DOCUMENT RESUME

ED 276 412 IR 012 409

TITLE Implementation of Principles of Technology. Three Case Studies.
INSTITUTION Agency for Instructional Technology, Bloomington, IN.
PUB DATE 86
NOTE 57p.
AVAILABLE FROM Agency for Instructional Technology, Box A, Bloomington, IN 47402 ($2.50).
PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Case Studies; Course Descriptions; Formative Evaluation; High Schools; Pilot Projects; Program Implementation; *Secondary School Curriculum; *Technology; *Vocational Education

ABSTRACT

This report describes a collaborative project between the Agency for Instructional Technology (AIT), the Center for Occupational Research and Development (CORD), and a consortium of 42 states and provincial education agencies in developing an applied science course, Principles of Technology, for high school vocational students. The project underwent considerable pilot testing during the 1985-86 academic year using a formative evaluation process. Case studies from three diverse cultural, geographic, and academic settings are presented which provide an in-depth look at the problems and solutions involved in the integration of this course into their curriculums. The course consists of 14 units, each focusing on a principle that underlies today's technology. The 14 units are intended to be covered over 2 years; the first 9 sequentially, and the second 5 at the teacher's discretion. Each unit consists of a student manual, a teacher's guide, hands-on laboratories, and video programs. Each of the studies tells about the setting of the school, how the course was implemented and taught, and what the students were like. Issues are discussed at the end of each case study, and factors affecting decisions about funding, facility allocations, course credit, teacher selection, and student recruitment are included. A listing of the participating agencies and names of the content review team are appended. (DJR)

Implementation of *Principles of Technology*

Three Case Studies

PRINCIPLES OF TECHNOLOGY

Agency for Instructional Technology

AIT

The Agency for Instructional Technology is a nonprofit American-Canadian organization established in 1973 to strengthen education through technology. In cooperation with state and provincial agencies, AIT develops instructional materials using television and computers. AIT also acquires and distributes a wide variety of television, related print, and computer materials for use as major learning resources. It makes many of these materials available in audiovisual formats. From April 1973 to July 1984, AIT was known as the Agency for Instructional Television. Its predecessor organization, National Instructional Television, was founded in 1962. AIT's main offices are in Bloomington, Indiana.

CORD

The Center for Occupational Research and Development is a nonprofit organization established to conduct research and development activities and to disseminate curricula for technical and occupational education and training. CORD has developed over 36,000 pages of instructional materials for technicians on 14 major curriculum projects in advanced technology areas. This includes the Unified Technical Concepts course on which *Principles of Technology* is based. These projects were sponsored by contracts with federal and state agencies, and by industrial support from the private sector. The products developed by CORD are used in technical institutes, community colleges, vocational high schools and industry training programs. CORD has been tailoring educational programs to meet workforce needs for 10 years. The CORD office is in Waco, Texas.

Implementation of *Principles of Technology*

Three Case Studies

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Acknowledgments

Teaching is a difficult job to do well. The rewards are more intrinsic than extrinsic.

The three teachers who are the central figures of these case studies allowed two researchers to be their "shadows" as they went on about their profession. They did so knowing the researchers would ask many questions of any available people.

The authors wish to thank them for their openness and hospitality during the period of this research.

The authors wish also to acknowledge the contributions of other teachers and of students and administrators at the three sites who made these case studies worthwhile.

Contents

Introduction

This report describes how three very different schools first put ***Principles of Technology*** into action.

Principles of Technology is an applied science course for high school vocational students that is being developed collaboratively by the Agency for Instructional Technology (AIT), the Center for Occupational Research and Development (CORD), and a consortium of 42 states and provincial education agencies. (See Appendix A for a list of cooperating agencies.) The course consists of 14 units, each focusing on a principle that underlies today's technology. The 14 units are intended to be covered over two years; the first nine sequentially, and the second five as the teacher sees fit. Each unit consists of a student manual, a teacher's guide, hands-on laboratories, and video programs.

The entire project is being developed with the help of a formative evaluation process that systematically collects data from a special review team (see Appendix B for members of this team), consortium representatives, and classroom pilot testing sites. A considerable amount of data, including questionnaire data, pre/posttest data, and attitudinal data, has been collected. All research is formative—research designed to be used to revise the instructional materials. During the summer after the materials for year one were pilot tested, the project staff, consultants, and the consortium had a chance to pause and consider the usefulness of the data collected during the first year. The project's status was somewhat unusual: materials for year one were being revised and distributed widely at the same time that materials for year two were being developed and pilot tested.

Further insights were gleaned when pilot site teachers, consortium representatives, project staff, and consultants discussed the research. It became apparent that ***Principles of Technology*** had been pilot tested in a wide variety of settings. The data from the first year, however, lacked any in-depth descriptions of these settings. A series of case studies was proposed to clarify some of the contexts in which the pilot test was occurring. Also, as widespread implementation of the course began, it was hoped that more in-depth study of the course in some sites could uncover issues important for successful implementation.

And so, these studies were conducted during the second year of implementation of ***Principles of Technology***—the 1985-86 academic year—in three diverse cultural, geographic, and academic settings.

These three case studies are intended to give you some of the same kind of information that you would gather if you were to visit one of these ***Principles of Technology*** classes. After reading them, you will have more than just an idea of some of the problems and solutions that other people have encountered in their implementation and use of ***Principles of Technology***. We hope you will feel as though you have been there yourself.

Each of the studies tells about the setting of the school, how the course was implemented and taught, and what the students were like. Issues are discussed at the end of each case study.

PT is a complex curricular innovation. Educational innovations are rarely adopted without struggles. In documenting some of these struggles, the researchers are in no way evaluating those who agreed to participate. This report uses pseudonyms for all people and places because the names are not important to the understanding of the cases. The insights that can be gathered from a detailed description of these experiences are, however, of paramount importance.

Each study was written after one school week of interviews and observation at each site and is as complete as that one week permitted.

Because the purpose was to take a snapshot, so to speak, at one point in the ongoing implementation process, the descriptions may not accurately reflect things as they are now. Some important decisions had not yet been made. We have tried to describe the context for such decisions and the information that went into them. When we could, we have added postscripts about how these decisions were resolved.

How you use these studies will depend in part on your specific involvement with the implementation and delivery of ***Principles of Technology*** in your school, state, or province. Rather than trying to select the one case that seems to be most relevant to your overall situation, you will probably find it more helpful to consider specific aspects of each of the three cases.

Northside High School

The Setting

Northside High School is located in a rapidly growing southwestern community. Although the community is an incorporated entity that was once on the outskirts of the area's major metropolitan region, the growth of the entire area has blurred the once clear-cut boundaries between the metropolitan region and this community. Its neighborhoods mirror this rapid growth; they are new and look it.

Geographically one of the state's largest, the school district encompasses more than 350 square miles. Its students come from four different cities and several rural areas. Although each of these cities is a distinct community, the growth of the entire area blurs any sole identification with one's own city.

If you drive a mile north of Northside, you can be on rutted dirt roads heading into the mountains. If you drive a mile south of Northside, you have passed several high-tech industries and are probably on a highly travelled road.

The majority of parents in the community (76%) have completed high school and several (15%) have completed four or more years of college. Almost all students (94%) are white. The minority groups include Hispanic Americans (3.9%), Native Americans (.51%), Asian Americans (.47%), and Black Americans (.42%). The upwardly mobile appearance of the community is supported by its income levels; the mean household income is $28,000.

Many of the parents of Northside students work for the high-tech industries in the area. Some own construction firms or do other contracting work. According to one Northside teacher, "These kids' parents don't want their kids to work for Sperry. They want them to own it."

Agriculture also plays a major role in the lives of some Northside families. Much of the land on the edge of the district is currently undeveloped and still available for orchards and tree farms. Northside's industrial education department offers courses in horticulture and vocational agriculture. The school supports an active FFA chapter.

The Northside school district has nearly 12,000 students. These students are spread among nine elementary schools, two junior high schools, and one high school. However, the growth of the area is increasing both the number of students and the number of schools required to serve those students. A new high school and a new elementary school will open in 1986. To meet the needs of the growing community, school system officials predict a new school will be needed every one to three years.

Northside High School's sprawling campus includes six single-story classroom buildings, a two-story vocational center, and several temporary classrooms. Reflecting the explosive growth of the community, the enrollment is 3,600 students. When the new high school opens next fall, enrollment at Northside is expected to dip to 2,600 students. Over 150 certified faculty members work at the school. Some will be transferred to the new high school next year.

The buildings at Northside are well-maintained. There is no graffiti on the walls. The atmosphere is upbeat and doesn't appear to be overly constrictive. Students come and go freely from building to building between classes.

Northside was designed to be a showcase for vocational education. In fact, the vocational education center was the first building constructed. As more high schools are built in the district, the plan calls for Northside to become the voc-ed magnet school. Students will be bused from other schools in the district to benefit from Northside's well-equipped voc-ed facility. Some of Northside's voc-ed courses are articulated with post-secondary technical schools and community colleges in the area. A student graduating from Northside can, in some instances, receive college credit for high school work.

In the science department at Northside, 19 teachers teach 3,675 students. (The number of students taking science courses is greater than the number enrolled at the school because while some students may take no science course, more students take two science courses.) The science department offers 93 sections of 17 different science classes. Two of these classes, ***Principles of Technology*** and CHAMP (Careers in Health and Medical Practice), are offered by the science department as part of the voc-ed curriculum.

Northside is an academically oriented school; over half the students begin some type of higher education. Many Northside students take elective science classes. Students in the advance-track science classes receive extra grade points just for being in the advanced track. For instance, a "C" in an advance-track chemistry class is worth the same number of points to a student as a "B" in a regular-track chemistry class. ***Principles of Technology*** is taught in Northside's science department as a regular-track class by Ms. Anderson, Northside's physics teacher. In addition, she teaches three sections of physics and one section of chemistry.

Students at Northside begin their academic days at 7:45 a.m. (6:45 a.m., if they have an "early-bird" class). In the second period at 8:45 a.m., every student at Northside rises, says the Pledge of Allegiance to the American flag, sits down, and listens to the daily announcements. As seniors, many Northside students expect to enroll in four classes—English, Government, and two electives—and go home or to work at 11:38 a.m.

Students are encouraged to have career goals by the time they graduate from Northside. In the counseling department, a poster on the wall shows two people. One of them is well-dressed, smiling, and has good posture. The other is wearing nice, but wrinkled, clothes and looks beleaguered and slovenly. The difference, according to the caption, is a matter of whether one has goals at the age of 15 or 16. Students at Northside are expected to succeed and many of them probably will. They do not seem to feel any pressure in this environment but are proud of it and feel quite lucky. After all, most of their parents moved families a long distance in the middle of careers to make better lives for themselves.

The *Principles of Technology* Experience at Northside

Principles of Technology was introduced to administrators at Northside in the spring of 1984. Mr. Michaels, the system's administrator for career and vocational education, presented the ***Principles of Technology*** course at a meeting with Northside's principal and the assistant principal in charge of curriculum. (Mr. Michaels told the researchers that he was initially introduced to the project nearly two years before at a regional vocational meeting, where ***Principles of Technology*** was presented by the president of CORD.) At the 1984 meeting, these three administrators discussed the course and agreed to participate in the two-year pilot test. They made several decisions that would have profound effects on the implementation of the course at Northside.

After examining its content, the principal recommended that the course be taught by a certified science teacher. He thought, and others agreed, that the course contained enough physics that it ought to be taught by Northside's regular physics teacher. The administrators also decided that ***Principles of Technology*** would be given elective, rather than science credit while being pilot tested. The cost of the lab equipment, a VCR, and part of the physics teacher's salary would be paid from state funds provided to the vocational department. A vocational teacher would also assist the physics teacher in securing the necessary equipment. After these ground rules were established, the physics teacher was notified that she would be teaching a new course.

The next task was to recruit students. Because it was already late spring, recruitment was more difficult than under more normal circumstances. Both the teacher, Ms. Anderson, and the assistant principal for curriculum, Dr. Jones, worked at recruitment. Their efforts consisted primarily of visits to geometry classes to explain the new class. Geometry classes were targeted as the most likely sources of appropriate students for ***Principles of Technology*** because geometry students would already have passed in algebra. Fifteen students enrolled in the first year.

After attending an orientation held in Dallas in the summer of 1984 for all ***PT*** teachers, Ms. Anderson began teaching the class in the fall. By the end of the year, enrollment had shrunk to ten students. Ms. Anderson attributed most of the declining enrollment to normal attrition caused by moves, dropouts, and schedule changes. While she felt satisfied with most of the material, the lone exception to her satisfaction was the lab equipment. She reported repeated problems in getting the equipment on time and in getting it to function properly when it did arrive. A vocational instructor, Mr. Jenkinson, had been assigned to help her locate and set up the lab equipment. However, they both reported some difficulty in getting together to discuss the equipment because their preparation periods were at different times and he taught building trades in the vocational building (on the far side of the large campus from the science building). Nonetheless, Ms. Anderson said Mr. Jenkinson had been helpful in dealing with the various equipment problems. Ms. Anderson thought that these problems had perhaps been detrimental to the reputation of the course at Northside. She said students had begun referring to the course as "Jury-rigging I." Ms. Anderson completed six of the seven units in year one of the pilot test.

