CHAPTER 19 — IMPLEMENTING A TECHNOLOGY PLAN

Introduction

This chapter has two major sections, each focusing on a specific aspect of technology. The first, *Technology: A Bridge Between Mathematics Education and Thought*, opens with a brief vision of a technology infused classroom. It is followed by a discussion of the connections between mathematics education and technology. Since technology influences how and what we teach, the types of changes we might need to make concerning content, instructional practices, and assessment are also discussed.

In the second section, *Incorporating Technology into an Existing Mathematics Program*, a sample game plan is provided. The steps necessary to add technology to a program are explored and discussed in the order in which they should take place in a well-conceived curriculum revision. Special attention is paid to taking an inventory of current technology use, creating a vision of future use, drafting a plan for the district, providing for professional development, selecting appropriate hardware and software, and creating a budget and locating funding.

Technology: A Bridge Between Mathematics Education and Thought

Overview

The mathematics education community is in general agreement that learning is enhanced by doing mathematical assignments and projects that have meaning, by employing multi-sensory stimuli that improve retention, and by working in cooperative learning groups that foster group decision making and interpersonal skills. The use of technology in schools provides a vehicle through which all of these modes of learning can be realized. In order for New Jersey's *Mathematics Standards* to be fully implemented, technology must be infused into the daily lives of mathematics students in all New Jersey classrooms.

What might a mathematics classroom that uses technology to enhance all learning look like?

A Look at the Future

On the way to school, Ms. Gomez thinks about yesterday's excitement in her sixth grade class as students completed the tasks of collecting data about the circumference and diameter of a variety of 20 cans and jars they had brought to school. She wonders if the homework assignment in which students were to draw a conclusion by writing about the relationship between the circumference and diameter of the cans was too difficult for some of the students.

Shortly after arriving at the school, Ms. Gomez checks a variety of types of messages that she has received about the assignment: e-mail, faxes, and voice messages left by students and their parents as the students were working on the assignment at home.

She thinks about the messages from parents and students and then opens up a file on her portable computer to review the day's lesson plan to see if she needs to make further adjustments.

Ms. Gomez decides to present alternative strategies that may appeal to the various types of learners who are having trouble with the assignment. Her strategies include: using a calculator to guess and check, using a computer with a geometric sketchpad to draw diagrams of circles, and using a spreadsheet or a database to extend the problem to a general solution through investigation.

In order to assess whether these new strategies have provided students with a better understanding of the problem and solution process, Ms. Gomez circulates around the room with her hand held scanner recording individual student responses as her students work in cooperative groups. She will then be able to study and analyze each student's level of concept mastery.

After students discover the relationship, Ms. Gomez uses the video, *The Story of* π, to help students visualize and connect historically with how the concept of π was developed. Students who want additional information use several History of Mathematics sites on the Internet and retrieve more information about the development of π and the formula for the circumference of a circle.

As a culminating activity, students will create presentations about π using the multi-media workstation in their classroom.

While this vignette may seem a bit futuristic, Ms. Gomez and her students use only equipment and technology that people in business and industry use in their jobs every day and which are becoming ever more present in New Jersey classrooms! Central to this vision of teachers and students using technology to learn about π is the realization that technology can help to enhance, deepen, and extend learning. Technology is not simply a collection of faddish products that are fun to use. Technology does not lead us away from inquiry, but rather enables us to think anew about how we make sense of our world. As technology shapes our reality, we, in turn, through selective and specific use, shape it.

Curricular Implications

With the infusion of technology into the schools, the educational community will need to reevaluate the content, instructional strategies, and assessment devices that are current practices in our schools. What we teach, how we teach, and the means by which we evaluate the relative success of that teaching and learning are inextricably influenced by technology. As a result, some of what we have been teaching needs to be eliminated or revised. In addition, skills and strategies we previously didn't teach now need to be stressed.

This section addresses some curricular implications that arise from the incorporation of technology into the math classroom. While the following lists are not intended to be comprehensive, the examples provided are intended to illustrate the kinds of changes that should take place in the related areas of content, instructional practices, and assessment at both the K-8 and 9-12 levels.

Suggested K-8 Curriculum Changes and Revisions

Content:

- Greatly reduce the amount of cumbersome paper-and-pencil computations such as: unreasonable column addition, large multi-digit operations with whole numbers and decimals, long division, and fractions with unrealistic denominators. Students must not, however, become dependent on calculators and computers to perform computations that can more efficiently be completed without the use of technology.

