DOCUMENT RESUME

ED 300 624 CE 051 289

TITLE Principles of Technology. Units 1-10 Pilot Test Findings.

INSTITUTION Agency for Instructional Technology, Bloomington, IN.; Center for Occupational Research and Development, Inc., Waco, Tex.

PUB DATE Nov 87

NOTE 774p.; For related documents, see ED 276 412 and ED 290 039.

PUB TYPE Reports - Research/Technical (143) -- Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF05 Plus Postage. PC Not Available from EDRS.

DESCRIPTORS Competency Based Education; Curriculum Evaluation; Demonstration Programs; *Field Tests; High Schools; *Learning Modules; *Physics; *Science Curriculum; Science Instruction; *Technology; *Vocational Education

IDENTIFIERS *Principles of Technology

ABSTRACT

This document provides the findings of pilot tests of 10 units for an applied science course for high school vocational students. Each of the reports on the pilot tests of the Principles of Technology units contains information on procedures, methodology limitations, sample, the pretest/posttest instrument and results, student attitude results teacher results, and conclusions. Pilot test findings are presented for these units: force, work, rate, resistance, energy, power, force transformers, momentum, waves and vibrations, and energy convertors. Appendixes provide pretest/posttest by objectives (and by percentages for some units), mean scores, pretest/posttest frequencies, student attitude data, and teacher data and comments. (YLB)

PRINCIPLES OF TECHNOLOGY

UNITS 1-10

PILOT TEST FINDINGS

Agency for Instructional Technology

Center for Occupational Research and Development

PRINCIPLES OF TECHNOLOGY

UNIT 1: FORCE

PILOT TEST FINDINGS

AGENCY FOR INSTRUCTIONAL TECHNOLOGY

CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

December 18, 1984

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Introduction

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 33 state 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. Each unit consists of a student manual, a teacher's guide, hands-on laboratories, and video programs. The prospectus for the project was issued in June of 1983; the initial development work began in November of 1983.

An important part of the developmental process is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working, and 2) to identify specific problems with the materials. Each consortium agency has designated 2 sites in their state/province as pilot test sites. All pilot test teachers were oriented to the *Principles of Technology* course and the pilot test procedures at one of two meetings in Dallas, Texas, held in the summer of 1984.

The pilot testing of Unit 1, FORCE, began in most sites with the start of the 1984-85 school year. This report details the findings of the Unit 1 pilot test.

Pilot Test Procedures

Unit 1 pilot test materials were mailed to the teachers in mid-August, 1984. These materials consisted of:

1) Pre/post-tests (see Appendix B)
2) Computerized scoring sheets for the pre/post-tests
3) Student attitude questionnaires (see Appendix E)
4) Teacher questionnaires (see Appendix F)

Teachers administered the pre-test before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the post-test and the student attitude questionnaires. All Unit 1 evaluation materials were then mailed back to AIT. Data contained in this report include all material received by November 28, 1984.

Limitations of the Methodology

There are two major limiting factors that must be considered when interpreting the findings: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered including:

*Lack of matched control groups

The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in terms of time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

*The pre-test/post-test format

The same test was used for both the pre- and post-test. The effect of memory of the pre-test on post-test performance was another concern. The research design addressed this concern in three ways:

1) Students were not given the correct answers to the pre-test. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

2) The post-test was administered more than one month after the pre-test. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

3) A correlated t-test was used to analyze the pre/post-test data. This technique helps to partial out any variance that might result from an intruding correlation--in this case memory.

*The pre-post test as an instrument (See section on development of the instrument, page 7).

The test cannot measure all objectives. Therefore objectives had to be sampled. Also, the items do not always <u>directly</u> match the intended objectives. The test was a cognitive test. Many of the objectives, (particularly the lab objectives) are psycho-motor objectives. Each of these factors must be considered when assessing the validity of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results including:

*Equipment problems

Several teachers reported problems in securing necessary lab equipment.

