Bybee, 1997; National Research Council, 1996).

To the reader with an interest in some of the curriculum movements of the late 1980s, this study recognized the contributions of the science-technology-society (STS) structure for science education. However, it does not focus on STS except to place it in the broader context of some of the primary curriculum issues of the 1980s and 1990s. STS regarded technology primarily as a philosophy and design process rather than as a set of tools (Solomon, 1994).

Scientific literacy represented the “why” of this study. Representing the “how” are the technological tools used to achieve goals in scientific literacy. In particular, the focus will be directed toward the use of three technologies and their roles in science education: the motion picture, the television, and the computer. While other technologies have been helpful in the process of science teaching, these three are still, in one fashion or another, still available for purchase. Each of these technologies was lauded as “solutions” to the problems faced by education; each offered many of the same promises for improved teaching and learning; and each was subsequently criticized for not living up to its promises. Following their evolution to the current practices in the 1990s affords the opportunity to see how the same tools were used during different conceptions of scientific literacy (King, in press).

What also emerged from this study were general findings with respect to the use of technology in science teaching; the trends associated with the use of technology in the science classroom, the ones unique to each technology, and the broader trends present among all three of them. In addition, how these trends impacted teaching practice and advanced the purposes of science education were examined.

Finally, the last purpose of this study was to provide a broader historical perspective for the use of technology in science teaching during the twentieth century and to offer suggestions for additional study. Examining the technologies of the past and examining why their potential was not met can provide insights into better use of technology in the future.

The need for this study is related to the purpose identified previously. With the ever-increasing clamor encouraging the use of technology in the nation’s science classroom, the utility of a historical study is clear. By placing contemporary uses of technology into a broader context, the current and anticipated uses of technology may more clearly be ascertained. Technologies that may be “mature” in terms of their theoretical use may be suffering from the struggles related to the early stages of implementation for some individual teachers and schools. To this end, this study will provide a comprehensive overview of how the motion picture, the television, and the computer have been used to support the goals of science teaching. If a future reader is able to perceive his or her use of technology as part of a broader canvas, then the goals of this investigation have been met.

Limitation of the study to three media was necessary due to the large array of possible technologies in current and past use in the science classroom. Each of the technologies examined during the course of this study remains in use in one form or another. Other technologies, such as the overhead, have no applications unique to science teaching such as the motion picture, the television, and the computer provide. Lastly, a comprehensive body of literature describing their use from their inception is available. Some technologies such as the overhead projector and the slide projector were veritable ciphers within the science education literature. These technologies remain for future investigations.

As part of the methodology, numerous representative software applications, television programs and motion pictures were examined. Examples of these pieces of software were contemplated during the narrative to show representative classroom applications of technology.

Before examining the motion picture, the television, and the computer, an audit of the various incarnations of scientific literacy was appropriate. This will offer the broader context for the remainder of this investigation.

.02. Scientific Literacy (Return to Index)

The view of scientific literacy underwent a number of transitions during the twentieth century. Though the term “scientific literacy” was first coined in 1958 (Hurd, 1958) and has come to represent a certain set of goals in the teaching of science, other science education goals have been present throughout the twentieth century. In the earlier part of the century, the primary consideration of what constituted scientific literacy related to the depth and scope of content knowledge by students (The Commission on the Reorganization of Secondary Education, 1918, 1920). As the decades wore on, to the content knowledge was first added a set of thinking skills and then a recognition of the role of knowledge in a broader societal context (National Society for the Study of Education, 1960; National Science Teachers Association Curriculum Committee, 1964). The acquisition of the thinking and content tools of science would allow the scientifically literate citizen to “engage intelligently in public discourse and debate about matters of scientific and technological concern.” (National Research Council, 1996, p. 13)

As various technologies have been used in support of teaching practice, they also reflected their times and the best thinking as to what constituted scientific literacy. The use of the motion picture and television, for example, was justified in terms of bringing the outside world to the classroom (Finegan, 1930; Freeman, 1924; Poole, 1950). Making a situation more authentic for a student and enhancing the student’s level of understanding provided justification for the use of a technology that was consistent with the existing concept of scientific literacy.

By the early 1990s, the concept of scientific literacy had expanded to make science learning more inclusive for all students. Science for all Americans(American Association for the Advancement of Science, 1989) was not only a title of a document promoting scientific literacy, but it also served as a signal that anything less than universal scientific literacy was not to be tolerated. For example, current uses of the computer as a classroom tool helped to develop this theme in classroom practice. The computer helped to provide all students with access to information, thus providing an avenue for all students to achieve the goals of scientific literacy.