As year one drew to a close, recruitment efforts for the following year began. Year two of the course (still part of the pilot test) would be available only to students who had completed year one, which meant that the potential pool of students for year two was ten students. At the same time, recruitment of students for year one (no longer part of the pilot test) was initiated. The primary responsibility for recruitment fell on Ms. Anderson. Ms. Anderson expressed slight resentment at having to recruit students, which she thought was really not her job. She and some of her year-one students went to the geometry classes as she had done the previous year. This year's efforts to enroll students were enhanced by better timing. The class was listed in the catalog of classes under the science section, along with 16 other available science classes. Students were still offered only an elective credit. The result of the recruitment efforts was an enrollment of fourteen for the year-one class. Only one student signed up for year two.

Northside classes are scheduled through the counseling department. According to one counselor, "There are two essential types of plans: one for students who are going to college and one for students who are not going to college." All the counselors with whom the investigators spoke were generally aware of ***Principles of Technology*** but knew very little about the details of the course. Dr. Jones had personally told counselors to fill the ***PT*** course, but college-bound students preferred to take physics (all physics sections are in the advanced-track), and there was virtually no recruiting of ***PT*** students from voc-ed courses. Only the fourteen students mentioned above asked their counselors to schedule them into ***PT***.

Dr. Jones considers low enrollment to be *PT*'s only problem. He would like to see enrollment grow so that the course can "make it" in the years to come. He attributed the low enrollment primarily to the fact that students did not get a science credit for it. He advised further that changing the name of the course from ***Principles of Technology*** to something more academic like "Basic Physics" or "Applied Physics" would help.

The high-tech industries in the Northside district get many of their technicians from outside the state. Dr. Jones sees ***PT*** as a course that can improve the background of vocational students and hopes that such courses will encourage local high-tech industries to hire Northside graduates.

The Class

Ms. Anderson's daily ***PT*** class began at 7:45 a.m. and ran until 8:38 a.m. Thirteen males and one female were enrolled in the course. Eight students had taken no other voc-ed courses and three of the other six had taken only electronics. One student had a fairly comprehensive vocational background: electronics, woods, automotive, and two voc-ag courses. The biggest difference in academic background between Ms. Anderson's ***PT*** students and her physics students—the class with which most Northside students compared ***PT***—was in mathematics. The physics students all had taken geometry and two years of algebra. All the ***PT*** students had had at least one year of algebra. Only five had taken geometry, and only three had had two years of algebra.

Throughout the week, whenever a student did not understand a problem, Ms. Anderson would explain it. Sometimes Ms. Anderson would touch upon a concept and then say, "but we don't have time to go into that right now"—and she was always right.

Students at Northside High School saw ***PT*** not as a technical course, but as a science course. Specifically, they saw it as a physics course for students who, because of algebra grades or career interests, did not take physics. Several ***PT*** students, when asked what they thought was probably the biggest difference between physics and ***PT***, said something like, "***Principles of Technology*** goes slower and uses videos." When asked if ***PT*** could be used in an electronics or a welding class, one student wrinkled up his face and said, "Why would anybody want to?" ***PT*** as a vocational education course was not a perception that anyone at Northside seemed to encourage.

Students liked the videos and expected to review the overview video before each test. The role models in the videos were enjoyed by some students but were confusing to others. One student remarked, "The people who actually do stuff are kind of dry. They make grammatical errors, and sometimes you can see them reading their cue cards." Another student, however, said, "When you can see the people working, that's kind of neat. It would be nice to get one or two of them to talk to our class. My dad thinks I ought to be taking physics and that would show him that ***PT*** really does help me." (This particular student's father had called the school requesting that his son be placed in physics. However, due to his algebra grades, the student has remained in ***PT***.)

Texts for the mathematics labs were seen as relevant to the coursework—especially to the hands-on labs. Most of the students did not read their texts outside of class but found them necessary because the problems and the labs described in the book were used in class.

By and large, ***PT*** students who expected to go to college would rather have been in physics. This was primarily because of the higher status of the physics class and the help that simply being in physics gave to grade point average. (All physics courses were in the advance-track.) ***PT*** students who did not expect to go to college were generally satisfied with the course. It met their needs as a "hard science" course and, because of the lab work and the videos, it was interesting. The one exception was a student who wanted a technical career in robotics and expected ***PT*** to teach more "skills" than "concepts."

Principles of Technology Classes

Day 1: Unit 1, Final Test; Unit 2, Introduction

Monday was a holiday. The first observed ***Principles of Technology*** class began at 7:45 Tuesday morning. Although it was the first class of the day, all the students were on time and seemed relatively alert. Ms. Anderson began by announcing the plan for the week. She told them they would start with the unit test for Unit 1: Force, followed by the first lecture for Unit 2: Work. She asked whether anyone had questions about the week's activities. No one did.

Then she announced the Unit 1 test. A student asked to see the Unit 1 overview video again. Ms. Anderson agreed and cued the tape. (Later, she said that she usually showed the overview tape as a summary before a test.) The teacher's guide contained the following description of the program:

> This video segment introduces force as a push or pull that can cause change in the motion or shape of an object. Using examples from everyday life and the world of technology, the program shows that force can cause an object to start moving, stop moving—or to move in a different direction. A force can also change the shape of an object, as when a car is put into a crusher or when a person crushes a soft drink can.
>
> Pressure, voltage, and temperature difference are prime movers that act like forces. Each causes a movement within its own kind of system: mechanical, fluid, thermal or electrical. Blood flows through our bodies and water flows through pipes because of pressure. Voltage causes the movement of electrons. This movement may be through wires and circuits,

> and—in part—makes possible the technology that allows us to produce video programs. Heat energy moves from warmer to colder areas because of temperature difference. Because modern technology often combines mechanical, elecrical, thermal and fluid systems in complex devices, technicians must understand all four systems and the similarities among the four prime movers—force, pressure, voltage, and temperature difference.

Although there was some chatter at the beginning of the tape, the students became more attentive with the first narration of the program. There were some chuckles at the humorous parts, although at the end of the program one student said, "This must be the funny part."

After the video, Ms. Anderson distributed the test, which had been used as a pretest for the pilot test of Unit 1. (She said she thought this was a good test because it covered most of the objectives and was closely tied to them.) The test was the same version that had been sent for the pilot test the year before. The students wrote the answers on their own sheets of paper. When students finished, they brought their tests to Ms. Anderson.

They were then instructed to go to the bookstore to get their copies of the text for Unit 2: Work. Ms. Anderson told the class that she had tried to get copies of the student book for them, but the bookstore personnel insisted that the students had to come personally to the bookstore to get the books. Dutifully, the students individually went to the bookstore, which was a five-minute walk to another building. They had to show their student IDs to be issued their books. One student told a researcher that they had paid for their books at the beginning of the semester, but received them only unit by unit. Ms. Anderson expressed frustration at the process for distributing the student books and said that in the future she planned to have the students go in pairs to the bookstore during labs to avoid missing class time.

When all students had returned with books in tow, Ms. Anderson began with Unit 2. She introduced the students to the unit on work, telling them that there was no work in the thermal system and that they would go through the work unit faster than Unit 1. One student remarked, "It has a shorter book."

Ms. Anderson showed the overview video program for Unit 2. The tape was not accurately cued. During the couple of minutes it took to cue the tape, she announced the homework assignment for Unit 2, which was to read the first 15 pages of the text. She then turned on the program. The teacher's guide describes the program as:

> The technician's definition of work is different from our everyday use of the term. In everyday speech, we equate work with force; but in the technical world, work is accomplished only when a force is **applied** to an object and the object **moves** while the force is applied. An ant performs work when it moves a heavy object from one place to another, just as a robot on an assembly line does work when it picks up a motor. The equation that expresses this relationship is: Work = Force x Distance

Which examples show work being done as the technician defines it?

- water behind a dam (none of the examples involves "work.")
- a bridge
- a battery—connected to nothing
- a person on a construction site holding a heavy object but not moving

When a hydraulic pump causes a hydraulically powered robot to move objects from one place to another on the assembly line, fluid work is also being done. Here, work is the result of pressure (the force) changing (or displacing) a volume of fluid (a liquid or gas) in the hydraulic cylinders and motors of the robot. Fluid work is also being done when water flows from a firehose. Here a pressure difference—the force—moves a constant volume of fluid through the hose. Work also is performed in electrical systems, such as those that weld automobiles on an assembly line. Here, voltage acts as the force that moves electrical charge through the parts being welded.

A visit with a technician demonstrates how the concept of work must be considered when dealing with complex devices. The video program concludes with a recap of how work in mechanical, fluid and electrical systems relates to the unifying idea that work is done when a force causes movement.

Although most students were attentive throughout the program, two students were writing (not notes on the program; it looked like other work) for most of the program. There were comments from students about various parts of the program, and at the end one asked, "Was that supposed to be the funny part?"

Following the tape, Ms. Anderson briefly reiterated the definition of work that had been presented in the program. She reminded the students that the homework assignment was to read the first 15 pages of the text. With the Unit 1 test and video, the trip to the bookstore, and the Unit 2 introduction, time was pressing. The bell rang at 8:38, and students left. Ms. Anderson moved to another room to teach her next class, advance-track physics.

Day 2: Review Unit 1 Test; Overview of Unit 2

Ms. Anderson began the class at 8:45 by writing the following extra-credit assignment on the board.

Name the scientist associated with:

a) photoelectric effect (theory of relativity)
b) the light bulb
c) the periodic table of elements
d) father of genetics

She said, "I'll give you guys a break. You'll need it after yesterday's test." She then passed back their tests while telling the students how to calculate their score. Most students worked on the extra-credit problems and one asked, "Aren't two of these guys the same?" Students worked on the extra-credit problems for about five minutes. Ms. Anderson had them pass their papers forward and then gave the answers. (To prevent trips to the local science department, the answers are given here: A—Einstein, B—Edison, C—Mendeleev, D—Mendel.) Since the top score on the test was 51%, she said that she would give two points for each correct answer on the extra-credit test. She added that since the scores were so low, she would probably have to grade "on the curve."

She then went over the 30-item test, item by item. She told students to check their answers as she gave the correct responses. She used the grading process to teach. She explained some of the more difficult items and solved a couple of problems requiring calculations on the board. Students asked a couple of questions about items they didn't understand. For one item she said, "I don't think we stressed that enough in class. I may just give everyone two points on that one." At the conclusion of the test review, she advised students to re-check the totals. No one mentioned any errors in the totals.

Ms. Anderson then advised students to take out their texts for Unit 2: Work and open them to page one, which contained the objectives for the unit. She began by reading the objectives aloud to the students while they read along, lecturing about the initial definitions in the unit and writing on the board to augment her words. Ms. Anderson defined work, using some examples. She then defined work (including linear and rotational work) in the mechanical system, the fluid system, and the electrical system. For each system, she explained the units that were used to measure work in that system, and how those units were derived.

After asking a question to which no one responded, she implored, "Look at page five, guys. You should have read this last night. That was your assignment!" Later when she asked how many had read the assignment, only one of the 12 students in the class raised a hand.

In the middle of the lecture, she was interrupted by a message from her student teaching assistant. "Your son's on the phone and he wants to know where his Boy Scout bag is." She left the room for a brief moment while the students talked quietly. She apologized when she returned and resumed the lesson. Later, the assistant popped in with, "He found it." Everyone chuckled and one student said, "That's the highlight of the day—he found it."

Concluding the overview material, Ms. Anderson moved to the mechanical system. She began the subunit work by showing the video program. The teacher's guide describes this program as:

> Lifting weights to improve your body is fun. It can even be work. Technically, it's only work when a force is moving an object. Without force **and** movement, work isn't being done. So when a robot on an assembly line holds an object without moving it, or when a construction

> crane holds an object without moving it, no work is being done—in the technical sense. Consider a robot lifting a weight and a person lifting a weight. When are they working and when aren't they? They work only when they're moving the weight...not when they hold the weight still.
>
> When an elevator cable lifts the elevator car, you can find the amount of work done by multiplying the feet the elevator car travels by the force needed to lift the elevator. This gives you the amount of work in units called "foot-pounds." If you're using SI, you multiply the distance the elevator car moves in meters by the force, in newtons. This means work is expressed in Newton-meters.
>
> How fast a force moves an object doesn't influence the amount of work that's performed. So an elevator performs the same amount of work carrying ten people as it goes from the ground floor of a building to the top floor—whether it makes no stops, or makes ten stops. Work is important in the technical world because of its relationship to efficiency. Efficiency compares the amount of work put into a system with the amount of work you can get out of it. Efficiency gives you an idea of how much waste there is in the system. The less waste, the closer the system will come to the ideal—of being 100% efficient. A block and tackle removing a car engine is less than 100% efficient because the amount of work performed by the system is less than the amount of work put into it. Work also is performed in rotational systems, such as a cement mixer or a roller coaster. The basic relationship of Work = Force x Distance in a rotational system is stated in terms of torque (Force x Length of Lever Arm). The distance can be expressed in degrees or in radians. Radians are explained in the video by special graphical techniques.
>
> Work in mechanical systems, both linear and rotational, is the result of force moving an object. Both force (or torque) and the movement of an object are required for work to have been done.