- Move away from teaching and learning which are focused on disconnected skills.
- Add content that emphasizes real-world settings and problems which call for the intelligent use of estimation, mental math, and number sense.
- Add projects and investigations that use technology to help students make connections among the different strands of mathematics as well as to content from other disciplines.

Instruction:

- Move away from rule-based mathematics, rote drill and practice, and teaching strategies that confine the teacher's roles to providing information and confirming solutions.
- Use group explorations with calculators, data bases, spreadsheets, and computer environments such as Logo. The explorations should frequently revolve around open-ended problems or projects for which there are many possible solutions.
- Use multi-media technology to address the diverse learning styles of students. Multi-media workstations can offer all students dynamic presentations of real-world applications that cannot easily be replicated in the traditional classroom setting.
- Use technological research tools, like the Internet, to enable students to collect real-world, up-to-the-minute data about mathematical or scientific issues of concern to them, and then to share their findings and conclusions with other students around the world.

Assessment:

- Avoid assessments that stress only or primarily computation.
- Use assessments that reflect the changes made in content and instruction. Be sure to provide for the use of appropriate technology when assigning group and individual projects, open-ended questions, and journal writing.

Suggested 9-12 Curriculum Changes and Revisions

Content:

- Revise courses that do not allow or encourage the use of calculators and other technology. Reduce the emphasis on procedural and symbolic manipulation skills.
- Eliminate segmented, discrete subjects and courses that treat various strands of mathematics as separate entities rather than parts of the whole. The United States is one of the few industrialized countries of the world that does not organize and teach mathematics as an integrated discipline.
- Add topics, subjects, and courses to the curriculum that reflect an integrated approach to mathematics so that computers and calculators can be utilized to enable students to see the connections between data analysis and algebra and between algebra and geometry.
- Add technology-enriched topics such as matrices, self-similarity, the iterative process, dynamic systems (chaos), probability and statistics to the curriculum for all students. These topics are both easier to teach with the new technologies and more important for an understanding of today's

mathematical world.

- Use the investigative power of computers and calculators to build intuitions about mathematics. Such topics as key sequence, scaling, zoom-in, zoom-out, domain, range and cell definition take on new and deeper meanings in a technological context.
- Use calculators and computers to help students explore and develop conceptual understanding. Graphing utilities and instructional software such as the *Geometric Supposer* or the *Geometers' Sketch Pad* enable students to visualize relationships and test ideas quickly.

Instruction:

- Greatly reduce the occurrence of *watch and do* mathematics. Instructional practices which emphasize teachers lecturing and students sitting quietly, practicing procedures and memorizing rules, fail to take advantage of the variety of tools available to help students build solid mathematical understanding.
- Emphasize estimation and visualization so that conjectures can be confirmed through computer and calculator use.
- Use technology to diversify instruction to take better advantage of whole class, small group, and one-to-one opportunities.
- Use multi-media technology to address the diverse learning styles of students. Multi-media workstations can offer all students dynamic presentations of real-world applications that cannot easily be replicated in the traditional classroom setting.
- Use technological research tools, like the Internet, to enable students to collect real-world, up-to-the-minute data about mathematical or scientific issues of concern to them, and then to share their findings and conclusions with other students around the world.

Assessment:

- Reduce the use of assessments and questions that only require recall of knowledge and note manipulation of rules and fail to assess conceptual understanding.
- Increase the use of assessments that require calculator and computer use.
- Use assessments that encourage student investigation through the use of technology.
- Allow students to construct answers to open-ended, essay-type questions with the use of a word processor that has the ability to import graphs and charts to encourage the connections between language and mathematical representations.

Incorporating Technology into an Existing Mathematics Program

Developing a Technology Plan

Any technology plan must recognize that the velocity of change and growth in technology will make last year's innovation archaic by next year or the year after. In order to make recommendations for curricular improvement, a technological infusion plan needs to be developed. The plan for increases in technology in the mathematics classroom needs to be clearly outlined with distinct educational goals. Additionally, the plan needs to be flexible enough to allow the professional staff to modify their expenditures in response to the available hardware and software and the changing technological environment.

In the box on the next page, a game plan is provided which describes the steps that need to be taken to assure appropriate integration of technology in the mathematics program. While the list is organized chronologically, and the steps are intended to be completed in the order listed, no real-life process will ever be as smooth and easy as this theoretical model. Given the different technologies to be integrated, the realities of merging the instructional needs of mathematics with those of other content areas, and the myriad of issues that surround funding possibilities for the infusion, many of the items on the list will most likely be addressed at more than one time and quite possibly out of the ideal sequence. The list does serve, however, to remind planners of the many issues that need to be addressed in this kind of innovation and of their interrelationships. In the box, items marked with a * are discussed further in separate sections, while the remaining items are relatively self-explanatory.