Scientific literacy has come to represent the goal of science teaching. The complete acceptance of this goal can be seen as numerous states have adopted similar goals for their own state learning standards. Illinois, to take one example, identified a number of broad goals consistent with the pursuit of scientific literacy, as well as specific classroom-level objectives that are consistent with scientific literacy objectives.

The evolving definition of scientific literacy has been evident through the practice of science education throughout the twentieth century. The notion that students should have a command of the content and processes of science has been in place for most of this century (The Commission on the Reorganization of Secondary Education, 1920). What occurred as the century progressed was an expansion of the goal to include all students. In the 1950s, Hurd’s essay captured the essence of the need for a scientifically educated populace; by the 1990s, the idea of scientific literacy had formed the core of what science education should comprise.

Related to the evolution of the concept of scientific literacy was an observation by Bybee (1997) that one of the critical differences between the science education movements of the Sputnik era compared to those conceived during other times was that Sputnik era reforms were not organized through the development of policy statements. Most of the reforms of the 1960s tended to be curriculum packages and curriculum reforms, without the overarching structures of being part of a reform movement.

The reform movements of the 1980s and 1990s provided several competing, yet compatible views of the scientifically literate student. Reformers recognized the need for a scientifically educated student body, wise in the ways of science, technology, and society. A precise means of implementing the goals and policy remained a critical need through the end of the 1990s.

With similar goals adopted by the states and two national initiatives promoting the same general view of what represents scientific literacy, the broad notion of scientific literacy should remain intact for the foreseeable future. Barring another Nation at Risk type of document, with an emphasis on returning science education's focus exclusively to content, or a movement promoting the needs of an educated elite over the masses, the current conception of scientific literacy should take science education well into the next century.

The likelihood of a national curriculum of some form–including some goals related to that of scientific literacy is strong. Both the Clinton administration and the American Federation of Teachers have endorsed such a proposal; the Clinton administration's goal of national testing could serve as a first step toward the adoption of national educational goals and an attending curriculum. Arguments in favor and against this approach exist. The perceived need for consistency in content and identifiable goals for learning lend support to the introduction of a national curriculum. Arguing against a national curriculum are advocates of local control of schools and supporters of allowing maximum freedom for teachers to teach to the needs of their students. This argument will likely continue whichever approach the future holds.

With the context of one hundred years of science education providing the background, we may now turn to an examination of technology and its applications in science education during this century. A “how to” statement regarding the use of technology in the classroom was needed 100 years ago; it would still be of use today. How technology has been a means of enhancing scientific literacy provides the organizing principle for the remainder of this study. The assorted successes and failures using technology to achieve this end provide the narrative.

.03. The Motion Picture (Return to Index)

The use of the motion picture over the last nine decades underwent several transitions in classroom application. In 1922 Thomas Edison made the following statement regarding the use of the motion picture in instruction:

I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks. I should say that on the average, we get about two percent efficiency out of schoolbooks as they are written today. The education of the future, as I see it, will be conducted through the medium of the motion picture…where it should be possible to achieve one hundred percent efficiency. (Cuban, 1986, p. 9)

The “Wizard of Menlo Park” played a significant role in America's infatuation with technology, receiving several hundred patents over the course of his life. Many of his inventions and their direct technological descendants are still in use today. Also present is the attitude that technology can help us to achieve closer to “one hundred percent efficiency” in our daily tasks–including education. Looking back from the future Edison envisioned, the goal of “one hundred percent efficiency” has not been achieved, yet technology has impacted science education in ways that scarcely could have been conceived.

The film was one of the first electrical-mechanical technologies to enter the domain of education, with a long and storied history. One of the first notable articles on the use of the motion picture in science teaching came in 1913, in a brief article describing how the Germans had introduced the then-new technology into science teaching (School Science and Mathematics, 1913). In the early days of the motion picture in the science classroom, the focus was on two issues: efficiency and accuracy of content knowledge. Numerous studies attempted to teach students identical sets of content, with the experimental group experiencing film-based instruction and the control group exposed to more traditional methods of instruction. This, in principle, served to address both goals. Teaching larger groups of students and teaching with a minimum of teacher interaction served the purposes of efficiency (Finegan, 1930 Rolfe, 1924). Teaching with film as a tool allowed for the content knowledge to be prepared by experts, increasing the accuracy of the content (Rulon, 1933). This point connected strongly with the scientific literacy considerations of the early part of the century, when the increased quality of content knowledge among students was a critical issue. (National Society for the Study of Education, 1932)

As the decades wore on, and use of the motion picture became more common, advances in hardware, such as videotape, allowed for some changes in practice to take place that helped teachers to achieve more sophisticated objectives.