During the program, one student wrote throughout (not taking notes on the program), two chattered for a while, and the rest watched attentively. At one point, the program told viewers to pay particular attention: "See if you can tell when work is done in this example." Students became so involved in debating the example that Ms. Anderson asked them to "pipe down." Again, they chuckled at the ending gag, and one said, "That was the humor in this show."

After the video, Ms. Anderson told the students that she was trying to get the first hands-on lab by Friday. (She had previously told the researchers that she wanted them to see a lab. Because of the Monday holiday, this resulted in the unit's being more rushed than it usually would have been. Nevertheless, the researchers were delighted to be able to observe a lab.)

She told the students to do the exercises on page 15 of the text and said that they would do the work problems the next day. She added that they would be doing Lab 2M1 on Friday, and again reminded them to read pages 1-15. Students then sat and talked quietly for the remaining two minutes until the bell rang. Ms. Anderson moved down the hall for her second-period physics class.

Day 3: Mechanical Subunit of Unit 2

Class began at 7:45 with the students in their usual seats. Ms. Anderson told them to open their books to page seven and added, "If you did not do your homework, I'm collecting it tomorrow instead of today, so be sure you get it done."

She told the students to look at the objectives for the subunit "Work in a Mechanical System." She then read each objective to the students. She paused to ask a couple of questions about units and how the SI work units differed from the English work units. Students volunteered answers to her questions and seemed to understand the units. She gave examples of the efficiencies of several common household items including toasters, ovens, and space heaters.

As she went to the board she said again, "Take out your notebooks and let's get through this."

The remainder of her teaching this day was done at the board. She wrote down some of the key concepts of the unit, including linear work and rotational work (as she defined them), and listed the appropriate formulas for the concepts.

Ms. Anderson then said, "Look at the problem on page nine."

She had a student read the problem aloud and look at the solution (which was provided with the problem), as she explained it to them. She proceeded to a problem on page ten of the book. This time, she read the problem to them and they worked the problem and called out answers. She asked that students respond one at a time, so that she could understand their answers. The problem was one in which students calculated the efficiency of a machine. The correct efficiency was 88%. She asked whether that was a good efficiency. She informed them that 88% was an excellent efficiency and compared it to a modern furnace, which she said would be extremely efficient at 70%.

She moved on to an example on page 12 of the text. Most of the students were attentive throughout the sequence of solving problems from the text. Two students used hand calculators. Again, Ms. Anderson worked through the problem from the text with them.

Next, she gave them a problem that was not in the text, telling them to write it down in their notebooks. For those who didn't have notebooks, she pointed out some extra space on page 16 of the text. At this point, the students were louder and she told them to be quiet and copy down the p[illegible] She wrote the problem on the board, explained it to them, and then said, "I wish [illegible]ys would copy this down. I don't see anybody writing."

She told students to take five minutes to solve the problem. Most students worked on the problem, but two students appeared to be doing nothing. One head went down on the table. One student went up to the teacher's table in front of the room to ask about the problem and Ms. Anderson explained it to her.

After students worked on the problem for a few minutes, she asked them for their solution. One student gave an incorrect answer. She told him, "That doesn't make sense logically," and asked him how he got his answer. She then explained the correct answer and added, "That's kind of a hard problem, I think."

She had the class turn to page 12 in the text and went over the example on the board. She explained radians to them, using the example provided in the text. Two students in the back of the room looked at a catalog of camping equipment, shielding it from her view. She continued explaining radians, with the rest of the class attending to her work at the board.

Ms. Anderson moved on to page 13 in the text and pointed out several key terms. She noticed that the two students who had appeared to be doing nothing were intent over something tucked away in their shared text and she moved away from the board and stood closer to them. The boys were studying the pictures in a camping equipment catalog and Ms. Anderson told them that she did not want to see the catalog in class ever again.

With about five minutes left in the class, Ms. Anderson told the students that she knew she went through the material quickly, but she wanted to get to a lab the next day. (This was so that the researchers could observe a lab.) She said to use the remaining time to work on the homework assignment. Three students worked on the problems, while the rest sat and chatted. When the bell rang, the students moved on to their next class, as did Ms. Anderson.

Day 4: Mechanical Lab for Unit 2

The last day of observation, a Friday, was lab day. All seniors in the school were released to the auditorium for the first two periods to participate in a college get-acquainted session at which several of the local universities and colleges explained their programs. Nine students remained in Ms. Anderson's ***PT*** class. (She later informed the researchers that it was easier to run the lab with fewer students.)

After the seniors left, the other students opened their texts to the lab. Ms. Anderson read the lab objectives.

> When you've finished with this lab, you should be able to do the following:
>
> **1.** Determine the work done by a force that acts on a pulley.
>
> **2.** Determine the work done by a pulley that acts on a load.

3. Show calculation that the work done by a pulley on a load is less than the work done by the force acting on the pulley.
4. Calculate the efficiency of a pulley system.

She then started to read the main ideas for the lab. A loudspeaker announcement interrupted that today was college day for seniors and all seniors should go to the auditorium. Since her seniors were already on their way to the auditorium, Ms. Anderson was visibly upset by the interruption. "We know! We know!" she exclaimed, as she continued reading about the lab.

She then had the students look at the descriptions in the text as she briefly explained the equipment that would be used. She pointed out the table for entering data in the text and told the students to be sure to enter all their data. After her explanation, the students collected the equipment from a cart in the front of the room.

The students separated into three groups of three to work on the lab. All students, including the two who were reading the camping catalog the day before, seemed excited about doing the lab. They glanced at the other groups' setups and seemed somewhat tentative as they fiddled with their own. The groups worked on their labs as Ms. Anderson circulated about the room and observed. Occasionally students asked questions of her. Two groups put the spring scale on backwards, and she told the entire class how to use the scale correctly. Two groups forgot to measure the distance pulled, and she told them to be sure to measure when they pull.

Students seemed to be into the lab. All wanted a turn: "Let me have it, everyone else had a try." "I'll do it. It's my turn again."

While observing their calculations, Ms. Anderson noticed that the weight was measured in grams but the force was measured in Newtons. She told the entire class that they must convert the units to make them comparable. She took a couple of minutes at the board to emphasize her point. (She later told the researchers that the text does not note the need for this conversion. She thought a teacher without a background in a mathematics/science might be likely to overlook this problem and that the oversight would make successful completion of the lab nearly impossible.)

As the lab progressed, some students went to one of the other groups to see how they had done the lab. Ms. Anderson pointed out to the entire class that the lab would be easier to complete if they read the text before attempting it. Students continued measuring and writing their findings in the data table. Ms. Anderson examined one group's results and characterized the numbers as a "weird result." When she asked them to set up the lab and do it again, the students showed no sign of being upset at doing it again.

One student asked, "How come every lab doesn't work out?"

Ms. Anderson replied, "Probably because you guys don't read about it beforehand."

Students completed the lab and returned the equipment to the cart at the front of the room. They talked quietly for the remaining five minutes of class. A male teacher, whose first class had been a prep period, moved into the room to begin setting up for his class which would meet there next. The bell rang, students moved to their next class, and Ms. Anderson moved down the hall to her physics class.

Principles of Technology—Year Two

Only one student of the nine who had completed year one signed up for year two of the course. Because one student was not a sufficient enrollment to justify using the teacher for an entire class period, the class was being taught as an "early-bird" class. Basically, early-bird classes are handled as independent study classes. Ms. Anderson met with the student for one class period per week. These ***PT*** sessions were held at 6:45 a.m. before school began. Ms. Anderson covered any problems the student might have had with the material. The student was responsible for reading the material, working the problems, and taking the tests. The labs for year two were not being used at all in the early sessions although the videos were used when necessary. The student will receive both a grade and a credit if the work is completed satisfactorily.

This arrangement for year two was complicated by the student's work schedule. He worked past midnight several nights per week and had some problems getting to the early-bird sessions. Ms. Anderson said she thought that year-two ***PT*** classes could work on an early-bird schedule. However, she also said that this student may not get a passing grade because of the problems he was having getting to the sessions.

It appeared likely that the year-two ***PT*** classes at Northside would continue to be taught as early-bird classes. Given packed student schedules and the parental push for physics classes, year two seemed unlikely to generate sufficient enrollment to justify an entire section. However, if year-one enrollment begins to increase, it should increase the likelihood that enrollment in year two would also increase.

Issues

There are two particularly significant aspects of the Northside case: dissolved relationship between ***PT*** and voc-ed, and low enrollment.

Whether the lack of a relationship between ***PT*** and voc-ed is a problem depends on one's perspective. Tightening this relationship may help enrollment. There may, however, be several equally, if not more effective, ways to increase enrollment.

The separation of ***PT*** from the vocational education department has occurred because of administrative decisions and because of the nature of Northside's environment. The principles taught in the course support the vocational curriculum, but there has been no attempt to help the two teachers assigned to ***PT*** work together during shared preparation periods or meetings between the departmental heads. There have been no attempts by Ms. Anderson or by Mr. Jenkinson of the voc-ed department to connect the ***PT*** labs to the "real world" applications in technology.

These observations are made as explanations rather than as pejoratives. It could be that in the Northside environment, attempts to connect ***PT*** to vocational education would be resisted by teachers in both departments as well as by parents and administrators. ***PT*** might best serve the needs of Northside High School if used as an overview physics course with some connections to the world of high technology.

Administrators and the teacher all had their own ideas about why the enrollment was so low. Their reasons included:

1. Lack of a science credit.
2. Lack of awareness of the course's existence.
3. Students' schedules. Most students already had enough science credits and full schedules.
4. The title of the course.
5. Lack of integration with the vocational department.

Lack of a Science Credit

The principal, assistant principal for curriculum, and teacher all felt that the lack of science credit probably hurt the enrollment. Because the course was listed as a science course in the catalog and was being taught in the science department, several students who were interviewed assumed that they were getting a science credit. To understand this issue, it's important to realize how a science credit is determined.

In the past, credits for courses were determined within the school by the principal and assistant principal for curriculum, with the final decision made by the principal. Recently, however, the school system initiated a new procedure. A committee now determines the credit for a course. This committee consists of the principals of the two high schools (the new school, which will open next year, already has a principal), the principals of the two junior highs, the system's administrator for vocational education, and the associate superintendent for curriculum. Ms. Anderson and the science department chairman developed a proposal to this committee that ***PT*** be designated as a science credit. Although the committee had not yet met on the matter when the investigators visited, there was consensus among those interviewed (several of whom were on the committee) that ***PT*** would be granted a science credit.

As in many states, the graduation requirements for science credits were being increased. This year's graduating seniors were required to have only one science credit. However, after this year, the requirement was being increased to two science credits. If *PT* is designated to earn science credit, it seems that the increase in required science credit could boost its enrollment.

Lack of Awareness of the Course

Awareness of the course among faculty, guidance counselors, and students seemed minimal. It was listed in the course catalog along with 292 other courses. Ms. Anderson had made presentations in the geometry classes about the course. These were the only information activities undertaken for the current year.

Ms. Anderson wanted to increase awareness of the course among the faculty and staff by having a meeting of the vocational faculty, science faculty, guidance counselors, and some administrators. She planned to show the *PT* information program (which she felt was very good) and to discuss her experiences with the course. It seemed likely that such a meeting would in fact increase awareness of the course. Furthermore, it seemed reasonable to assume that increased awareness among faculty and staff, particularly among guidance counselors, would result in increased awareness among students.

Students' Full Schedules

Obviously, students can take a finite number of classes while at Northside. With the increased graduation requirements, students will be required to have 22 total credits to graduate, two of which must be science credits. If *PT* is granted a science credit, it will be one of 17 different courses available to students to fulfill the science requirement.

Students at Northside determine their schedules in a collaborative process with the guidance counselors. Each counselor is responsible for over 400 students. The counselors help the students determine what courses to take from the 292 courses listed in the catalog. *PT* is listed as follows in the science department section of the catalog.

> PRINCIPLES OF TECHNOLOGY
>
> This is a practical-oriented course stressing basic-level physics concepts. The course is designed for the student who may not want to pursue an engineering degree, but would like to be prepared for a high-tech occupation in modern industry.
>
> LENGTH OF COURSE: year
> PREREQUISITES: Algebra 1-2
> GRADE LEVEL: 10-12
> CREDIT OFFERED: one

Among the counselors interviewed, there was an admitted lack of awareness of the specific students who should be targeted for ***PT***. The information contained in the catalog seemed to be their primary source of information about the course.