Making an Inventory

One of the first steps in ascertaining what is required to create technology-oriented mathematics classrooms is to inventory current practices concerning technology use. A sample questionnaire to aid in the conduct of such an inventory is provided in the Appendix. There are several points to remember in the survey:

✓	*SUGGESTIONS*

✓ Use separate survey instruments for elementary and secondary levels. The needs and objectives at the two levels are very different and a single instrument will be incapable of probing both.

✓ Focus on instructional uses of technology only. Do not try to address administrative and school record-keeping or scheduling needs at the same time or with the same equipment.

✓ Create questionnaires that ask probing questions and require the respondents to provide detailed answers. Some of the best ideas and suggestions will come from staff members who have been prompted to share additional ideas.

Creating a Vision

Understanding the relationships between technology and mathematics education is critical, and an important starting point is a strong statement that expresses those relationships as they will be embodied in your district. Steven Willoughby wrote, “Rapid developments in technology are changing (and ought to be changing) the way we teach mathematics both because they modify our goals for the mathematics education of people and because they provide new tools with which we can better achieve our goals” (*Willoughby,* 1990, p. 60). It is evident that what is stressed in instruction and assessment will be altered as a result of the use of technology. “Template exercises and mimicry mathematics — the staple diet of today’s texts — will diminish under the assault of machines that specialize in mimicry. Instructors will be forced to change their approach and their assignments. It will no longer do for teachers to teach as they were taught in the paper-and-pencil era” (*Everybody Counts*, 1989, p. 63). We have the opportunity and the responsibility to use and be influenced by technology in order to help all of our students become mathematically powerful.

Technology Infusion Game Plan

1. Establish a District Technology Steering Committee which includes at least one mathematics teacher.

2. Establish a K-12 mathematics technology committee to develop plans which clearly identify issues, develop time lines, and focus on determined goals. This committee should function as a math-specific subcommittee of the District Technology Steering Committee and should report its findings and recommendations to that group. It should also propose a professional development plan in mathematics for the district staff.

3. * Inventory the current mathematics program with regard to technology infusion and use.

4. * Develop a vision and then goals (long term, short term, and immediate) that will enable the district to achieve technology-oriented mathematics classrooms.

5. * Write a draft of a district technology plan using the information gained through the inventory, as well as input received from all of the content-specific committees and other stakeholders. Special attention should be paid to the gap between the results of the inventory about present technology use and the vision and goals expressed for future use. Widely disseminate the draft, asking all stakeholders to respond, react, suggest, and question the technology plan. Revise the draft and again disseminate the plan. Continue this process until consensus as to the vision, goals, means, and assessment is reached.

6. * Begin a strong staff development program even before hardware and software purchases are made and provide additional training whenever new software or hardware is purchased.

7. Evaluate available software. Decide on the appropriate balance between software that promotes higher order thinking skills and software that provides drill and practice.

8. Begin to plan courses and instructional programs that truly integrate the technology.

9. Be sure that your district plan addresses compatibility of equipment throughout the district, buildings, and departments. While it is sometimes acceptable to use incompatible hardware in different buildings or even for different uses within the same building, such decisions should be made with great care and for compelling reasons.

10. Decide on a maintenance program before equipment is purchased. Decide on a person at each site who will be responsible for keeping the equipment in running order.

11. * Determine the hardware that is best suited to run the selected software.

12. * Prepare a budget and seek internal and external sources of funding. Technology should become an annual budgetary item and a board of education policy should be passed to support the use of technology for all students.

13. Buy enough equipment so *all* students have equal access.

14. Begin to offer the technology-enriched program.

15. Make computers available to staff and students before, during, and after school.

16. Plan for the continuous upgrading of software and hardware and for the regular evaluation of the instructional programs which use the technology.