Further refinements in the pedagogy associated with the motion picture were part of this era. Walter, Brenner, and Kurtz (1957) examined the use of repetition and questioning as a tool to make more effective use of films in the science classroom. Though the significant effects of the study were small, it was determined that in the study’s experimental conditions, there was a tendency for boys to be more successful than girls through the use of motion pictures as an instructional medium. Significant in terms of this study was the drive to achieve increased use of the motion picture. Films were already an important part of the curriculum, according to the Walter, Brenner, and Kurtz (1957) investigation, so the question becomes what can be done to make their use more effective? How can student learning of science (i.e., scientific literacy) be enhanced? Other studies continued to seek more effective means for the use of the motion picture in the science curriculum.

The curriculum projects of the 1960s brought about an interesting application of the motion picture. Over thirty years after the introduction of the “talkie” as the standard approach for commercial and educational films, the film loop found a place in the science curriculum.

Rather than attempting to duplicate an entire lesson, or develop more than one idea in a lengthy film, film loops were single-concept artifacts. The film–a continuous strip–was enclosed in a cartridge for ease of operation. With the need for threading and rewinding the film eliminated and a simple set of controls for the teacher (which included the ability to stop the film loop in action, with minimal damage to the film itself), the film loops provided teachers with a means of better using the moving images to develop concept knowledge. The Physical Science Study Committee (PSSC) physics program is notable for the extensive library of physics film loops developed under its auspices. Such topics such as vector addition and the collapse of the Tacoma Narrows

Bridge (notoriously difficult to duplicate in the classroom) were among the many titles available.

In its current guise as videotape, the motion picture continues to serve as a helpful classroom tool. The convenience offered though the use of taping television broadcasts for classroom use has been popular with the current generation of teachers. As the availability of pre-recorded tapes continues to grow as it has over the last fifteen years, videotape technology will continue to find itself welcome in the classroom.

The videodisc provided another example of how improvements in hardware could be used to achieve educational goals Hinerman, 1991; Hoffmeister, Engelmann, and Carnine, 1989). The extreme flexibility of the videodisc allowed for a greater degree of interactivity in its use in the classroom. As an interactive frog dissection, it helped students to focus on relationships between systems as well as on the identification of individual organs. For teachers, the traditional ability to bring the world into the classroom was supplemented by the capability of arranging the sequence of video images in any order desired. Uses for review and assessment, such as those outlined with the Britannica Science Essentials series, were also helpful for achieving goals of science literacy in terms of providing an avenue for performance-based assessments of thinking skills, rather than rote recall of content knowledge.

A potential change in the distribution system of motion pictures may be made through the Internet. As connection speeds increase and allow greater amounts of information to be more rapidly accessed by teachers and students, the means of accessing video information will likely be from central distribution centers. This idea is already in practice with the Folkways and Twin\Tone record companies; music is available for consumer download rather than traditional over the counter purchase. This allows each company to keep their entire music catalog “in print.” For video, the process would be similar, with teachers able to access desired video images from a central distribution facility. This is similar in concept to the “Education Utility” endorsed by Gooler (1986). This approach will be addressed in more detail shortly.

Digital Video Disc (DVD) technology is another area of critical interest, offering improvements and refinements in other aspects of the software and delivery system. Possessing the information storage capabilities of a twelve-inch videodisc, and much more, with the physical size of a CD-ROM, it leads to a number of areas of interest, in particular the development of interactive multimedia applications.

DVD was available by the late 1990s as a medium for commercial motion pictures, but the area of particular interest is its potential as an interactive learning tool. The DVD offers the ability to include as much as eight hours of video content on a disc only five inches in diameter, along with eight audio tracks, and interactive hypertext capabilities (without the use of a separate computer). DVD will offer creative educators an excellent tool to share video images with students–and a challenge for the creators and developers of educational media to make use of DVD’s potential.

.04. Instructional Television (Return to Index)

The use of the television as an instructional tool may best be described in Fischbeck’s words: television wasn’t replacing the teacher–but rather just “helping out” (Eddy, 1971). Though television did not revolutionize the teaching of science as early advocates such as Poole (1950) had hoped, it did provide a useful tool for bringing the world to the classroom as had the motion picture in previous generations.

As with the use of the motion picture, literature surrounding the instructional use of television presented three distinct phases:

1. Development of interest and focus on the hardware.
2. Development of appropriate pedagogy, and
3. Dissemination of software as the use of technology enters a mature state.

Examples to support this view were evident throughout this study. Examples of the first phase included Poole’s Science Via Television (1950), Planning for Schools with Television (1960), and This is Educational Television(1954). Planning for Schools with Television, in particular, highlighted the technical issues associated with the hardware and classroom arrangements needed to optimize television teaching.