*Student characteristics

At this time the project does not have adequate data to describe the students in the pilot test, although there seems to be considerable variability in the kinds of students in the course. Attempts have been made to collect these data, which should be available for subsequent units.

*Teaching pattern

There appears to be considerable variability in terms of length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to describe the impact of the various conditions on the outcomes.

So both research design and external constraints must be considered when interpreting the results. It's important to remember that the overall pilot test was designed primarily as a formative evaluation to improve the materials, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

Sample

Materials were mailed to a total of 72 sites. At this time (November 28) materials have been returned from 31 sites. Due to missing data, the numbers don't always total 31 sites. Attempts have been made to contact by phone each teacher who has not returned materials. Even with repeated phone calls, it was not possible to pinpoint each of the non-returnees. There are distinct categories among the non-returnees including:

1) State level delays - Washington state was among the original 72; they have since dropped out of the project (2 sites). Alaska and Ontario have decided not to pilot test the materials this year (4 sites). Kentucky (2 sites) and Georgia (2 sites) joined the project late and haven't begun testing, although they have been sent pilot test materials.

2) Equipment problems - Several sites have delayed starting the pilot test due to problems in securing equipment. These problems have been of two types. The one that has most affected the pilot test has been a funding problem; funds were not available for equipment when the pilot test began. In other sites, the equipment was ordered but had not yet arrived, so they delayed starting the pilot test. (As the attached teacher comments indicate, several sites had problems with equipment arriving late, but not all of them delayed starting the pilot test because of it.)

3) School Routine - The normal school routine of several schools has resulted in delays. These routines include schedules (some teachers, for example, teach *Principles of Technology* every other week and don't expect to finish Unit 1 until late November), time for achievement testing, conferences, and vacations.

4) Dropouts - One teacher has left his school and one has discontinued the pilot test.

5) Illness - Two teachers have had extended illnesses. One was severely burned by an exploding cotton gin and missed a month of school.

Thus, the non-returnees represent a range of administrative and "real world" problems.

What are the characteristics of the teachers who did return materials?

Relevant teacher characteristics include (details can be found in questions 1-9 of the teacher questionnaire):

*Physics Background

-Almost half of the responding teachers (44%) have had 1 or less college physics classes.

*Mathematics Background

-Almost all teachers (97%) have had 2 or more college mathematics courses; several (29%) have had 5 or more college mathematics courses.

*Teaching Pattern

- Most (68%) taught *Principles of Technology* on consecutive days
- Most (80%) taught sessions that were 60 minutes or less
- Several (41%) indicated they had combined some classes into one session

*Preparation Time

- Over half (59%) indicated they spent 60 minutes or less preparing to teach each unit on FORCE. Another third (32%) indicated they spent 60-90 minutes.

Unfortunately, the project currently doesn't have adequate information about the characteristics of the 602 students. Forms about student characteristics have been sent for both students and teachers to complete, but to date forms from only 6 classes have been returned. So, at this point only grade and sex data can be described:

*Grade

9=1% 10=15% 11=54% 12=21%

*Sex

Male=87% Female=13%

Pre/Post-Test as an Instrument

To understand the results, one must first understand the characteristics of the test as a measurement instrument, including the process by which the test was developed and what statistical analyses reveal about the reliability and validity of the instrument.

Over 90 test questions were initiated at CORD by the content specialists. In a collaborative process between evaluators and content specialists these questions were pruned and revised to the eventual 30 items. Each item is tied, as directly as possible, to a specific objective from Unit 1. As some reviewers have pointed out, the item/objective match is not always exact. This is a valid criticism, but it's impossible to directly match items to objectives because of the way the objectives are worded (recognize, define, etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and often approximations of objectives are as good as cognitive test developers can do. With only 30 items (targeted number of items that can comfortably be tested in the available time), all objectives could not be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were determined based on the relative importance of the concepts. (A copy of the test with the objective each item addresses listed next to the item appears in Appendix B).