Parents also seemed to have a major impact on determining the schedules of students interviewed. The only female in the year-one ***PT*** class said she noticed the class in the schedule. She then talked it over with her dad and enrolled when he thought it looked like a good course. In another case, a student's father called the school to get his son removed from ***PT*** and into a physics class. (Because of the student's grades in algebra, the father's request was denied.) For the many Northside students who are college bound, the parental pressure seems to push students into the higher-status physics course instead of ***PT***.

Freshmen, sophomores, and juniors are required to attend six class periods a day. Seniors, however, are required to attend only four classes a day if they need only four credits to graduate. The teacher, administrators, and several students indicated that many seniors plan their schedules so that they can be out of school every day before noon during their last year. It's likely that this factor works to the detriment of year-two enrollment.

Course Name

The science department chairman, the teacher, and the assistant principal for curriculum all thought the name ***Principles of Technology*** was detrimental to enrollment. The proposal submitted for science credit included the suggestion that the course be listed as "Applied Physics." The teacher and administrators felt this name change would be more appealing to students at Northside. Given the upwardly mobile thrust of the system's constituents, it seems likely that a name change would enhance the appeal of the course for many students and for their parents.

Lack of Integration with the Vocational Department

PT was designed for vocational education students interested in technical careers. It was initiated at Northside by the system's vocational education administrator and underwritten by funds supplied by the state vocational education department. But there the ties to voc-ed end. At Northside the course is a science class taught in the science department by a science teacher. Calling ***PT*** "Applied Physics" will likely make the scientific roots of the course clearer. It seems to be the consensus of the administrators, the science department chairman, and the teacher that the more clearly the course is labeled as science, the better its chance for survival will be. Given the upwardly mobile, college-bound thrust of most of the community, it seems entirely possible that any connection with vocational education could diminish parents' and students' impressions of the course. At any rate, it seems very probable that ***PT*** will remain a science course at Northside.

The Setting

If you're flying to Charles Valley Vocational Center, it doesn't matter where you land—you'll have to drive some distance. You might drive about 90 miles through a river valley, old mountains, and little towns all dressed up for Christmas before you arrive at Charles Valley. The nearest town is five miles south of the school and another town is about eight miles north. The air is clean, and when you stop at restuarants or gas stations, you'll enjoy smiles and pleasant conversation.

School buses drive to Charles Valley from as far as twenty miles away—as the crow flies. By the time the bus has wound down and around the old two-lane mountain roads to the river valley and up to the school, it will have covered many more miles.

Until 20 years ago, the economy of this area was built around the textile industry, agriculture, and foundries. Lower taxes and labor costs, however, sent much of the industry to the southern United States during the 1960's. Then the recession of the 1970's damaged the economy of this river valley even further. Now the economy is being rebuilt with light industry and service industries. In Lippville, at the southern end of the district served by Charles Valley, the Southard-Delmar Medical Center serves an area even more vast than the Charles Valley School District. In Burk, the town closest to the Charles Valley school, there is Burk State University—an NCAA Division II university that was recently upgraded from a "college" to a "university" by the state's Board of Regents. Vineland, a town eight miles east of Charles Valley, is the home of what once was a large railway-car construction facility and now is used on an occasional basis by heavy industry. If you drive around within a five-mile radius of the Charles Valley school you will be traveling through rolling farmland on narrow two-lane roads maintained by the state.

Charles Valley serves an area that is also covered by seven regular school districts. Six of the seven high schools are feeder schools to Charles Valley. At the end of ninth grade, students in the feeder schools opt to go to Charles Valley or stay at the "home high school." Students who attend Charles Valley generally do so because of career interests. Some of Charles Valley's graduates go on to college in engineering or in other academic areas, but most begin careers or enter the military right after high school. About two-thirds of Charles Valley's students score in the fourth, fifth, and sixth stanines on nationally normed achievement tests, and about one-eighth score in the upper stanines. Consequently, Charles Valley's 640 students pretty well reflect the national averages in general mathematical and verbal abilities.

Charles Valley has an advisory board composed of the superintendents of each of the six home high schools. Meeting monthly, the board discusses curriculum, relationships between Charles Valley and the home (feeder) high schools, administrative issues, and other facets of the Charles Valley school. Also, each of the occupational areas taught at Charles Valley has an advisory board composed of industry representatives in the Charles Valley area. The occupational advisory boards have no budgets and make no binding decisions on Charles Valley. However, the board members' relationships with the school are good and their opinions are respected. For instance, when the occupational advisory board to the automotive mechanics department told the school that computer diagnostic equipment was needed in the auto mechanics shop if Charles Valley was going to keep pace with the industry, the board's opinion was considered as proof that the auto mechanics teacher was legitimately requesting the new equipment. This role as an advocate for an occupational department is not uncommon for the occupational advisory board.

Each of the home high schools is responsible for busing students living in its district to Charles Valley. Because of the large area served by this vocational center and the narrow, mountainous nature of the roads in the far reaches of the district, some Charles Valley students spend as much as three hours per day riding a school bus. Accommodating the bus schedules of six different systems and still having enough class time for students who must spend four periods per day in one occupational department has required Charles Valley to be very exacting in scheduling the daily routines. There are eight 41-minute periods in every day. (The state requires that students spend 120 hours in each course during the academic year. At 41 minutes per class, students at Charles Valley just fulfill this requirement and are still able to meet their bus schedules.) Students spend four consecutive class periods in the occupational areas and go to their four academic classes during the other four periods of the day. A student may spend the first four periods of the day in English, history, mathematics, and science; go to lunch; and spend the last four 41-minute periods in graphic arts or auto body repair or one of the other fourteen occupational areas.

Charles Valley has a cooperative employment program in which about one third to one half of the senior class participates. When Charles Larkin, director of the co-op program, hears about a job opening that might meet the program's needs, he approaches a teacher about a student who could fill the position. When a student has been agreed upon and has been offered and has accepted the position, the student spends several hours per week on the job, earning both money and academic credit. Mr. Larkin, who also administers the school's placement program, said that the only limit on the number of students participating in the co-op program is the number of jobs available.

The placement service at Charles Valley is extended beyond graduation. While one of the investigators was talking with Mr. Larkin, a phone call came in from a man who had graduated from Charles Valley two years ago and was now looking for a job as an electrician.

Charles Valley also has a comprehensive athletics program that includes varsity football, wrestling, boys' and girls' basketball, and other sports. Athletics was cited as one of the reasons, however, that a student might prefer to stay at the home high school rather than attend Charles Valley. Coaches in the home high schools encourage the better athletes to stay at the home high school and play for crowds of people they have known all their lives.

The academic environment at Charles Valley reflects a recognition that most of the students want to do well in their occupations but do not, in most cases, plan to attend college. Students spend half of each day in academic classes and half in the occupational areas. There are no study halls at Charles Valley. There used to be, but the state upgraded its math and science requirements for graduation, and at Charles Valley, that meant there was no longer room in the daily schedule for study halls. The tenth-grade mathematics courses are taught as independent studies, with each student using a text based on the special math needs of his or her chosen occupation. That means that mathematics teachers at Charles Valley must be familiar with sixteen different textbooks at the tenth-grade level.

The sixteen different occupational areas at Charles Valley are:

Auto Body Repair	Automobile Mechanics
Carpentry & Construction	Cosmetology
Data Processing	Drafting & Design Technology
Electricity	Electronics
Food Preparation	Graphic Arts
Health Occupations	Horticulture-Floriculture
Machine Shop	Marketing & Distributive Education
Plumbing & Heating	Welding

Students in all areas except data processing, electronics, and health occupations are required to take ***Principles of Technology***. Students in those areas are required to take chemistry.

The *Principles of Technology* Experience at Charles Valley

Principles of Technology first came to the attention of school-system officials when Mr. Scolini, director of the Charles Valley school, heard the president of CORD give a presentation about the course at an American Vocational Association (AVA) conference. Thus, there was already an awareness of the course when State Department of Public Instruction officials approached the principal, Mr. Mahan, about reviewing pilot test materials as they were developed. Mr. Mahan, Mr. Scheidler (the physics teacher), and Mr. Litton (the electronics teacher) all agreed to review the materials and attend the teacher orientation meeting about the course in Dallas in the summer of 1984. The school's operating committee agreed to pay the costs for the principal to attend this meeting, with the ***PT*** project paying the costs of the teachers. So these three went to Dallas, admittedly not knowing what to expect.

Mr. Scheidler, the physics teacher, said that he went to this meeting with a fairly negative attitude about the project. Although he feared the curriculum might supplant his physics courses, he began to see physics instruction presented at the meeting in ways that he had never conceived of before, even though he was a long-time physics teacher. He said he had studied all of the systems that were being presented (mechanical, fluid, electrical, and thermal), but had never considered the parallels among the systems, at least as they were being presented in the ***PT*** course. He, the electronics teacher, and the principal all indicated that they were very much impressed with the course as it was presented at this meeting, and they approached the state officials about becoming one of the official pilot sites for the state. Thus, in the course of a three-day meeting, the physics instructor went from being fairly negative about the course to volunteering to be a pilot-site teacher.

After returning to Charles Valley, Mr. Mahan discussed ***Principles of Technology*** with Mr. Scolini and they decided to ask the operating committee to approve of approaching the state with a request to be a pilot site. According to Mr. Mahan, after Mr. Scolini's presentation, the operating committee gave not only its approval, but its "blessing" to the project.

With the school accepted as a pilot site, the two teachers and principal began to decide how the course would be taught at Charles Valley. Because the content was primarily physics, it was agreed that the physics teacher would teach the course. The industrial education teachers—including electronics, carpentry, auto mechanics, plumbing, welding, and machines—would be available to help create the lab materials. Because class periods at Charles Valley are only 41 minutes long, it was decided that the mathematics department would be primarily responsible for teaching ***PT*** mathematics in its classes. Finally, it was decided to make the course a requirement for most juniors at the school.

Amazingly, all these decisions were made either at the Dallas meeting or shortly thereafter. Two factors in the fast pace of these decisions seem noteworthy. First, the group was clearly impressed with the materials presented at the meeting. Second, the rapid implementation of the decisions made at this meeting was probably enhanced by the relatively small size of the school. These decisions were not contingent on any other administrative actions. That independence greatly speeded their implementation.

With the approach of the first semester, Ms. Scovin, chairperson of the science department, examined the content of the course and decided that she too would like to become involved in the course. So two days before the start of the semester, she was assigned to teach two sections of the course. For the initial pilot test year, six sections of the course were offered: four taught by Mr. Scheidler, the physics instructor, and two taught by Ms. Scovin, the science department chairperson. Over 150 juniors were enrolled in these six sections.

Mr. Scheidler said that, overall, his first-year experience was positive, but it was also trying at times. The course required significantly more preparation time than any other course he has taught. He said he spent well over an hour a day preparing to teach it.

Much of his time was spent securing the necessary lab equipment. Some of the equipment was ordered from commercial vendors, but much of it was manufactured with the help of the various industrial education departments. Mr. Scheidler and Mr. Litton, the electronics teacher, were each given one day per month to work on lab equipment. Substitute teachers were provided for both teachers for these days. The two teachers spent this time examining the equipment requirements, purchasing materials from local stores, and making equipment for various labs. They also worked with teachers from other shop areas—carpentry, plumbing, auto mechanics, and machines—to develop necessary equipment. This entire process underscores the time required initially to prepare the lab equipment. It also underscores the school's commitment to the course.

Even with the extra time devoted to developing the lab equipment, Mr. Scheidler found the labs sometimes frustrating. There seemed to be several sources of this frustration. First, the equipment that was ordered from the vendors rarely arrived on time. Second, there were problems in getting some labs to operate properly. Finally, when the labs worked properly, the 41-minute class periods were often too short to complete the labs.

Ms. Scovin's experience with ***PT*** was somewhat similar to Mr. Scheidler's, but her attitude was different. When asked what she thought of ***PT***, Ms. Scovin responded immediately, "I hate it!" She went on to explain that she thought the course was very good, but because of the labs, arduous to teach. She seemed to think of ***PT*** the same way that many people think of medicine: it tastes terrible, but it's good for you.

"If anyone had told me that these kids could be taught the stuff that's in the course, I would never have believed it until I started teaehing it," Ms. Scovin said. She observed that many of the students' mathematics skills ended after addition and subtraction when they began taking *PT*, but that at the end of the course, those skills showed great improvement.

Asked whether the labs would become easier to teach as time went on, she said, "Maybe, but I doubt it. We're doing so much adaptation that the labs haven't quite settled down yet."

She thought that it was not the slower students who had trouble with the labs, but the smarter ones. "The smart kids memorize formulas but don't learn how to apply them. The slower kids have to start with applications or the formulas will never make sense to them."