The second phase of television infusion, development of the appropriate pedagogy, was exemplified by works such as Diamond’s (1964) A Guide to Instructional Television, which detailed many of the important instructional issues related to the use of the television in the classroom. Many of the examples he used were designed to demonstrate the effective teaching of scientific principles via television. Many efforts during the 1950s and 1960s (see, for example, Rock, Duva, and Murray, 1952; Rock, Duva, and Murray, 1954; and Levenson, and Stasheff, 1952; Midwest Program on Airborne Television Instruction, 1961) helped to develop and disseminate effective pedagogy for television instruction.

The final phase in the evolution of the television as a tool for science teaching–the dissemination of software–was more problematic than with the motion picture. The availability of useful science television programming was through either a locally produced set of materials [see TV Schooltime(Caristi, 1997; Iowa State University, 1998), Fischbeck's General Science(Eddy, 1971), or the Hagerstown (David, 1963) application] or through programs which were more “educational” than “instructional” (NOVA, 1-2-3: Contact, or the Scientific American Frontiers series). Instructional applications were adapted on a case-by-case basis for science instruction by classroom teachers.

The example provided by the TV Schooltime series is particularly noteworthy. Developed as a means of getting information to students–by increasing their exposure to ideas and principles of science, it evolved from a content-centered approach to science education in the early 1950s to a more process skills orientation by the time of its cancellation in 1974 (Caristi, 1997; Davis, 1953; Iowa Joint Committee on Educational Television, 1952).

Though videotaping relieved the teacher from being held captive to the broadcast time slot, the limited availability of useful classroom materials has been the greatest deterrent to more liberal use of television in the classroom. Some children’s educational programming, despite the attention given to scientific accuracy of content, tended to support unfortunate stereotypes.

A final area for reflection had to do with the challenge of balancing entertainment versus instruction, especially when applied to the commercial television and cable ventures that were not related to a particular curriculum. The advantages of showing a diverse group of young people engaging positively in science would be considered a virtue; the entertainment value of placing television scientists in lab coats and fright wigs sent a different message (Steinke and Long, 1995).

The development of instructional television for the science classroom has undergone a transition from capturing live broadcasts to making use of videotape to use broadcasts at the convenience of the instructor (Barth, Payne, and Spague, 1958; Schreiber, 1952; Smith, 1961). This practice will likely continue. Also the transition from locally produced programming to programs produced at a regional or national level should also continue.

Instructional television, at the outset, offered a few key differences between itself and motion pictures. In particular, the ease of use for the technology and the ability to experience live broadcasts of some interest gave it an immediacy not offered by the motion picture (Schreiber, 1952). As the decades have passed, the increasing use of prerecorded broadcasts has allowed the differences between the motion picture and the use of a television as a teaching tool to become minimal.

Likely to change will be the means of receiving information via television. As in the home, the shift to cable and satellite-distributed broadcasts will likely become more common in schools (Dunbar, 1998).. This will allow for a greater variety of educational programming to be used in the classroom, and videotaping will allow the broadcasts–whatever the source–to be used at a time deemed appropriate by the instructor.

Klopfer (1980), drawing on several decades of experience, offered some thoughtful insights into the use of television in science education.

Among the alternative forms for science education, the use of television as a medium of science instruction has a history of about two decades. The medium has now outgrown its infancy, and sophisticated programs dealing with science topics and science-related social issues are being produced with increasing frequency. The advent of convenient, affordable videotape and videodisk playback systems promises to make a powerful instructional alternative readily available, since viewing of televised programs is no longer restricted to times when they can be broadcast…Via either playback systems or direct broadcast, televised *science programs offer a means for expanding scientific literacy of the entire citizenry, not only students in schools. (p. 4)*

The Internet may also find service as a means of bringing television broadcasts into the classroom. With greater sophistication in technology and greater delivery speeds occurring on a regular basis, the use of telecommunications technology to serve as a means of distributing television broadcasts would seem to be a logical progression in the classroom use of the television. As the video feed technology and content of the Internet continue to improve, it is quite possible that within a few years, the Internet will resemble a television set with thousands of channels available.

The Internet as a potential television receiver led to a consideration of what the future holds for the computer, and what new practices may be anticipated.

.05. Computer (Return to Index)

By examining the purposes served by the computer (as presented by Tinker, 1987)–as an instrument to acquire information, to analyze data, to offer creative expression, and to communicate with others–an appropriate organizational pattern was available.

The most common applications of the computer in science teaching were its use for simulation and information retrieval applications. Simulation software, available in both commercial and teacher-created varieties, provided an excellent means of developing science process skills and higher order thinking skills as a part of the student’s interaction with the software (Computer Learning, 1978) .