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?) The reliability (Spearman-Brown test of internal consistency) of this instru-

ment is .72, which is acceptable by most standards. Validity is a bit more complicated to judge. A factor analysis of the instrument indicated almost all items related to discrete factors. This is expected, since each item is tied to a separate objective. Readers are encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?
2) Is a sufficient range of objectives addressed?
3) Overall, is the instrument a fair measure of Unit 1 instruction?

Pre/Post-Test Results

A variety of analyses of the pre/post-test have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 30 items. The findings included:

Mean differences - The overall pre-test mean was 12.5. The overall post-test mean was 20.07. This increase was statistically significant (T-test) at the .01 level.

The attached graph lists the pre/post-test means by each site. In all sites but one the increases were statistically significant. (See Appendix C for graph.)

Frequencies - An examination of post-test frequencies (see Appendix D) reveals some interesting findings:

* 70% was scored on items 1, 4, 5, 6, 7, 9, 11, 12, 14, 15, 21, 22, 23, 24, 27

* Less than 70% was scored on items 2, 3, 8, 10, 13, 16, 17, 18, 19, 20, 25, 26, 28, 29, 30

It's important to note the content of the items on which students scored less than 70%. Several of these items (numbers 2, 8, 10, 13, 16, 17, 18, 19, 20, 29) relate either directly or indirectly to mathematics skills; students were required either to manipulate a formula or remember a formula.

In terms of sub-units, students scored less than 70% on:

Mechanical - 4 out of 11 items
Fluid - 6 out of 10 items
Electrical - 2 out of 6 items
Thermal - 3 out of 4 items

Thus, items relating to mathematics skills, the fluid and the thermal sub-units, were the units on which the students performed the most poorly.

Variables

The impact of several variables on the students' test performance was examined including:

1) student's sex

2) student's grade
3) teaching pattern
    a) consectuive days
    b) length of class periods
    c) combined activities
4) teacher background
    a) physics background
    b) mathematics background

These variables were analyzed using an analysis of covariance, which controlled for pre-test scores. All means reported below are for the post-test.

*Sex

There were no statistically significant differences according to sex.

Males=20.22 (n=460)   Females=19.61 (n=64)

*Grade

There were no statistically significant differences according to grade.

10 (n=77)=19.74
11 (n=296)=19.93
12 (n=116)=21.28

Although the grade 12 mean was more than 1 point higher, keep in mind that this statistic controls for pre-test scores, which means the pre-test scores of grade 12 were higher as well.

*Consecutive Days

Whether or not the teacher taught the course on consecutive days was statistically significant (.02).

Yes (n=388)=20.53
No (n=172)=19.03

Although the difference is only 1 1/2 points, it is statistically significant.

*Time per Session

The time per session was statistically significant (.01).

50 minutes or less (n=338)=20.00
50-60 minutes (n=107)=21.69
60-90 minutes (n=30)=20.17
90+ minutes (n=85)=18.28

*Combined Classes

Whether or not teachers combined class was also statistically significant (.01).

Yes (n=127)=22.01
No (n=433)=19.50

Since the above three variables are likely to be related, the following charts examine the variables in combination.

	Time Taught Per Session			
	LT 50 minutes	50-60 minutes	60-90 minutes	90+ minutes
Consecutive Days	†296 20.81	78 22.14	14 21.07	0
Not Consecutive Days	42 19.40	29 20.48	16 19.38	85 18.28

	Time Taught Per Session			
	LT 50 minutes	50-60 minutes	60-90 minutes	90+ minutes
Combined Classes	42 21.18	39 22.56	0	46 21.72
Did Not Combine Classes	296 19.74	68 21.19	30 20.16	39 14.23

	Combined Classes	Did Not Combine Any Classes
Taught on Consecutive Days	65 23.05	323 20.02
Did Not Teach On Consecutive Days	62 20.92	110 20.48

† The top numbers equal the number of students in each cell; the bottom number represents the mean scores.