Ms. Scovin also taught ***PT*** in summer school after its first year of implementation. The summer-school course was taught in daily two-hour sessions over a three-week period. The class covered the first five units.

Most of the mathematics for the first-year classes was taught by the mathematics department. The department used the material in the ***Principles of Technology*** text and supplemented it with other resources. The science teachers and the mathematics teachers regularly communicated about the mathematics needs of the ***PT*** students. This communication was facilitated by the proximity of the mathematics and science departments (they're across the hall from one another) and the good personal relationships among the teachers. (Mr. Scheidler is the brother of Ms. Gustin, the mathematics department chairperson.)

Overall, then, a notable feature of the Charles Valley experience with the first year of ***PT*** was the amount of collaboration among various departments, including science, mathematics, and industrial education. It seems that this collaboration was facilitated by a combination of administrative support and encouragement, the small size of the school and faculty, and good personal relationships among the faculty involved. Even with the support and cooperation of fellow faculty members, however, the two teachers who actually taught the first year of the course found it to be a time-consuming experience marked by frustration with much of the lab equipment.

The summer between years one and two found the ***PT*** teachers still busy with the course. Mr. Scheidler and the principal attended the summer workshop in Dallas. Additionally, both Mr. Scheidler and Mr. Mahan made a presentation at a workshop sponsored by the State Department of Public Instruction.

Year two has seen growth in both the total sections offered and the total students enrolled in ***PT*** at Charles Valley. There continue to be six sections of ***PT*** year one taught in the science department: Mr. Scheidler teaches one section, Ms. Scovin teaches one section, and Mr. Liedtke teaches four sections. Over 150 eleventh-grade students are enrolled in these six sections. Mr. Scheidler is also teaching two sections of ***PT*** year two, with over

50 students enrolled. Students who elected not to enroll in the year-two class either are not taking a science class or are enrolled in Biology 2.

Mr. Liedtke is teaching the class for the first time this year. His background is in biological sciences and he told the researchers that he had taken only one college physics course. Therefore, he said he is spending at least one hour a day preparing for his ***PT*** classes. This time is spent familiarizing himself with the concepts and preparing for the labs. Even though most of the year-one equipment is in place, Mr. Liedtke said the labs still require extensive preparation on his part. He also said he thought the reading level of the text was too high for some of the students in his classes.

Principles of Technology has become an integral part of the curriculum at Charles Valley in a fairly short time. It has fostered and benefited from collaboration among the science department, the mathematics department, and the industrial education department. And the administrators and teachers at Charles Valley all said that they felt the course addressed a real curriculum need for their students.

Charles Valley Students

As described on page 18, students at Charles Valley are academically similar to students at the area home high schools. The home high schools have a slightly higher proportion of students in the upper stanines of nationally normed achievement tests, but the Charles Valley student body represents the full range of academic achievement.

What was the impact on students of all the faculty efforts to implement ***Principles of Technology***? Several students were interviewed—some who had elected to continue with year two of the eourse and some who had elected not to take year two. Students voiced a wide range of attitudes about ***PT***. Many enjoyed the course, as witnessed by the enrollment in year two. Reasons for taking year two included enjoyment of the labs, enjoyment of the video programs, popularity of the teacher, and career-oriented reasons: "It helps me understand auto mechanics more than biology does."

Students who did not choose to take year two mentioned difficulty with the mathematics more than any other reason. One students said, "All of the formulas made it hard." Some students found the reading difficult, and one student specifically mentioned that the texts had too many "big words."

All students seemed to enjoy the videos. They mentioned that the videos helped with the tests and helped them understand workplace applications. The role models in the video programs were appreciated, although many students wished that the role models "rambled and babbled less."

Using the Videos

Among the three teachers there were different approaches to using the ***Principles of Technology*** video programs.

Ms. Scovin considered the videos self-explanatory and instructive without classroom discussion. She would turn on the VCR and show the program. Her introduction to the program would consist of, "OK, now. Be quiet and let's watch the program." After the class viewed the program, she would proceed with the class without comment about what had been viewed.

Mr. Liedtke introduced the programs to his students by reading the objectives from the unit. He connected the objectives to the unification formula and told his students to be prepared to discuss after the program what they were about to see. He explained this approach to the investigators by saying, "You guys already know I'm new at this class. I think that next year I'll handle things more flexibly, but right now I'm just using anything I can to get the concepts across. I think the students are more likely to pay attention if I give them something in particular to look for. I hope that reading the objectives to them accomplishes that purpose, but I don't know if it does or not."

After watching the program, Mr. Liedtke would ask students to say where in the video they saw each of the objectives emphasized. Usually two or three students would answer all the questions. More students would respond when Mr. Liedtke asked them to identify home or workplace applications of the principles presented in the video.

The third teacher, Mr. Scheidler, would watch each program before he showed it to the class, and from his viewing would write questions that the students should answer as they watched. For instance, before the students watched the program for the electrical subunit in Unit 3: Rate, Mr. Scheidler handed out a paper with the following questions:

1. How do you measure rate in an electrical system?
2. What's an ampere?
3. What might be the result of uncontrolled rate in an electrical system?
4. How does alternating current differ from direct current?

Many students could be seen writing the answers to these questions as the program was being shown.

After the program, Mr. Scheidler would go through the questions and briefly help students discuss the answer to each one.

In Mr. Scheidler's second year *PT* classes, the questions for the Overview program for Unit 9: Waves and Vibrations were:

1. Give examples of when vibrations can create a problem.
2. What do waves have to do with vibration?
3. Give examples of times when vibrations and waves can be useful.
4. What is the difference between mechanical and electromagnetic waves?
5. List three characteristics that all waves have in common.

After the program, there was very little time left in the 41-minute class period. (The video was not the first activity of the class.) Mr. Scheidler asked the students to identify from their lives examples of situations in which vibrations occurred. Examples they cited included vibrations created by a poorly balanced tire, by a hammer hitting a nail during roofing, and by a loose piece in a radiator fan in the classroom at that moment. Examples of useful vibrations such as sonar and ultrasound were also elicited.

Because the class period was so short, the class discussion had to be moved quickly to the next question. In the time available, however, Mr. Scheidler was able only to make the point that vibrations caused waves, and then students had to move on to their next class.

The Oscilloscope Lab

The researchers had an opportunity to observe each of the *PT* teachers conducting the oscilloscope lab. The text describes the objectives for this lab as:

1. Use an oscilloscope to measure the period and amplitude of an electrical signal.
2. Use an oscilloscope to determine the frequency of an electrical signal.
3. Use a function generator to provide a specified electrical waveform (signal).

As with most of the activities observed, the teachers had different ways of dealing with the lab material.

The day before the actual lab day, Mr. Scheidler explained the function of the oscilloscope to his students. He passed out a sheet of paper illustrating the controls to the oscilloscope. He had the same drawing on an overhead. He labelled the parts of the oscilloscope and had the students label the parts on their sheets. He concluded this activity at the end of the class period.

On the actual lab day, Mr. Scheidler had his students report to one of the other science classrooms for the lab because his classroom wasn't equipped to conduct the labs. (See Facilities section on page 30.) When all the students were in one place, he began with a review of the oscilloscope material from the previous day. He then told them what they would be measuring in the lab. A senior electronics student was in the class to assist him.

The electronics student gave a brief presentation about the equipment and how to use it properly. The students then went to their lab stations to conduct the lab. Working in groups of three or four, they fussed with the equipment, asked frequent questions of Mr. Scheidler and the electronics student, and entered the data in the data tables. Most of the groups had completed the lab when the bell rang.

Ms. Scovin began her lab day at the board. She began with a review of frequency, writing the formula "f = m/t" on the board as she explained it. She then conducted a quick review of some of the mathematics involved in the material because, she said, they "haven't had it yet." Most of this review was conducted at the board. She then sent the students to the back of the room to do the lab. Two advanced electronics students were in the class to assist her with the lab. Her students fiddled with the equipment and asked several questions, most of which were directed at the electronics students. They also entered their results in the data table. The class concluded before some of the groups were finished with the lab.

Mr. Liedtke also began his lab day at the blackboard. After briefly summarizing what the students were supposed to have learned from the previous day's demonstration of the oscilloscope, he told the students that he was only a little more experienced with the instrument than they were. The two electronics students had the lab equipment on a cart and had been setting it up in the back of the room during Mr. Liedtke's introduction to the class. At this point, Mr. Liedtke and the electronics students moved around the lab tables and gave the ***PT*** students a lot of hands-on assistance.

By the end of the class period, most students in the class had not finished the lab, but they did seem to be much more comfortable with the use of the oscilloscope. Some of the students were now helping each other rather than relying on the electronics students.

Issues

Time

Probably one of the major factors affecting ***Principles of Technology*** at Charles Valley is the length of the academic class periods—41 minutes. These short periods were designed to accommodate two needs of the school. First, because it is a vocational school, students spend half their day in academic classes (mathematics, English, social studies, science) and half their day in their vocational areas (carpentry, auto mechanics, etc.). Because all the academic classes must be completed in only half the school day, these classes are only 41 minutes long. Second, because students attend Charles Valley Vocational Center from six different regular school systems, the bus schedules of the home schools were considered in scheduling the overall length of the school day at Charles Valley. The day can begin only when the latest bus arrives and must end when the earliest bus departs. Due to this combination of factors, the academic classes at Charles Valley are the minimum length the state will accept for credit.

Principles of Technology was designed to be taught in 50-minute class periods. How has the 41-minute class period affected ***PT*** at Charles Valley? None of the three teachers who were teaching the course thought 41 minutes adequate for many of the activities, especially the labs. Indeed, in several of the classes observed, the bell rang before the planned activities were completed. Clearly, 41-minute class periods are too short for much of the course.

How has Charles Valley attempted to cope with this problem? First and foremost, most of the mathematics from ***Principles of Technology*** is being taught in the mathematics department. This decision was made for both curriculum development concerns and time considerations. Both the mathematics and science department teachers felt that the mathematics could be better taught and learned in the mathematics department. Moving most of the mathematics instruction to the mathematics department made more time available for the other ***PT*** activities. Second, Mr. Scheidler said that on very rare occasions students are kept for a few extra minutes in the ***Principles of Technology*** classes. He said he doesn't like to do this, but occasionally feels he must. Beyond this, little can be done to ease the constraint caused by the short time periods. It is a constraint to which the teachers and the students have become accustomed.

Lab Equipment

Charles Valley builds much of its own lab equipment. This not only saves money and familiarizes teachers with applications of the lab concepts, but also, by the way it is done, shows Charles Valley's commitment to the ***Principles of Technology*** program. Mr. Scheidler and Mr. Litton, the electronics teacher, are each given one day off per month to work on lab equipment. The school pays for substitutes to teach their classes.

During this "lab equipment day," Scheidler and Litton put lab equipment together, searching local auto parts shops, hardware stores, electronics shops, etc., for parts that can be used as lab equipment. They also work on designs that can be given to the machine shop teacher, the welding teacher , and the plumbing teacher to build for use in class.

According to the principal and the Charles Valley business manager, the money spent on substitute teachers to release Mr. Scheidler and Mr. Litton for one day per month more than pays for itself. Because Charles Valley builds so much of its own equipment, it saves a substantial amount compared to the cost of vendor-supplied lab equipment.

During the course of this investigation, Mr. Scheidler was involved in creating a rocket sled out of a model train car and about thirty feet of track. The "rocket sled" was to be used for a lab in Unit 8: Momentum. It was decided that the rocket sled would have to be operated in the hallway to have enough room to come to a stop without artificial braking. This event was anticipated around the school. During the previous spring, students had been required to build their own landing pads onto which eggs could be dropped from the school's roof without breaking. Of course, it is pretty difficult to have a class of students dropping eggs off the school's roof without drawing attention. Similarly, the predisposition Charles Valley has toward building its own lab equipment not only saves money and thoroughly familiarizes teachers with the labs, but also provides some publicity for the class. Building lab equipment and using it so publicly gives ***Principles of Technology*** a special image at Charles Valley.

Building lab equipment also involves several industrial education teachers in the course. In addition, a senior electronics student is given responsibility for maintaining the electronics lab equipment. He has an assistant, a junior in electronics, who will take over the maintenance next year.

All in all, Charles Valley feels that it has made the right decision in building its own equipment. Mr. Scheidler pointed out that there are some pieces that cannot be built or purchased locally. Those pieces have to be ordered from a vendor. There are also instances in which Charles Valley will purchase one piece of lab equipment from a vendor and use it as a model to determine whether it would be more cost-effective to build or to purchase others like it.

Mathematics

Mathematics is part of a student's work every year at Charles Valley. Before ***Principles of Technology***, students took mathematics only in the tenth and twelfth grades. About the same time that Charles Valley was implementing ***PT***, however, the Department of Public Instruction mandated one more year of mathematics.