Microcomputer Based Laboratories, though well-represented in the science teaching literature, were challenging endeavors during their early incarnation. While it is certain that students would benefit from their use of the MBL, the requirements for the teacher’s knowledge base were extreme; few teachers would be likely to use them, due to the large amount of programming and hardware knowledge required (Cooper, 1983; Graef, 1983).

The Internet and Interactive Video were among the most recent technology infusions into science teaching. Interactive Multimedia provided a number of simulation and investigation experiences for students in the sciences, with the level of interactivity much higher than in previous types of simulations (Howe, 1983). The Internet, both as a source of information and as a communications medium, found its way into larger and larger numbers of classrooms during the 1990s. Several initiatives engaged students in interactive learning with other students located across states, nations, and continents (Journey North, 1998).

Scientific literacy issues were clearly supported by the use of the computer in the classroom. In particular, software that allowed students the chance to analyze and interpret data as well as empowering ever-larger groups of students to engage in scientific investigations, promoted the best ideas of contemporary scientific literacy (Thompson and King, 1997; King and Thompson, 1998).

Lastly, the pattern of hardware-pedagogy-software presented itself though any number of articles supporting the use of computer technology in the science classroom. As the development of hardware and software accelerated and the availability of computers in the home and school expanded during the 1980s and 1990s, so too did the number of articles assisting teachers with the infusion of technology in the classroom. Nonetheless, the pattern of hardware-pedagogy-software dissemination remained intact.

Reflecting on the place of the computer in science teaching, one was struck first by the similarity in the pattern of adoption seen with the motion picture and the television. The initial fixation on the hardware followed by the development of teaching strategies to be used with the computer represented the first two steps in the infusion of the computer in science instruction. Lastly, the application of software supporting instruction dominated much of the discussion pertaining to current computer use in the classroom.

Early articles in science teaching journals such as The Science Teacher, and Science and Children show this pattern. In the 1960s, focus on the acquisition of hardware was predominant. Slagel (1969), to cite one example, extolled the virtues of the computer as a tool for learning in the science classroom (See also Elmer, 1969). More than half of his article discussed not the educational strategies he used, but rather the process he went through to acquire access to computer technology. By the 1990s, the use of computer technology in the classroom had evolved significantly. In the best practices captured in the middle school science journal Science Scope profiled the use of the computer as a means of connecting students in different cities, but to allow them to manipulate the data and share the results (King and Thompson, 1998). These tasks in the Science Scopearticle were congruent with the contemporary conception of scientific literacy.

A challenge facing future curriculum developers may relate to the flexibility inherent in some of the new technologies. It may be that the pattern of hardware-pedagogy-software may become a relic of a simpler, pre-digital age. Scripting DVD for learning situations has essentially no precedents. When used in conjunction with the computer, approaches to learning involving the interaction between the learner and software may place the creation of the software before the development of the most effective pedagogy. At the very least, a more iterative process in which the movement ahead depends on the interaction among the pedagogy, software, and even the hardware would seem to be a conservative speculation.

An additional reflection on this continuum of how technology's use evolved in classroom practice related to individual differences within schools and within teachers. Though the theory and practices are well advanced, individual schools and teachers are located farther down on the continuum. How to accelerate this process and engage more teachers in the use of technology in their teaching remains a challenge.

Tinker (1987) described a number of conceptual uses for the computer: information acquisition, data analysis, creativity, and communications represent areas for growth in the use of the computer in the science classroom.

The area of information acquisition offers some exciting possibilities. As mentioned previously, the ability to transmit video images via the Internet is showing great improvements in both quality and speed of downloading. Enormous amounts of data and text are already available via telecommunications; adding improved video and audio to the database are the next logical steps.

From this point of view, entire curricula could be accessed electronically. The Education Utility, mentioned previously, provided a framework for this approach:

The Education Utility is an electronic delivery and management system that will provide instantly, to the desks of educators and students located anywhere in the world, massive quantities of continually updated instructionally interactive information (software programs, databases, sophisticated graphics capabilities, news services, electronic journals, electronic mail, and other instructional and administrative materials). All of these materials will be stored or accessed through a main "host" computer. Individual educational sites…will be connected via a state network. (Gooler, 1986, pp. 11-12)

Through this Utility, individualized instruction, group work, and large group instruction could be organized electronically. This sort of approach would be well-served by a national curriculum, as the Education Utility would be ideally situated to operate as a delivery and management system. The philosophical issue as to how this would impact student and teacher autonomy remains to be decided. It is worth considering also that the Education Utility described by Gooler was more than simply a theoretical construct: it described an actual working program. That it was developed a decade before the common use of the Internet suggests that it was a sound approach, but the lack of supporting technology and software prevented it from becoming a historical curiosity, as well as a model for delivering instruction.