Differences appear to be substantive as well as statistical. However, relationships are not linear but are curvilinear. That is, we cannot say that as time per session increases the score will also increase. Rather, there appears to be an optimum teaching pattern. Chart 1 indicates that the highest mean score was obtained in classes that were taught on consecutive days for 50-60 minutes. On the other hand, the lowest mean score in Chart 1 is for students who had the course for over 90 minutes per day on non-consecutive days.

*Physics Background

The college physics background of the teacher was statistically significant (.01). However, the data appear not to be causative, based on an examination of the means.

However, as you can see, the means form no pattern from which we can infer that the teachers' background in physics has caused a change in test scores.

0 classes (n-116)=19.00
1 class (n=119)=21.8
2-4 classes (n=211)=19.51
5-7 classes (n=45)=20.38
8+ classes (n=69)=21.45

*Mathematics Background

The college mathematics background of the teacher was not statistically significant.

1 class (n=20)=20.20
2-4 classes (n=359)=19.71
5-7 classes (n=103)=20.51
8+ classes (n=78)=21.12

Thus, the mathematics background of the teacher appears to have little impact on students' learning gain; physics background needs more consideration.

Student Attitude Results

The student attitude questionnaires (Appendix E) indicated:

- Most students (80%) liked the FORCE unit either a lot (18%) or a little (62%)

- The most appealing components were the hands on labs (43%) and the video programs (21%)

- The least appealing components were the written material (39%) and the math labs (16%)

- Half (53%) indicated the material was not difficult for them to understand

- Most (89%) indicated they thought the material was very (48%) or sort of (41%) important to understand

These are fairly positive findings. However, judgment about student attitudes should probably be withheld until data from subsequent units are available.

Teacher Results

Questionnaires were received from 31 teachers (2 did not return a questionnaire). Appendix F, which lists all the teacher's comments, should be carefully examined. Teacher background and teaching pattern have already been reported (see "Sample," Page 5). Overall, findings from the teacher questionnaire included:

*Teacher comfort

Almost all teachers (97%) indicated they felt comfortable teaching the material in the FORCE unit.

*Time

Almost a third (29%) indicated the 26-day plan of 50-minute classes is probably not realistic for the FORCE unit. Of these, 8 teachers indicated that some components (labs, C2, or math lab, vectors) required more time.

*Problems

To the question, "What, if anything, caused you the most problems in teaching the unit on FORCE?" twenty-five teachers responded. Over half of these (13) indicated the labs caused the most problems. Some reported problems getting the lab equipment; others reported problems setting up equipment. Other reported problems included:

- converting between SI and English units (1)
- too much reading for students (1)
- vectors (1)
- student acceptance of material (1)

Much of the specific teacher data is contained in the chart in which teachers reacted to each component of the unit. The tally of their answers along with the attached comments contain a wealth of information about each component.

Conclusions

There were certainly positive findings among these data. As a formative tool, the developers also culled much from these data that suggested both general project and specific unit modifications. Some of the key findings included:

1) Students and teachers were fairly positive about the FORCE unit.

2) In all classes but one, statistically significant learning gains took place.

3) Students performed the most poorly on test items dealing with mathematics, the fluid sub-unit, and the thermal sub-unit.

4) Both student test scores when compared to teachers' reports of time spent and the teachers' own comments indicate that 50-60 minutes per session is an optimum time allotment for many of the activities.

5) Teachers' comments indicated the most problems were encountered with the labs. Although many of these were problems securing the equipment, problems were also encountered in understanding and running the labs.

6) Many specific recommendations for changes were contained in the teachers' comments.

As with most research, these findings raise additional issues. Foremost among these issues is determining, if possible, the impact that student characteristics have on performance in the course. The project will attempt to collect data that will address this issue. It will also be interesting to see how the findings for Unit 1 compare to findings for subsequent units. Since a similar evaluation will be conducted on each unit, these data will be forthcoming.