To that end we need to consider the role of technology in connection with how we educate our students and prepare them to be life-long mathematical learners. Generating a mission statement, goals, and curricular objectives, and reviewing educational guidelines established by state, national, and professional organizations represents our beginning point. It is important to note, however, that we in New Jersey are not starting at ground zero. There is much work that has been done in this area on a statewide level that represents both valuable resource material and even mandates. The 1993 report *Educational Technology in New Jersey: A Plan for Action*, prepared by the New Jersey Department of Education, outlined a bold plan for the entire state's progress. Current documents with information about educational technology, such as the Department's Strategic Plan, are posted on the Department of Education's home page at http://www.state.nj.us/education. Districts should be aware that the New Jersey State Board of Education adopted a resolution in August, 1992 that requires that the Early Warning Test (EWT) and the High School Proficiency Test-11 (HSPT-11) "be constructed on the assumption that all students will be using calculators as they take those tests." Given this resolution, districts must start their technology planning by establishing student proficiency with a variety of calculators as an absolute minimum level of expectation.

Professional Development

Even before hardware and software purchases are made, and for a considerable period of time afterwards, professional development of mathematics teachers in the district is essential. Studies have shown that the amount of technology-related teacher education in a district can be a significant factor affecting student achievement.

✓	*SUGGESTIONS*

✓ The National Council of Teachers of Mathematics (NCTM) recommends that teachers model the use of calculators in computation, problem solving, concept development, pattern recognition, and graphing. The NCTM Position Statement on *Calculators and the Education of Youth* suggests that "school districts conduct staff development programs that enhance teachers' understanding of the use of appropriate state-of-the-art calculators in the classroom." (*NCTM*, 1991)

✓ NCTM also calls for teachers to be "educated on the use of computers in the teaching of mathematics and in examining curricula for technology modifications ... Teachers should be able to select and use electronic courseware for a variety of activities, such as simulations, generation and analysis of data, problem solving, graphical analysis, and practice." The NCTM Position Statement on computer use goes on to state that teachers should be able to use various programming languages and spreadsheets and to keep up with advances in technology. (*NCTM, 1994)*

✓ The Association of Mathematics Teachers of New Jersey, in an effort to support the professional development efforts of the state's teachers in this area, published *The New Jersey Calculator Handbook* in 1993. It contains numerous sample professional development plans and workshop outlines and includes many suggestions for the use of calculators with K-12 students.

✓ Teachers' professional improvement plans may include objectives for implementing technology into the classroom. In order to assist the teacher in reaching the objectives, staff development needs to be extensive and ongoing. Districts must provide time for extensive exposure regarding the use of technology in the mathematics classroom via conferences, expert instruction, individual exploration, refinement, experimentation, observation of other teachers, review and discussion of print and electronic materials, and teamed instruction.

✓ Attendance at professional conferences is essential for motivation, development, and maintenance of technological awareness. Conferences such as the annual meeting of the Association of Mathematics Teachers of New Jersey and regional NCTM conferences provide a broad overview of the many technological products available for classroom use. In addition, they also provide a fertile environment for proposing and exchanging ideas.

✓ Programs such as TRANSIT-NJ promote systemic change in mathematics education through the use of technology. In-service workshops and follow-up meetings help teachers become proficient at enhancing the instructional environment through the use of calculators and computers. Schedules of programs for teachers can be obtained by calling (201) 655-5353 or via email at wolffk@alpha.montclair.edu.

✓ Professional development resources to facilitate the use of technology in promoting inquiry-oriented instruction in K-12 mathematics and science are available from the Center for Improved Engineering and Science Education (CIESE) at Stevens Institute of Technology. Resources include workshops, video series and related print support material, Internet-based lesson activities, administrator conferences, and turnkey training programs. Use of the Internet for collaboration, consultation with experts, and access to "real-time" data on scientific and natural phenomena, as well as instructional mathematics software are emphasized. For more information, contact CIESE at (201) 216-5375 or via email at pdonnell@stevens-tech.edu. Web site: http://k12science.stevens-tech.edu.

✓ Provide professional and support staff inservice activities focusing on specific aspects of technology in the mathematics classroom. Consultants (within and outside the district), curriculum coordinators, and telecommunications networks are some of the sources who can provide services.

✓ Provide teachers with work areas furnished with the same technology equipment and supplies found in their classrooms or laboratories. These work areas need to be available before, during, and after school.

✓ Professional development must focus not only on instruction in the operation of particular pieces of hardware and software, but also on the instructional strategies that are most effective for the successful integration of computers, calculators, and other technologies into the curriculum.

✓ Professional development opportunities should also include specific sessions on the advantages and on the special problems associated with the use of technology in assessment.