After reviewing the text, administrators at Charles Valley thought that the mathematics presented in ***Principles of Technology*** was slightly more advanced than the mathematics Charles Valley students received in their tenth-grade courses.

In addition to the State DPI mandate and the perception that the ***PT*** mathematics was slightly more advanced than tenth-grade mathematics classes, there was a third factor leading to the decision that Charles Valley administrators made about their mathematics curriculum. That third factor was time. The 41-minute class periods might not have been long enough to teach ***Principles of Technology*** as only one course.

Administrators lifted the mathematics instruction from the texts to create an eleventh-grade mathematics course. This decision helped Charles Valley in the following three ways:

1. It created a mathematics course to fulfill state requirements.
2. It made teaching *Principles of Technology* in 41-minute class periods possible.
3. It brought students' math backgrounds up to the levels considered appropriate by the local administration.

The teacher-administrator cooperation that was needed to put the mathematics togther as a course of its own is just one more way in which members of the Charles Valley community worked together to make *Principles of Technology* operational.

Facilities

Principles of Technology is taught in the science wing of Charles Valley. Two of the ***PT*** teachers teach the course in rooms that are equipped as biology/life science labs. The labs are at the back of these rooms. The front of each room contains traditional classroom seating—facing the teacher and the board for lectures, videos, and demonstrations. During the labs, students cluster around the tables in the back of the room in groups of three to five. The tables are fairly close together, and the result is a somewhat cramped feeling, especially as a teacher moves from group to group. Nonetheless, these rooms, although fairly small, seem to be adequate for the various activities.

Mr. Scheidler, the physics teacher, on the other hand, teaches the course in a traditional classroom. His desk, in the back of the room, faces the rows of chairs that face the board. He does most of his teaching from the front of the room, using the board to augment his lectures and demonstrations. Although he can conduct most of the demonstrations with this arrangement (there is a table in the front of the room), the room is clearly inadequate for most of the hands-on labs. On lab days, he frequently trades rooms with one of the other teachers. The proximity of his room to the other rooms, which are just around the corner, makes trades relatively easy. However, students seem to forget when the room changes will occur (this seems to be true of most students, who are creatures of habit), and valuable class time is sometimes lost in the confusion.

Overall, then, the classrooms that are used to teach ***PT*** at Charles Valley would probably be classified as less than ideal. However, the cooperation of the three teachers who teach the course lessens the impact the facilities have on their implementation of the course.

Collaboration

Principles of Technology is "not an add on," said Mr. Mahan. The principal's attitude pervades the Charles Valley environment. Perhaps this can be seen best in the interweaving of people's jobs at Charles Valley to make ***PT*** succeed. Already documented in this report, this level of cooperation is possible partly because Charles Valley, as a vocational school, has a more concentrated educational focus than does a school that must satisfy a wider variety of needs.

Faculty, students, their parents, and the administration at Charles Valley still have a wide enough variety of needs, however, that the degree to which they cooperate deserves to be independently reported. Note the following examples:

1. Much of the lab equipment is built in the industrial education classes.
2. The mathematics department has worked with the science department to use ***PT*** as a separate course.
3. The school pays for substitute teachers so that two teachers can work together on the labs.
4. Electronics students maintain some of the lab equipment.

Charles Valley has turned ***Principles of Technology*** into a schoolwide project.

The Setting

Mountain View High School is in a community of about 35,000 people in a desert basin of a northwestern mountain state. The land around Mountain View itself is barren but the school is true to its name. Mountains can be viewed in three directions from the school and some of the best downhill skiing in the world is only a 90-minute drive away. Thus, the horizon is beautiful and as a visitor to the area said, "This is lovely and, if I didn't think I'd miss trees, I could live here forever."

This is an area in which one religion is predominant. About half the population are members and about sixty to seventy percent of Mountain View's students are members. A seminary is located on what appears to be school property but is actually owned by the church. Students may choose to attend classes in the seminary instead of going to study halls.

While the church's influence is still strong, it is diluted compared to what it was ten or more years ago. Ten years ago, administrators could call the bishop as a blind reference on a teacher candidate. If the candidate was not in good standing with the church, he or she might not have been hired. This practice has stopped but the church's influence is still felt. Family orientation is strong in the community, and affects student's behavior and attitudes.

About twenty-five percent of the population is employed by the Northwestern National Engineering Lab (NNEL). The NNEL is federally funded and does research in nuclear engineering, genetics, and in other areas of the natural sciences. The lab is so advanced that its staff is soon to install a Cray computer , and so secure that any person on unauthorized property is discovered, contacted, and ushered from the premises within five minutes of first contact with the forbidden ground. The potentially controversial nature of the research at the NNEL seemingly creates little if any unrest in the Mountain View community. The people rely on the NNEL for the foundation of their economy and point out that the nuclear research done by the NNEL is for peaceful energy purposes.

The economy was not always dependent on the NNEL. Twenty to thirty years ago, the area was highly agrarian and there were primarily two types of farming. Dry-farming required tilling of several hundred to a few thousand acres and would yield sixty to seventy bushels of grain per acre in a good year. Farmers who used irrigation could triple the yield and till fewer acres. Dry-farming is virtually gone from the area and even irrigation pays less well than it used to. The reliance on farming has decreased so much in the area that Mountain View dropped vocational agriculture from its vocational curriculum a couple of years ago. A sugar beet processing plant ated across the road from Mountain View has been closed down for ten years. No uses for it have been found. Mountain View High School is not located in a rich district. As one teacher said, "We kind of supply the bedrooms for people who work in other school districts." There is very little industrial (i.e., tax) base in the district itself. Property owners in the Mountain View district have the highest tax rate in the state although the district's budget is the state's third smallest. A new shopping mall has been built in the district and there are plans for a new hospital, both of which are supposed to add to the tax base. It will be a while, however, before the impact of either of these can be appreciated.

There are a total of 6,718 students in the district. There are eight elementary schools, two junior high schools, and one high school. Two of the junior high schools are currently sharing the same building.

The district seems to be able to respond quite readily to community curricular needs. When some parents felt that Mountain View should offer a course in Japanese, the course was implemented over the summer—including hiring a new teacher. Japanese died, however, due to lack of enrollment. Courses about computers are offered even in the elementary schools.

Mountain View School itself is on the edge of town. The building is about ten years old and designed with a couple of very modern concepts. When you walk into the building, you enter a large common area. The commons is brightly carpeted and surrounded by students' lockers. Students mill around in this area before classes and during lunch. Also, some classes, such as aerobic dancing, can be taught in the commons area. According to one teacher, the commons is very nice because it gives the students a place to congregate and they seem to treat the area respectfully. Depending on the time of day, it may be cluttered but there is no graffiti or other signs of vandalism.

From the commons you can walk up a short flight of stairs in just about any direction to a classroom pod. Each pod has five classrooms. There is a science pod, an English pod, a math pod, etc. When students move from one class to another, they simply leave the classroom pod, walk down the short staircase through the commons and up a few steps to the pod where their next class is located.

Industrial education classes are taught elsewhere. There is a small cluster of older buildings at the other end of the football field from the school. Auto mechanics, auto body, welding, carpentry, and metals are taught in this small cluster. Adding a vocational education pod onto the school building is in the school board's plans, and a bond issue was passed recently for more construction in the school district. The money from that issue must go, however, to building a new junior high school. When asked when the new vocational pod would be constructed, one industrial teacher responded, "The millenium plus ten years."

Industrial education teachers have mixed feelings about not being part of the high school building. They complain about not being kept informed. ("If there's a change in the bus schedule because of the weather, we find out because the buses arrive early.") But they also enjoy the freedom. ("We kind of run our own little nation out here.")

Counselors told the investigators that enrollment in ***Principles of Technology*** (which is slightly better than the national average for the pilot test project) would be much higher if Mr. Swenson, the ***PT*** and metals teacher, was willing to teach in one of the high school's rooms.

The schedule at Mountain View is unique. It is referred to as an "8-period, modified block" schedule. Each period is 95 minutes long and a "schedule day" actually lasts two calendar days with four periods in each calendar day. So students and teachers will have specific classes on Monday, Wednesday, and Friday of one week, followed by the same classes on Tuesday and Thursday of the next week. Many teachers thought the new schedule to be a good idea because it allowed for more contact time during the day than a more traditional six- or seven-period day allowed. So far, for Mountain View, the 8-period, modified block schedule seems to be working. (One impact of the schedule on this study was that only two days of ***PT*** classes could be observed.)

Mountain View has also inherited a couple of special circumstances from the State Department of Education. There is a C-average rule that requires students to maintain a C average in their core classes (English, mathematics, reading, and speech) in order to graduate. Also, regardless of in-class test performance, students in this state do not receive credit for taking a course in which they have missed ten percent of the classes.

Many, many students in Mountain View have their own cars. At the end of the school day, the parking lot is hectic. Also, students who have to go from the high school to the vocational area commonly drive out of the parking lot and then down the road to the vocational parking lot rather than walk the roughly two hundred yards required to get to vocational classes. This is a phenomenon that occurs even in the most beautiful weather.

The *Principles of Technology* Experience at Mountain View

Mr. Swenson, the ***PT*** teacher at Mountain View, first heard about ***PT*** from Mr. Arrington, the state department representative for vocational education. Mr. Swenson told the researchers that, after 14 years, he had reached a point of burnout in his teaching and was searching for something new to use in class. As a result, he wrote a proposal to the state department for a computer manufacturing program. While that proposal was being considered, the state department approached him with a program that would be pilot tested over the next two years. Of course, that program was ***Principles of Technology***. Mr. Swenson agreed to become one of the two pilot test sites for the state. Interestingly, his proposal for the computer manufacturing program was also funded, so Mr. Swenson would be implementing two new programs the following year.

Mr. Arrington, the state department vocational education representative, then contacted Mountain View's administrators. He presented the program to Mr. Adler, the principal, and Dr. Smithers, the system's superintendent. Since both of them approved, Mountain View became an official pilot test site. The costs of implementing the course would be underwritten by the state vocational education department. These costs included the lab equipment and a videocassette recorder for the classroom. Mr. Swenson, an industrial education teacher, would teach the class.

During the following summer, Mr. Swenson went to Dallas for the introductory workshop. The group that Mr. Swenson was traveling with arrived late to the workshop, and so they walked into the meeting after the initial sessions had begun. Mr. Swenson told the researchers that he was somewhat overwhelmed at this workshop, because much of the material being presented dealt with concepts that he hadn't covered in quite a while. This material included both the physics and math content. So Mr. Swenson returned home somewhat apprehensive about the upcoming year, feeling that he would have to work hard to be able to teach the material to his students.

Mr. Swenson began that year teaching four sections of metals, the new computer manufacturing class, and the ***Principles of Technology*** class. Since the ***PT*** class wasn't in place in the spring, students were recruited during the first week of school. Most of this recruiting was handled by the counselors. The result was a first year enrollment of 21 male students. These students included eight twelfth-graders, seven eleventh-graders, and six tenth-graders.

The class was taught in Mr. Swenson's metals lab. This lab is in its own building in the industrial education cluster. Mr. Swenson told the reseachers that he had to work very hard during the first year of the pilot test and, in many instances, felt like he was learning the material as his students were. He said he frequently spent as much as one-and-a-half to two hours in the evenings preparing for the next day' s class.

Overall, Mr. Swenson was pleased with the first year of the project, even though it had its problems. Most of these problems were with the lab equipment. Frequently, the lab equipment didn't arrive when it was needed. Also, he had to work hard to stay on top of the material. Nineteen of the 21 students who began the year completed it.

For year two, nine of the eleven first-year students who weren't seniors returned for year two of the course. Another fifteen students enrolled for year one of the course and, at the time of this study (March), twelve of the fifteen were still enrolled in the class. The other three either dropped out of the class or dropped out of school. Mr. Swenson reported he was much more comfortable in year two of the pilot test, both in teaching the year-one course, since he had been through all of the materials the previous year, as well as in teaching year two of the course.

During year two of the course, Mr. Swenson made a presentation to the school board about the ***Principles of Technology*** course in which he showed the overview video program to the board and discussed how he was teaching the class. Board members responded enthusiastically. According to the superintendent, "Several board members said they wished they could have had such a course when they were in high school." At the conclusion of the presentation, the school board voted to grant a science credit for each year of the course.

What does the future hold for ***PT*** at Mountain View? Mr. Swenson has undertaken extensive recruiting efforts in the junior high schools. (These efforts are described in detail on page 43.) If these recruiting efforts are successful, it is possible that up to four or five first- year sections of ***PT*** will be offered at Mountain View. If this many sections are necessary, it would present a dilemma for both Mr. Swenson and for the school administration. Mr. Swenson told the researchers that although he likes ***PT*** and is committed to it, he wouldn't want to teach only ***PT*** sections. He said he also enjoys teaching metals and the computer manufacturing course and wouldn't want to give them up. If more sections are required than Mr. Swenson can teach, the school administration then must select another teacher to teach the course. The principal informed one of the researchers that he is committed to having a vocational teacher teach the course, since he feels such a teacher can most effectively communicate the hands-on aspects of the course. So, if a significant number of students elect to take the course, it seems likely that another vocational teacher will be selected to teach additional sections. Of course, these decisions await the results of the recruitment efforts.