. 06. Anticipation of Future Trends (Return to Index)

Having examined science education and technology through the course of the century, it is appropriate to place the use of technology in science teaching into a broader context and to consider other avenues for research into what the use of technology could bring to science education.

Technology has not necessarily produced radical innovations on the level of the teacherless classroom; rather, it has allowed some innovative activities to take place in individual science classrooms. Reports from science teachers have offered numerous practices that automated and innovated science instruction. Technology has been a tool for more effective instruction as teachers sought to achieve the evolving goals of scientific literacy.

Trends for the use of technology are difficult to predict. The leap from teaching machine to telecommunications was barely seventy five years: Pressey (1927) offered these thoughts on a teaching machine he developed in the mid 1920s:

The important feature of the work here reported is the exemplification of the fact that machines can be built which meet, automatically, certain very important requirements of efficient teaching. This apparatus is further evidence that labor-saving devices should be a possibility in the near future. (p. 552)

Two generations later, the Microsoft corporation promoted the use of their computer software with the slogan, “Where do you want to go today?”From the vantage point of a generation ago, some predicted that all teaching would have been taken over by machines in the name of both efficiency and effectiveness. What has transpired has been the use of technology to help students and teacher manage, present, and communicate information. The machine as teacher has appeared in some small ways, but the teacher using a machine is quite commonplace.

The greatest concern that can be expressed for science teaching is that the hands-on/minds-on experience should remain preeminent. Technology represents an important tool for effective teaching, but the heart of the science program should be developed around student inquiry with materials. Technology is best suited for extending and deepening the level of investigation and understanding, but not as a substitute for the activity.

Anticipated changes will take place in two areas. The first includes the issues discussed in this study–the hardware, pedagogy, and software associated with using technology in the teaching of science. This will allow students and teachers to gain more information, to manage their information more effectively, and to communicate between and among students and classrooms beyond a single room. Hurd (1997) summarized the advantages of technology in science education:

The transformation of our powers of observation and the technology for the management of data emphasizes that the practice of science comprises both theory and craft….We can expect more changes in the practice of science as the “information superhighway” develops and makes it possible to locate and access all the knowledge ever produced in the sciences. (Hurd, 1997, p. 55)

The other area relates to educational policy. The Education Utility represents a vision that would require a serious realignment of the organization of the classroom, school, and school district. The Goals 2000 initiatives represent another policy issue that may potentially impact the way science teaching is carried out. Technology can ideally serve as a tool of democracy and empowerment, so long as all students have access to its resources. A worst case scenario would allow the current disparity in educational funding to continue in its present manner. This in effect would deprive students from impoverished school districts of access to technology.

This problem of disparity could be exacerbated if commercial publishers offer high quality (and expensive) curricula via the Internet. Technology-rich districts could access the finest curricula available, ultimately leaving other districts poorer in the technology and knowledge available.

Other changes in technology hardware are worth noting: among them are the further development of DVD, and improvements associated with the information delivering potential of the Internet.

Current difficulties accessing information are related to slow download times or overloaded servers. As these difficulties are addressed and more useful information is made available electronically, the use of the Internet should continue unabated. Further, as the ease with which students may publish on the Internet increases, the potential to raise the use of the computer to a communications medium rather than an information retrieval medium is enhanced. Higher levels of interaction among students are generally associated with higher levels of engagement and higher levels of learning.

A consequence of the computer serving as a means of accessing information encoded on a DVD is the further blurring of the boundaries between the technologies examined in this study. As the computer itself becomes a single device that can deliver motion picture, broadcast television programs, and operate a wide variety of software, the various technologies examined here become separate but related applications in a single device. When the additional communications and information acquisition potential of the Internet are included as well, the computer has even greater potential to serve as a highly sophisticated educational tool–the Education Utility, indeed.

.07. Suggestions for Future Research (Return to Index)

A general statement regarding the use of technology in the classroom may be derived from Salomon and Gardner (1986). The focus of their article was to provide a caveat for those technology enthusiasts who would recklessly infuse the computer into classroom practice before sufficiently informed pedagogy was developed. Learning from the struggles of advocates of instructional television, they made the point that educators must

…realize that learners bring many assumptions, proclivities, and active learning strategies to any encounter with a new medium or technology; and…[to] expect a range of usages and experiences and a variety of outcomes from any encounter between an individual and a computer. It is particularly important to carry out background research before computers become completely pervasive in the educational environment. (Salomon and Gardner, 1986, p. 13)

It is now ten years later and too late for the background research to be carried out. The computer is present in many classrooms and serves in many schools an ornamental function. The suggestion to be made here is that as we prepare to welcome new technologies into the classroom, the initial baseline data we collect can be of invaluable help during later efforts at infusion into instruction.