The Department of Education, through a competitive grant program, is establishing Educational Technology Training Centers, one per county, by the summer of 1997. Grant awards will be made to those local education agencies with demonstrated experience in providing effective professional development for the implementation of instructional technology practices. For an overview of the program, see the request for proposals (RFP) on the Department's home page at: http://www.state.nj.us/education/ (under grants) or directly through: http://www.pingsite.com/njded/grants/eetc/toc.htm/.

Types of Hardware and Software Needed in The Technology–Oriented Mathematics Classroom

Technology helps to contextualize mathematics by building bridges between theory and life. Imagine, if you will, a student who is learning about the mathematics involved with navigation. Through Virtual Reality she/he is living on Columbus' ship, learning first hand about Columbus' difficulties with navigation. Or perhaps that same student through Virtual Reality is exploring space and planning how to adjust her/his own orbital changes. Later that student might use a Verbal Computer Communications (VCC) system to report her/his learning. Through VCC, this oral text would be transcribed into written text, and if desired, the written text could be further transcribed into another language. VCC is a reality today, and will be in the classroom tomorrow. Perhaps that same student is learning about the development of the Arabic numeral systems by “visiting” the Middle East thousands of years ago and experiencing the sights, smells, sounds, and tastes of the environment, forever imprinting the experience and the information in her/his mind. Early versions of this type of multi-media instruction are currently being explored by Disney World, and will be available in the classroom in the near future. Technology can help to extend our students’ learning by building bridges across disciplines, thus connecting prior knowledge with new knowledge.

But what about today? Students now can access information through global information retrieval, using either commercial enterprises or the Internet. As more locations hook up with satellite transceivers, additional two-way and multiple hook-up interactions will become available throughout the world. Students will be able to statistically analyze the information received and compare their knowledge country by country, solving real problems on a real time basis. By using this technology to interact with professionals in their fields of interest, students will be entering the workforce with skills that were unheard of ten years ago. The use of technology in the mathematics classroom is exciting, challenging, thought provoking and necessary.

Calculators

Whereas Virtual Reality, Verbal Computer Communications systems, and multi-media instruction will transform instruction in the classroom in the near future, the premier and universal technological tool for today’s mathematics classroom is the calculator. John Kemeny, comparing how they performed the calculations used to develop the atomic bomb fifty years ago with the power of today’s pocket calculators, said, “It took twenty of us working twenty hours a day for an entire year, to accomplish what one student now can do in an afternoon.” Teaching students how and when to use calculators is critical.

A primary question that teachers and curriculum planners must deal with when incorporating calculators into mathematics classrooms is *What functions are most useful for this grade level? How sophisticated (and costly) do these calculators have to be?*   The New Jersey Department of Education provides at least a floor for this discussion in their *Guidelines for Acceptable Calculators for Use on the HSPT11 and EWT from 1993-1994 through 1995-1996.* This document establishes these functions as the minimum set acceptable for use on the tests:

- algebraic logic (i.e., automatically follows the standard order of operations);
- exponent key to do powers and roots of any degree;
- at least one memory; and
- a reset button or other simple, straightforward way to clear all of memory and programs.

In addition, the benefits of many other functions are described in great detail in the mathematics education literature and instructional approaches incorporating them are appearing in many commercially available programs. Algebraic logic is now available in very simple, four-function calculators for young children. Extensive capabilities to change the form of and operate on fractions provide for the creation of a class of calculators which are used widely in the middle grades. Statistical functions and even graphs and plots are available in inexpensive calculators which are finding their way into all grades from four through college. However, probably the most revolutionary effect of all is being provided by two classes of calculators that are capable of graphing functions and doing symbolic manipulations for algebra and calculus. Graphing calculators, used in conjunction with Calculator Based Laboratories (CBL), provide vivid examples of the applications of mathematics and provide excellent opportunities for collaboration between mathematics and science teachers.

Computers

In spite of the growth of calculator use in the classroom, with the many new features and the tremendous flexibility that they provide, the use of the computer is still essential. Software utility programs afford students opportunities to use spreadsheets to analyze data, to graphically represent mathematical formulas, to manipulate pictures, to make and test conjectures, to run multiple simulations, to write about mathematics, and to perform a myriad of other functions. They enable students to make connections between mathematics and the real world, to expand their own sense of reality, and to participate in generative and reflective learning.

The picture of mathematics classrooms where technology is fully integrated in intelligent, meaningful, and necessary ways is attractive. What types of hardware are needed to make this paper sketch a reality? The suggestions below may help develop a response to this question.