Finally, during the summer after the second year, Mr. Swenson will travel to a neighboring state for another ***PT*** workshop. Four mountain-area states have formed a mini-consortium to help one another with the implementation of ***PT*** in additional schools. Many prospective ***PT*** teachers will attend this summer workshop and learn about the course. A significant part of the workshop will be devoted to the lab equipment, including where and how to secure it and also how much of the equipment can be made on-site. Although Mr.

Swenson was not one of the presenters at the workshop, it seemed likely that he would be sharing his insights as one of the pilot test teachers.

Principles of Technology Students at Mountain View

Students at Mountain View who take ***Principles of Technology*** say they enjoy it. Nine of the eleven underclassmen who finished ***PT***-1 enrolled in ***PT***-2. Additionally, a student who had taken physics as a junior is now taking ***PT***-2 without having had ***PT***-1. One of the two ***PT***-1 students who did not take ***PT***-2 would have liked to but it didn't fit into his schedule. The other student who did not enroll in ***PT***-2 said that he would rather take a course such as ***Principles of Technology*** from a regular physics teacher.

The physics student who had not had ***PT***-1 said that he was not having any severe trouble with ***PT***-2. He explained that when the course dealt conceptually with physics, it was an easy review for him. When the students were in labs, he said that ***PT***-1 students sometimes understood the equipment better than he did but that he caught on as the lab progressed.

Three of the students in the ***PT***-2 class take no other classes in the vocational area. When asked, one of these students said that he was willing to go over to the metals shop for ***PT*** because "one of the counselors said it was a good class." When asked why more non-vocational students were not willing to go over to the industrial education area to take ***PT***, these students said that more students probably would be willing to if they knew about the course.

When the ***PT***-2 students were asked what they did not like about the course, the first thing they mentioned was the role models in the videos. "They don't seem like they know what they're doing," said one student. "And the way they explain stuff sometimes makes it more difficult to understand. Like that guy who was up in the skyscraper explaining vibrations."

Other things that the students did not like about the course were that too often the lab equipment was either not available or did not work when it was available. Students also suggested that some of the vocabulary in the text was a little too "high falutin'" and that many of the explanations "like the one about how an air conditioner works" might as well be left out because they make the lesson harder—rather than easier—to understand. Students explained, however, that they appreciated the class time Mr. Swenson would take to explain anything in the text that they did not understand.

Some students identified times outside of the class when they had thought of ***Principles of Technology***. One student who was a ski instructor said that he was teaching an engineer how to ski and, while he wasn't able to exactly explain how the forces were working on the skies, he was at least able to tell the engineer to think of skiing in terms of "forces" and that somehow made the engineer feel more comfortable about it. Another student mentioned that *PT* made his dad's irrigation system more interesting to him.

Students taking ***PT***-1 also seemed to enjoy the course. Of the eleven students present the day of the classroom interview, nine said that, schedules permitting, they would take ***PT***-2 next year. Year-one students said that they had no problems with lab equipment and that the labs were interesting and helpful for understanding some of the concepts discussed in class.

Several of the students in the year-one class said that ***Principles of Technology*** was helping them with the science section of the state achievement tests that they had taken that morning.

Principles of Technology Classes

PT Class—Resistance (Tuesday)

Mr. Swenson began class by holding up a brake shoe and saying, "We've been talking about resistance. You all know this thing in my hand works because of resistance. But look at it. (Mr. Swenson ran his finger over the brake shoe's smooth surface.) There's not much friction here so how do you suppose the resistance is created that makes your car stop?"

A couple of the students talked to each other and then one of them said, "Pressure?"

"That's right. So now that you've figured that out, what do you suppose the relationship between pressure and resistance is?"

Some students' eyes bulged when they realized that Mr. Swenson was expecting that, from something simple like a brake shoe, they should learn about the relationships among concepts like resistance, pressure, and friction. They looked at each other and chuckled as though they were getting used to such expectations as this.

After the class decided that resistance must increase as pressure increases, Mr. Swenson said, "OK, we're going to move on to the next idea here. How would you feel if you took your pickup truck into the mechanic for new brake shoes and he was dirty and had grease all over his hands and he put his hand on the brake shoe surface as he installed it in your truck?"

Several of the students said they would be angry about that.

"How come?" he asked.

"Because my brakes wouldn't work."

Mr. Swenson, through questioning the students until they gave the right answer, got them to say that the grease was a "lubricant" and from there he moved into a discussion of lubricants, friction, and resistance. Only after the students seemed to be able to discuss resistance in terms of a brake shoe did he go to the blackboard and start to explain the formula for calculating resistance.

After this, he asked students to identify good and bad examples of friction in their real lives. Students immediately said that friction was bad for automotive pistons and that by adding a lubricant, such as oil, they could cut down on friction that would otherwise cause too much heat and be harmful to their trucks' engines. Students also identified the relationship between friction and tire pressure. Mr. Swenson helped them explain this to him by drawing diagrams on the blackboard of a tire's footprint at 26 psi and at 32 psi. Students said that the higher the pressure, the smaller the footprint and the less the wear on the tires. They also pointed out, however, that the lower the pressure, the larger the footprint and the greater the safety since there was more contact with the road. Other examples of useful friction included sandpaper and the buffing machine that the students used in their metals class.

Mr. Swenson moved the discussion on to the heating and air conditioning system in a house. Students realized that when they were designing the layout for the ducts, they wanted as few bends in the system as possible because bends would create resistance and thereby reduce efficiency. At one point in this discussion a student mentioned that the same principle appled to the "PVC in their homes. Another student said, "What's PVC?" Mr. Swenson went to his ***PT*** equipment supply closet, emerged with a piece of white plastic tubing in his hand and said "polyvinyl chloride" and the discussion moved on.

Class ended with students being given the last fifteen minutes to read their texts.

PT Class—Energy Convertors (Tuesday)

Mr. Swenson's ***PT***-2 class began at 11:20 a.m. The class of six students sat around one table while Mr. Swenson opened his teacher's text to begin the class. Standing behind his "lectern" (a clean, plastic garbage can with a two-foot square piece of plywood on top), Mr. Swenson used the text as a lecturer would use notes. Except for reading the subunit objectives to his students, he did not read from the text. Rather he directed students' attention to different portions of the text and discussed the various concepts with them.

Mr. Swenson rarely used the blackboard and when he did, he drew diagrams more often than he wrote formulas to help students understand what was being discussed. As class went on, Mr. Swenson drew on what the students should have learned from other units. He referred students to the text as they discussed a thermopile. "Remember what efficiency is?" he asked. The student who was first to say "yes" was prodded into describing efficiency as a comparison of energy-out to energy-in.

Mr. Swenson stopped the discussion to give students a few moments to read about efficiency of a thermopile. After students read the text, Mr. Swenson wrote the equation for calculating the efficiency of a thermopile on the blackboard and asked students to consider in what units the equation should be worked. Students began leafing through their texts looking for the "answer" but Mr. Swenson admonished them saying, "Now quit looking in your books. Use your heads and a little common sense." He told students to explain these concepts "in your own words and give me an example of it." Students verbally considered relationships among joules, watts, and calories/second. Students considered that while they could actually work the equation in any units, they were most familiar with watts and they thereby determined that watts would be the units to which they would convert everything when calculating the efficiency of a thermopile.

High efficiency is not always the most important concern about energy convertors and Mr. Swenson pointed this out by discussing with the students how energy could be converted in space. The side of a space capsule that is toward the sun is very hot while the side that is away from the sun is very cold. Mr. Swenson pointed out that students should realize from this that while using a space capsule as a thermopile is very inefficient, it is a wise way to convert energy in space, because in this real-world example, no fuel is required. Rather the energy is converted from the natural temperature differences on opposite sides of the space capsule.

Mr. Swenson then asked the students to identify different kinds of energy convertors and a lengthy discussion ensued about many real-world examples of converting thermal to mechanical energy. Students identified engine starters, thermostats and toasters. At "toaster" Mr. Swenson laughed and stopped and said he wasn't sure that a toaster was an example of an energy convertor converting thermal to mechanical energy. Many members of the class said something like "yeah, maybe not," and the discussion went on without the question being resolved one way or the other. At one point, students were having trouble identifying any more thermal to mechanical energy convertors. Mr. Swenson went back into his supply closet and came out carrying a piece of equipment from a previous lab and asked "Remember this?" He pointed out that while the purpose of that particular lab had not been to study thermal to mechanical energy convertors, this particular piece of equipment was a very good example of one.

After this, Mr. Swenson reviewed the unit with students before they took the unit test. Rather than just reading the objectives, Mr. Swenson made sure that students could discuss the basics of each objective. The class then watched the unit overview video program.

Students were not able to finish the test before the class period ended, so Mr. Swenson told them that they could begin the following class period by finishing the test.

PT Class—Energy Convertors (Thursday)

Because of state achievement tests during the morning, all classes were compressed into the afternoon. Each class lasted 35 minutes.

Students in ***PT***-2 came into class and finished the test on Unit 10: Energy Convertors. Because of the shortened day and the unseasonably beautiful weather (the door to the metal shop was open), the students were somewhat unruly. Mr. Swenson had to talk to them more than once to get them to settle down and finish their test. Mr. Swenson had hoped to start Unit 11: Transducers by the end of the period, but the students finished the test with only about five minutes to go in the period, so Mr. Swenson chose to begin Unit 11 the following class period.

Issues

Facilities

Mr. Swenson teaches ***PT*** in his metals lab. This lab is in a small, older, metal building that sits across the football field from the high school. The inside of the building contains a small office in which Mr. Swenson has an Apple computer and printer. Most of the rest of the building is taken up with a large space that contains various metal-working machinery, the computer-assisted design machine, and classroom desks that face a blackboard in front of the room. The ***PT*** lab equipment is stored in a long walk-in closet that is next to Mr. Swenson's office. This closet contains a variety of shelving, and the equipment is very carefully organized. If students have questions, Mr. Swenson can quickly locate an apparatus from the closet that illustrates the principle in question. Mr. Swenson's classes are the only ones taught in this building.

Most of the other industrial classes are taught in another older building across the parking lot from the metals lab. However, all the industrial facilities are located about 200 yards from the high school.

The issue of facilities boils down to one of where the class should be taught: in the metals lab, or in the science pod of the high school. Mr. Swenson adamantly prefers that the class be taught in the metals lab. He said he thinks it is essential that he have complete and ready access to the variety of equipment that he has in the building. This equipment includes both the ***PT*** lab equipment and the variety of other equipment that he uses in his metals and computer manufacturing classes. The principal, on the other hand, would prefer that the class be taught by Mr. Swenson in the science pod of the high school. He feels that, if the class were taught there, the enrollment would be likely to increase for two reasons. First, many students are simply not willing to take classes in the vocational area because the buildings are too far away. Second, he believes that if the class is taught in the science pod, it might attract additional students who are on more of an academic track in their scheduling, but who would benefit from ***Principles of Technology***'s hands-on approach to science.

Thus, the issue of facilities is one that has yet to be resolved.

Teacher

Principles of Technology is currently being taught by an industrial education teacher at Mountain View. As we have seen, the course was taught by an industrial education teacher for two reasons. First, since Mr. Swenson himself already had submitted a proposal to the state department for a new program, the state approached him when the ***Principles of Technology*** pilot program became available. Also, the school's principal said that he felt the course should be taught by an industrial education teacher. If additional sections of the course are required, and Mr. Swenson is not able to teach all the sections, the principal said that he is committed to having another vocational or industrial education teacher teach these sections.

Mr. Swenson does not pretend to understand principles that are new to him or that he has not worked with since college. When something comes up in class that is outside his recent academic experience, he tells the students that he and they will have to learn about that together. Students remarked how much they appreciated that approach and said that they wished some of their more "academic" teachers would take the same approach more often.

Mr. Swenson relates everything in the course to his students' real lives as much as he can. For example, he said, "Pickup trucks are the 'in thing.' You've got to have four-wheel drive and big tires and jack the whole thing up. That's OK. We just use that to talk about torque. I asked, 'What happens when you increase the size of the tires?,' and they said, 'The rear end goes out.' We try and relate it to something that means something to them like that. That gets them interested in the class."

Norm Broughton, chairman of the Mountain View vocational department, said that vocational education needs more courses like ***PT***. According to Mr. Broughton, there's too little emphasis on teaching science to vocational students.

Whether ***Principles of Technology*** should be taught in the vocational buildings or in the high school building is an issue that Mr. Broughton feels strongly about. "They think that a lot of good students are missing out on ***PT*** because it's not taught over in the other building. That may be," he says, "but those students can come over here to take the course; and besides, there's no reason that our students should have the course removed from the setting they enjoy the most."