There are many technologies that previously maintained a presence in science teaching but are seldom seen at this date. The filmstrip represented a very popular technological tool for teaching, but is not commonly seen at this time. The greater availability of videotape and computer technology appears to have eliminated the use of the filmstrip as a commonly found teaching tool. By the late 1990s, only one manufacturer of filmstrips could be located. The Good News Productions, International corporation offered a focus on the creation of filmstrips designed to " effectively proclaim the gospel of Christ to the peoples of the world, " rendering the content unsuitable for the typical secular science teacher (on-line). Examining how or why improvements in the computer and motion picture technologies led to the demise of the filmstrip as a teaching tool would be useful in terms of developing data regarding the useful lifetime of a technology. The value of the filmstrip still remains in terms of its content and value as an instructional tool; the machine, however has vanished. Seeking out the reasons for the demise of the machine may prove to be informative.

Other technologies, such as the radio and film loops, likewise had estimable tenures within science education. A determination of why so little software was produced to support their use would be enlightening for the same reasons as for the filmstrip. With respect to the radio in science education, what became of the radio? A technology as simple and ubiquitous as the radio must have disappeared from education for specific.

An investigation into the use of technology informed by social psychology–particularly the use of expectation-value theory–can provide further insights into teachers' uses of technology. From the perspective of expectation-value theory, individuals engage in certain behaviors based on two factors: the value they attribute to engaging in the behavior and the expectation they have for success. Technology, with its promise of serving as an effective tool for teaching coupled with the challenge of requiring new skills for its user, would be well-served by a critical examination of the relative weight applied to these two factors.

There is an additional area warranting further investigation based on classroom observations of actual teacher practices. Actual classroom practice often departs greatly from what is reported on surveys and other forms of teaching inquiry. Time spent observing the actual classroom practices associated with the use of technology in science teaching could be most revealing. Findings from this body of investigation might well be applicable to both preservice and inservice education as teachers evaluate the benefits of using technology when weighed against the costs involved in its infusion.

An investigation into classroom uses of technology in other fields would also be of interest. Rather examining the use of technology in the context of scientific literacy, as was done here, examining the use of technology from the point of view of the dominant theories from educational psychology could prove to be most illuminating. How the dominant behavioral perspective from early in the century impacted the use of technology compared with the cognitive orientation present today would be highly engaging and illuminating.

A critical element missing in many instances is the modeling needed in colleges of education. The role of modeling has been well documented in the teacher education literature. Until such time as colleges of education promote the use of technology by modeling its use in all methods courses and requiring its use by preservice teachers, it is likely to remain a seldom-used tool.

And finally, the literature would be well served by an extension of the heart of this study into the next century. A continued and detailed accounting of the use of technology to achieve scientific literacy into the next century will provide a depth and scope of detail as to science teacher practice with the use of technology.

.08. Reflections on this Study (Return to Index)

At the outset of this study, it was predicted that numerous teachers would infuse technology simply for the sake of using technology. In essence, it was anticipated that the technology itself would provide a driving force for the infusion of technology into instruction. The technologies examined related a different story. Technology was more often than not implemented to achieve a particular instructional end–such as achieving scientific literacy–and not to promote the use of technology for its own sake. A typical article cited the advantages of using technology to assist teachers as either an “extra set of hands” or as a means of helping to develop science process skills and higher order thinking skills. The connection between the goals of scientific literacy and the potential that technology has offered to achieve that end has been consistent. Technology has provided such a tool for achieving scientific literacy.

The use of technology in science education underscores the need for a strong and coherent curriculum. Technology can serve as an excellent tool in the pursuit of scientific literacy, regardless of the device.

The recognition that most uses of technology are devoted to automating instruction rather than innovating instruction is a point worth making. Most practices, particularly related to the use of the computer, had an antecedent that did not make use of the computer. Dissections, communication, accessing information, and many other practices were common experiences in the classroom. Technology allowed these activities to occur with greater efficiency in some instances, and opened up opportunities to students that would not otherwise have existed.

Another trend with technology use has been the movement away from the view of teaching the entire lesson–viewing technology as a substitute for the teacher–to using the technology in only certain capacities. Though many educators in the early part of the century would have advocated the efficiency of a teacherless classroom–with all instruction offered by motion picture–this approach never really became common. Most examples from the literature described practices that attempted to do this, but the review of the literature did not reveal many instances of this becoming standard instructional practice. In essence, selecting the best tool for the task has become the common practice. Science fiction dreams of teacherless classrooms remain a fiction rooted in the past.

Another issue to consider regarding the use of technology in the classroom relates to student access. Democratic issues regarding access to technology for all students are a real concern. For all students to experience the advantages of technology, more equitable funding practices need to be implemented for American schools. As long as poor urban schools have to “ration crayons, pencils [and] writing paper” (Kozol, 1991, p. 64) technological equality is chimeral at best.