✓	*SUGGESTIONS*

✓ Introduce students to calculators at the earliest levels of schooling and progress to scientific calculators with algebraic logic, graphing, and programmable calculators as students advance through the mathematics curriculum. Overhead versions for all of the calculator models mentioned are available and should be used by the teacher for demonstration purposes.

✓ Provide mathematics teachers with access to computers with color monitors and liquid crystal displays for demonstration purposes. These stations should be equipped with high-speed CD-ROM and laser disk drives.

✓ Make a fully-equipped computer lab available to all mathematics classes. The lab should include modern computers with substantial internal memory, color displays, printer access, and appropriate software to accommodate teacher- and student-directed activities. The stations must have hard drives, and if possible should be networked.

✓ Choose a computer only after deciding on the software to be incorporated into the mathematics program, since programs that are well suited to specific needs may run on certain computers and not others.

✓ Make VCR's and video disc players available to every mathematics teacher, so that they can take advantage of the increasing number of quality mathematics programs being produced in these formats.

✓ Provide for interactive television, whether using fiber optics or ordinary telephone lines, as a practical means of visual communication between multiple sites. Mathematics courses which are otherwise too small or specialized can be offered with this tool. Specialized experiments and complex demonstrations can be conducted, and instructional resources can be accessed from remote sites, through this technology.

✓ Equip each classroom in the school with full telephone capability to support Local Area Networks as well as on-line search capabilities through electronic networks and data bases. Fiber optic cable is preferred for new installations. The state maintains a list of approved service providers (ISPs). The list is available online via the homepage for state contracts (http://www.state.nj.us/infobank/noa/t1572a.htm) or through a link on the NIE home page (http://k12science.ati.stevens-tech.edu/connect/connect.htm).

✓ Equip schools to receive externally produced programming via antenna, cable, or satellite. Advanced math classes are now available through the Satellite Education Resources Consortium (SERC). In addition, a school should have the capacity to disseminate the programming to the individual classrooms.

Making Connections

Miss Johnson spent part of her summer watching the 26 half-hour episodes of *Algebra: In Simplest Terms*, hosted by Saul Garfunkel. She made notes describing the application portion of each episode, since she planned to introduce these topics in her classroom.

During the school year, Miss Johnson showed her students specific sections from the series that highlighted direct application of algebra to the real world. For example, one episode the students enjoyed was about the use of ellipsoids in removing kidney stones. After the students had viewed the segment, Miss Johnson had her students conduct a laboratory investigation about ellipses with their graphing calculators. Wanting to stress connections between algebra and the real world, Miss Johnson provided her students with many tasks that year that involved investigating practical applications of the algebraic concepts they had just seen portrayed in a video segment. During her twenty-eight year career as a teacher, she had never seen such enthusiasm from students.

Miss Johnson is waiting for the laser disc version of the series so that retrieval and multi-media presentation can be more easily accomplished. To obtain information about this particular video series phone: 1-800-LEARNER.

Budget and Funding

Each district would like to provide the kinds of services and experiences that have been described in this chapter for their students. The most serious deterrent is obviously their cost. Schools have well-established funding mechanisms and sources to cover the basic day-to-day services they need to offer, but are ill-equipped to deal with necessary purchases of expensive equipment such as that needed to fully integrate technology into an instructional program. Many schools and districts have been successful, however, in accomplishing a major portion of the vision. They have used a variety of strategies including fund raising, some reliance on the local tax base, special bonding, corporate-sponsored grant and award programs, government-sponsored research and demonstration programs, and many more creative approaches. This section provides some information about activity at the state level and a sample of suggestions made by successful districts.

The State Plan

The state plan, *Educational Technology in New Jersey: A Plan for Action* (*NJDOE*, 1993), contains action plans to engage interest, guide collaboration, promote funding, and monitor policy implementation in order to ensure widespread integration of technology in all areas and at all levels across the school. Another document, *Giving New Jersey's Students Power to Perform*, developed by the 1993 Commissioner's Ad Hoc Council for Technology, suggests that it is imperative that key groups in the state work together to attract funding support for technology. The Commissioner's Ad Hoc Council for Technology made the following recommendations for funding the state plan activities:

Funding Recommendations

1. State legislature to appropriate funds to provide an annual entitlement of $50 per pupil for New Jersey's 1.2 million public school students. Fund to be renewed annually to assure that up-to-date resources for learning are available to all students.
2. State legislature to direct appropriations to fund a one time capital investment project to develop a statewide fiber optic telecommunication highway for education which will have the capacity to carry voice, video, and data communications throughout the state.
3. State legislature to provide financial incentives for districts to engage in new school construction and technology retrofit projects.
4. State legislature to appropriate funds to implement a megasystem for data management for the State Department of Education.
5. State legislature to appropriate funds for technology modeling incentives to support the planning and implementation of exemplary uses of educational technology; schools would demonstrate need and a commitment to become state-of-the-art centers for excellence.