Recruitment

While the researchers were at Mountain View, Mr. Swenson spent a day recruiting ninth-grade students for next year's ***PT*** course. Because both junior high schools use the same building (a new junior high is soon to be constructed), Mr. Swenson was able to make presentations to all ninth-grade earth science classes in one day. Conveniently, the junior high is located about 50 yards from his metals building. A substitute teacher was provided so Mr. Swenson could devote his entire day to recruiting.

After being introduced to each class, Mr. Swenson made a brief five-minute presentation about ***PT*** and explained where the class was taught. He told students that ***PT*** was "technologically current" and would give them a good foundation for understanding the technical aspects of the world in which they live. He explained to them how often technical employees had to be retrained in order to stay abreast of developments in their jobs and said that ***PT*** would give them an understanding of technical systems.

After his brief introduction to the course, he showed the overview video, "About ***Principles of Technology***." In the classes that the researchers observed, students were quite attentive to the video. In a couple of classes, one of the ninth-grade guidance counselors was also present. Mr. Swenson then answered students' questions. One student asked if the course could be substituted for biology since it was a science credit. Mr. Swenson didn't have an immediate answer for the question since the issue had not been addressed. After checking with the principal and the guidance counselors, he determined that biology was a required science credit for graduation, so ***PT*** could not be substituted for biology. ***PT***, it was explained to the students, would be granted an elective science credit.

In most classes, Mr. Swenson's presentation lasted about 20-25 minutes including the time for showing the video program. For some class periods, he had to make two presentations during one class period. During the day, Mr. Swenson addressed about 350 ninth-grade students.

Regarding ideal enrollment for ***PT***, Mr. Swenson said he would like to have at least two sections with 12 to 15 students in each section in order to feed one section of the second-year class. He also said that ***Principles of Technology*** was not for "the best kids" and that he would not want too many of them in ***PT*** anyway because "that would make the kids that this was intended for feel uneasy." Mr. Swenson wants all of the ***PT*** students to have at least a general math background and said he could even take a couple of special education students if the situation warranted it.

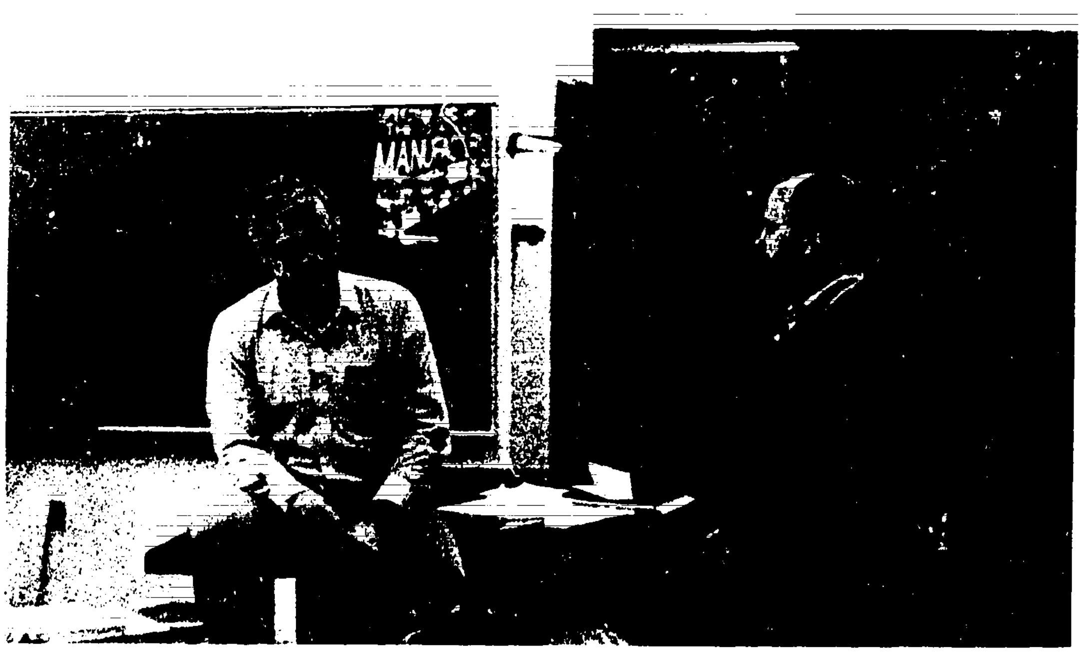
Relationship with Science Department

Two faculty members of the science department were interviewed by the researchers. These teachers taught physics, earth science, and biology classes in the science pod of the high school. Both teachers said they knew very little about the ***Principles of Technology*** course. Both said they had planned to get over to Mr. Swenson's class to observe but that to this point, they had not made the time. They knew the course had been funded well enough by the state to purchase a considerable amount of lab equipment and noted that the state funding created a difference in the amount of equipment available to their department and to ***PT***.

When researchers asked if it was okay that the ***PT*** students were receiving science credit, both teachers expressed surprise that science credit was being given. The physics teacher said that he wasn't sure that science credit should be given to students for taking a course from a non-science teacher.

(It is relevant to note here that in the pilot testing of ***Principles of Technology***, there were no significant differences between how students of industrial education teachers and students of science teachers performed on the pre- and posttests.)

Thus, there is almost no contact between the science department and the industrial/vocational departments at Mountain View. Since the departments are physically separated from one another—in separate buildings—a relationship between them is difficult to foster. For ***Principles of Technology***, this means the science department is virtually unaware of the course's existence.



Conclusions

This report described the observations of two researchers who were able to spend only one week at each of three schools. But even with such a brief glimpse, one can gain an appreciation for the complex combination of elements that affects ***Principles of Technology***'s implementation.

As a physics course designed for vocational students, ***PT*** is a curricular innovation. Implementation of any curricular innovation is affected by a variety of factors, including but not limited to:

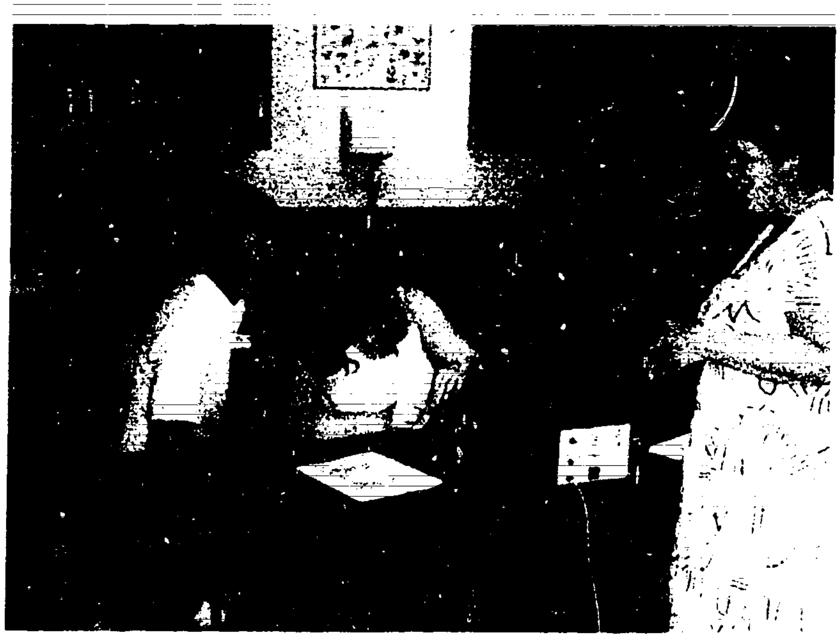
- the needs of the community served by the school
- the socioeconomic level of the community
- parental expectations
- the size of the community and school
- the state's policies
- the administrative structure of the school district
- the educational focus of the school
- the teacher's background and style
- the students' backgrounds and expectations

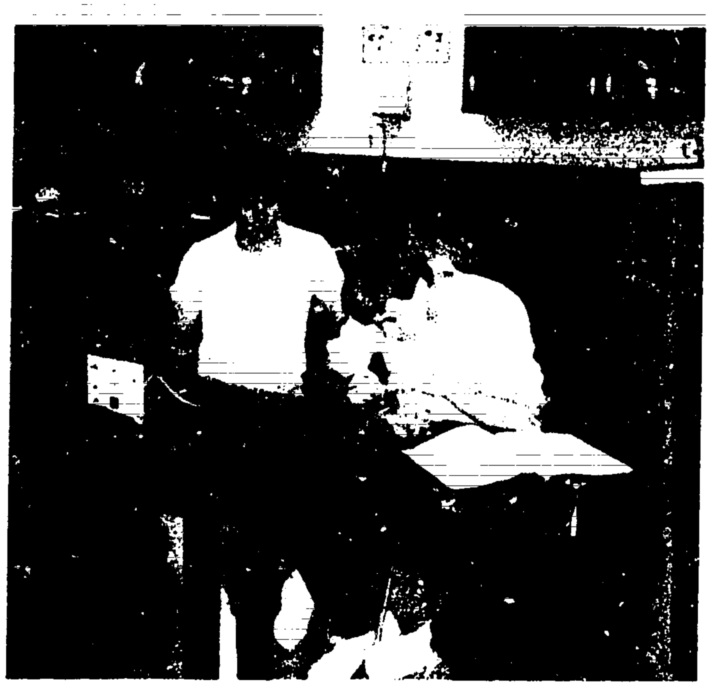
In the three schools described here, the relative importance of these elements affected many decisions about funding, facility allocation, course credit, teacher selection, and student recruitment.

In this study we've attempted to describe how these many factors seem to be affecting the course at the three sites. Yet, ultimately the implementation process rests on the backs of individual teachers. One of the beauties of teaching is that there are many different styles. Certainly, the five ***PT*** teachers observed in this study had their own individual styles. The differences in the ways science teachers and the single vocational teacher taught the course were striking. The science teachers tended to explain concepts through fomulas presented at the board. On the other hand, the vocational teacher observed tended to illustrate concepts with concrete examples. It's relevant to note that the pilot test results showed comparable pre/posttest gains in classes taught by science teachers and those taught by vocational teachers.

And so, after three weeks of observation, countless interviews, and much time spent writing and talking between ourselves, what have we learned? It is not easy to implement ***Principles of Technology***! For administrators, decisions about who will teach the course, who will take it, and where the funds can be found are complicated. Teachers have many components to coordinate, while at the same time concentrating on a dense curriculum and the needs of their students. For students, the course is a mixed bag of science and mathematics, demonstrations, and hands-on activities.

It's most encouraging to be able to report that even with all the challenges the course presented them, the administrators, teachers, and most students at ach of the three sites said that PT repaid their effort. As one principal said, "If you want to make it work, it will work. We think it's worth it."





Appendix A

Participating Agencies

Alabama State Department of Education
Division of Vocational Education

Alaska Department of Education

Alberta Education

Arizona Department of Education

Arkansas State Department of Education
Vocational and Technical Education Division

California State Department of Education
Division of Vocational Education

Colorado State Board for Vocational Education

Delaware
New Castle County Vocational-Technical School District

Florida Department of Education
Division of Vocational Education and Office of Instructional Television and Radio

Georgia Department of Education
Office of Vocational Education

Idaho Division of Vocational Education

Illinois State Board of Education
Department of Adult, Vocational and Technical Education

Indiana State Board of Vocational and Technical Education

Iowa Department of Public Instruction
Career Education Division

Kansas State Department of Education
Community College and Vocational Education Division

Kentucky Department of Education
Division of Vocational Education

Louisiana State Department of Education
Office of Vocational Education

Maine State Department of Educational and Cultural Services
Bureau of Vocational Education/Division of Program Services

Maryland State Department of Education
Division of Vocational/Technical Education

Massachusetts Department of Education
Division of Occupational Education

Minnesota Special Intermediate School District 916

Mississippi State Department of Education
Vocational-Technical Division

Missouri Department of Elementary and Secondary Education

Montana Office of Public Instruction
Department of Vocational Education Services

Nebraska Department of Education
Division of Vocational Education

New Mexico
A consortium of school districts

North Carolina State Department of Public Instruction
Division of Vocational Education

North Dakota State Board for Vocational Education

Ohio Department of Education
Division of Vocational and Career Education

Oklahoma State Department of Vocational and Technical Education

Oregon Department of Education
Division of Vocational Education

Pennsylvania Department of Education

Rhode Island State Department of Education
Division of Vocational Education

South Carolina Department of Education
Office of Vocational Education

TVOntario

Tennessee State Department of Education
Division of Vocational Education

Texas Education Agency
Division of Vocational Education

Utah State Office of Education

Vermont State Department of Education
Division of Adult and Vocational-Technical Education

Virginia Department of Education

West Virginia State Department of Education
Bureau of Vocational, Technical and Adult Education

Wisconsin Department of Public Instruction
Bureau for Vocational Education

Appendix B

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