The final word: good teachers use a variety of tools. Technology represents one of the most important and effective tools available to a classroom teacher. In all of its manifestations, technology represents a dynamic and engaging tool with which teachers may use to elevate their students’ understanding and appreciation of the goals of scientific literacy, now and in the future.

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19 THOUGHTS ON "“ONE HUNDRED PERCENT EFFICIENCY” THE USE OF TECHNOLOGY IN SCIENCE EDUCATION SINCE 1900”

E liquids
on **February 1, 2014 at 2:07 PM** said:

Obtaining My Kit To write electronic cigarette reviews, you have to actually dabble with the products. So I ordered my Green Smoke kit in December and was pleasantly surprised to discover it outside two days later. Blu Cigs, on the other hand, I ordered a month later, and I was quite disappointed because my e-cigarette kit took ten tediously lond days to arrive. So when it comes to delivery, Green is the winner.

best vacuum for pet hair

on **February 3, 2014 at 10:24 AM** said:

Hey! I know this is somewhat off topic but I was wondering if you knew where I could locate a captcha plugin for my comment form?
I'm using the same blog platform as yours and I'm having problems
finding one? Thanks a lot!

masticating juicer reviews
on **February 3, 2014 at 10:52 AM** said:

Fabulous, what a blog it is! This blog presents helpful facts to
us, keep it up.

best vacuum sealer
on **February 3, 2014 at 6:48 PM** said:

I blog quite often and I genuinely thank you for your information.
Your article has really peaked my interest. I am going to bookmark your site and
keep checking for new details about once a week.
I opted in for your RSS feed too.

best vacuum for hardwood floors
on **February 3, 2014 at 7:57 PM** said:

I love it when folks come together and share opinions.
Great site, continue the good work!

best espresso machine
on **February 3, 2014 at 9:45 PM** said:

Nice answer back in return of this question with firm arguments and telling the whole thing on the topic of that.

best scroll saw
on **February 3, 2014 at 10:22 PM** said:

I am truly happy to glance at this blog posts which consists of plenty of helpful facts, thanks for providing such statistics.

recumbent exercise bike reviews
on **February 3, 2014 at 10:24 PM** said:

My relatives always say that I am wasting my time here at web, however I know I am getting knowledge everyday by reading thes good articles.

best folding bike
on **February 3, 2014 at 10:27 PM** said:

I love what you guys are usually up too. This sort of clever work and exposure! Keep up the superb works guys I've added you guys to my personal blogroll.

band saw reviews
on **February 3, 2014 at 11:49 PM** said:

First of all I want to say superb blog! I had a quick question which I'd like to ask if you don't mind. I was interested to find out how you center yourself and clear your mind prior to writing. I've had trouble clearing my thoughts in getting my thoughts out there.

I do enjoy writing however it just seems like the first 10 to 15 minutes are usually lost simply just trying to figure out how to begin. Any recommendations or hints? Many thanks!

best rifle scope
on **February 4, 2014 at 12:18 AM** said:

Everyone loves it when people get together and
share views. Great site, continue the good work!

garment steamer reviews
on **February 4, 2014 at 12:34 AM** said:

excellent publish, very informative. I wonder why the other experts of this sector don’t notice this. You must proceed your writing.
I’m sure, you’ve a great readers’ base already!

induction cooktop reviews
on **February 4, 2014 at 12:50 AM** said:

You really make it seem so easy with your presentation but I find this topic to
be really something that I think I would never understand.
It seems too complex and very broad for me. I am looking forward for your next post, I will
try to get the hang of it!

best humidifier
on **February 4, 2014 at 1:39 AM** said:

WOW just what I was searching for. Came here by searching for songs

best table saw
on **February 4, 2014 at 2:24 AM** said:

When some one searches for his necessary thing, so he/she wishes to be available that in detail, so that thing is maintained over here.

best pressure washer
on **February 4, 2014 at 7:42 AM** said:

Hello there! This article couldn’t be written any better!
Looking at this post reminds me of my previous roommate!
He always kept preaching about this. I am going to send this information
to him. Fairly certain he will have a very good read. I appreciate you for sharing!

best crossfit shoes
on **February 4, 2014 at 6:06 PM** said:

I do not drop many remarks, but i did a few searching
and wound up here

best robotic pool cleaner
on **February 4, 2014 at 8:56 PM** said:

Your style is unique compared to other people I have
read stuff from. Many thanks for posting when you have the opportunity, Guess I’ll just bookmark this web site.

garbage disposal reviews
on **February 4, 2014 at 9:51 PM** said:

There is definately a great deal to learn about this subject.
I really like all of the points you’ve made.