Progress has been made in addressing these recommendations. The New Jersey Department of Education's Comprehensive Plan for Educational Improvement and Financing (May 1996), recommends that $50 million be included in the FY 1997/98 state budget (and for the four following years) for a distance learning network aid. Funds will be distributed on a flat, per pupil rate to all districts which amounts to $43 per student. The network for delivery of voice, video, and data offers all districts (including those that are poor and have large numbers of disadvantaged students) an opportunity to obtain quality programs for their students to effectively implement the standards. The third recommendation is addressed in part by pending funding legislation (S40 and A20). (Legislation is available on the NJ Legislative home page at http://www/njleg.state.nj.us/.) Data management is being addressed through the Department's Office of Technology, established in 1995. The fifth recommendation is addressed through the FY 95 and FY 96 grant programs for Classrooms: Connections to the Future and Educational Technology Consortia, which provided $1.3 million in funding for technology modeling incentives. For details on these and other Department of Education initiatives, see the Department's home page at http://www.state.nj.us/education/.

Local Suggestions

School districts that have already made considerable progress in educational technology recommend the following strategies.

✓	*SUGGESTIONS*

✓ Allocate a standard fixed percentage of the local school district budget, perhaps 1 or 2 percent, for technology equipment and maintenance.

✓ Establish a consortium of school districts for the purpose of negotiating cost effective benefits for hardware and software through group purchase, site licensing, etc.

✓ Develop a procedure for evaluating aging and obsolete hardware in light of local instructional needs, normal service lifetimes, and the need for systematic upgrades and replacements.

✓ Use special state or federal funds such as Chapter I and Chapter II funds. Consistently designating these funds for technology can provide technology for special need groups and for specially identified projects and programs.

✓ Seek funding from the National Science Foundation (NSF), the United States Department of Education, and other federal agencies. Work with colleges, state agencies, or district consortiums which have been awarded grants to promote the use of technology.

✓ Lease purchase current technology over a two or three year period. This plan makes large district-wide implementation easier to accomplish over a shorter period of time.

✓ Use Eisenhower funds. Each year create training models for mathematics and science teachers that target appropriate use of technology in the classroom.

✓ Hold a budget referendum. Present the public with a technology plan that is designed to create district-wide state-of-the-art technology-oriented schools.

✓ Establish at least one magnet school. Create a school specially focused on state-of-the-art technology and preparation for high-tech careers.

✓ Establish a business partnership. Many large corporations have competitive grants available in varying amounts. Technology products may also be obtained through the Computer Learning Foundation's non-profit program "Technology for Education" which sponsors multiple corporate partner label collection activities; call (415) 327-3347 for information.

Summary

Technology has changed and will continue to change what and how mathematics is taught. When we think about technology and the myriad of reasons why we need to infuse technology in the mathematics classroom, we should not lose sight of the following:

- In 1950, 40 percent of jobs in the United States were for unskilled workers. By the year 2000, only 15 percent will be.
- In 1900, 85 percent of all agricultural jobs were filled by unskilled workers. Today, only 3 percent of agricultural jobs require unskilled workers.
- 20 out of the 21 largest industrialized nations require one year of applied physics for all students. Only the United States does not require physics.
- In 1943, U.S. education was 5.5 hours a day for 180 days. In Japan it was 3.25 hours a day for 120 days. Today, in the U.S. it is still 5.5 hours a day for 180 days. In Japan, it is now 8.5 hours per day for 243 days.

- The percentage of college students graduating with degrees in mathematics, science, or engineering in these countries is: Japan, 20%; Great Britain, 14%; Germany, 13%; and the United States, 8%.

We are preparing our children for a different world from the one in which their parents grew up. In order to succeed in this increasingly technological world, we must provide them with the best possible education; an education that includes the most advanced tools, techniques, and methodologies available. Our nation must have the opportunity to compete in the global economy on an even playing field. Anything less will reduce our children's prospects and weaken our nation's future.

References

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On-line Resources

http://dimacs.rutgers.edu/nj_math_coalition/framework.html/

The *Framework* will be available at this site during Spring 1997. In time, we hope to post additional resources relating to this standard, such as grade-specific activities submitted by New Jersey teachers, and to provide a forum to discuss the *Mathematics Standards*.

Appendix — Sample Inventory Checklist

This checklist includes questions that address each of the categories of planning, staff preparation, curriculum, methodology, setting, availability of technology, and budget. For each question, there are three statements which are designed to help districts assess whether they are at a Minimal (M), Intermediate (I), or Advanced (A) stage of implementation.

1. **Planning. Is there an organized effort to address technology issues in mathematics instruction?**

   M Curriculum planning and documentation do not normally address technology.

   I The mathematics program is part of a district-wide technology plan that has just begun to be implemented.

   A Studies of the appropriate uses of technology in mathematics are ongoing at the department level.

2. Staff Preparation. (a) Is support provided for staff development to include technology?

M Staff is encouraged and expected to attend conferences, workshops, and courses with regard to technology.

I On the job support is used to encourage the use of technology in instruction.

A There is a staff development program with specific goals for all teachers.

(b) For immediate instruction — Does the staff have technology available outside of class so that opportunities to include technology in the classroom are realistic?

M Equipment and software are available to staff without denying student use.

I Staff have office and personal devices for preparation of lessons.

A Technology is available for clerical and communication tasks.

3. Curriculum. (a) Documents — Is there a formal, written commitment to including technology in mathematics instruction?

M Courses of study include technology.

I New topics/approaches are being added because of technology.

A Topics/approaches are being de-emphasized because of technology.

(b) Source of Content — What is the source of decisions made on content and how are those decisions translated into instruction?

M Local staff creates instructional sequences which use technology.

I Resource materials for creating technology-supported lessons are in use.

A Materials purchased for student use are purchased with the expectation of routine use of technology to solve problems and conduct investigations.

(c) Technology included in student materials — Are instructional materials selected and acquired to assure effective use of technology?

M Texts have technology addenda.

I Texts integrate technology into content.

A Texts are written based on technology as a way of learning.

4. Methodology. (a) Regular Instruction — Is technology used in the actual instructional process?

M Technology is used by the teacher during lectures and demonstrations.

I Students use technology in a class-laboratory setting.

A Inquiry methods replace some lecture sessions and technology is regularly used by all.

(b) Assessment — Is technology used by students during evaluations?

M Students are permitted to use technology while taking some tests.

I Students are permitted to use technology during assessments whenever appropriate.

A Assessments are designed to capitalize on technology.

5. Setting. (a) Demonstration equipment — Is instruction supported by technical presentations which can be seen and heard by all?

M Mobile units are available in a classroom with advance notice.

I Mobile units are available in classrooms on demand.

A Fixed units are installed in every mathematics classroom.

(b) Communications — Is there provision for exchanging ideas with others facilitated by technology?

M Technology is used to encourage students to write in mathematics classes.

I Access to a modem and a telephone line is provided to the mathematics department or program.

A Students regularly communicate about mathematics via computer.

6. Availability of Technology. (a) Technology is current— How are devices kept current?

M The mathematics program competes with other programs for new technology.

I A technology committee continuously reviews district needs.

A The mathematics program contains a plan for continual update.

(b) Individual Device — Are devices such as graphing calculators available to students in numbers that facilitate instruction with technology?

M There are sufficient numbers for mandated testing.

I There are sufficient numbers for classroom use.

A There are sufficient numbers to allow each student to use one at school and at home.

(c) Community Devices — Are devices such as computers available in numbers that facilitate instruction with technology?

M Demonstration devices are in classrooms.

I A laboratory setting is available for whole class access.

A Library-like availability exists for individual access.

7. Budget. (a) Are provisions made for continuing the purchase of technology?

M Yearly or special requests for the purchase of equipment/software is the vehicle used to obtain material.

I There is an established budget for software and minor equipment updating.

A There is an established budget to ensure continual modernization.

(b) **Supplies — Are supplies (ribbons, paper, diskettes, batteries, etc.) that are required for the use of technology available in appropriate quantity and accessible to facilitate instruction?**

M Supplies are available in limited quantity.

I Supplies can be obtained through advanced requests.

A Supply purchases are planned on an annual basis and controlled locally.

(c) **Repair and Back-up — Is there a plan in place to continue instructional activities in the face of technical failure?**

M Facilities are serviced when down.

I Back-up facilities are available to replace down items.

A Support services are in place to assure continual access to technology.