Appendix A

Cooperating Agencies

Cooperating Agencies

Alaska Department of Education

Alberta Education

Arizona Department of Education

Arkansas State Department of Education
Vocational and Technical Education Division

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
Occupational and Postsecondary 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

Nebraska Department of Education
Division of Vocational Education

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

TVOntario

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

Utah State Office of Education

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

Virginia Department of Education
Vocational and Adult 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

Pre/Post-Test by Objectives

PRINCIPLES OF TECHNOLOGY
UNIT I: FORCE
DRAFT STUDENT PRE/POST TEST

Objective 1, page 15

1. Force is best defined as:

   a. a scalar quantity
   b. a push or pull by one object on another
   c. something that is measured only in degrees
   d. a mass

Objective 3, page 15

2. When using the System International (SI) measuring system, mechanical force is measured in ____________

   a. newtons
   b. newtons per square meter (n/m^2)
   c. pounds
   d. pounds per square foot (lb/ft^2)

Objective 5, page 15

3. A net force means that all forces acting on an object

   a. create a balanced condition
   b. are in the same line
   c. create an unbalanced condition
   d. cause the object to be in equilibrium

Objective 4, page 15

4. Two teams are in a tug-of-war; each pull on a rope with opposite forces of 170 pounds. In this tug-of-war, the forces on the rope

   a. total 340 pounds
   b. are unbalanced
   c. are balanced
   d. cannot be calculated with the given information

In the following five questions match the words with their correct definitions. On your answer sheet fill in the letter of the definition that corresponds to the numbered word.

Objective 6, page 15

5. Scalar
6. Weight
7. Torque
8. Vector
9. Mass

A. The total amount of matter contained in an object

B. When a physical quantity such as a force is described by both magnitude and direction

C. When a physical quantity such as force is described only by magnitude

D. A measure of gravitational pull

E. The product of the force applied and the length of the lever arm

Objective 9, page 15

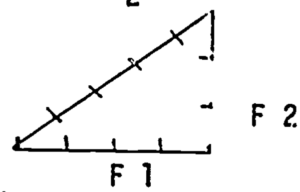
10. A torque wrench has a lever arm of 0.5 meters. A force of 20 newtons is applied to the end of the wrench to tighten a bolt. The torque applied is

a. 4 n-m
b. 20 n-m
c. 10 n-m
d. 100 n-m

Objective 7, page 15

11. Using the scale of "one division = 10 lb of force" the value of the resultant force of F_1 and F_2 below is

a. 100 lb
b. 140 lb
c. 70 lb
d. 50 lb



Objective 1, page 75

12. All fluid systems can be classified as either

a. solid or gas
b. hydraulic or liquid
c. hydraulic or pneumatic
d. pneumatic or gas

Objective 2, page 75

13. The density of a substance is defined as

a. the mass of that substance times the volume of that substance
b. the area of that substance times the mass of that substance
c. the mass of that substance divided by the volume of that substance
d. the area of that substance divided by the volume of that substance

Objective 3, page 75

14. The density of gold is 19.3 gm/cm^3. What is the specific gravity of gold?

a. 19.3 gm
b. 19.3 cm^3
c. 19.3
d. cannot be computed with the given information

Objective 4, page 75

15. Which of the following best defines buoyant force?

a. The apparent weight of an object placed in a fluid
b. The upward force on an object equal to the weight of the fluid
c. The mass of an object when placed in water
d. any fluid force

Objective 5, page 75

16. Pressure in fluids is defined as

a. force times area
b. force divided by area
c. force times volume
d. force divided by volume

Objective 5, page 75 — 17. Pressure is a

a. vec or quantity
b. scalar quantity
c. resultant of two vectors
d. liquid force

Objective 8, page 75 — 18. An automobile tire gage reads 30 PSI at sea level. Inside the tire, the trapped air pushes outward on each square inch of tire wall with a force of 44.7 lbs. This 44.7 PSI is

a. gage pressure
b. atmospheric pressure
c. buoyant force
d. absolute pressure

Objective 7, page 75 — 19. If 1 ft^2 - 144 in^2 what is a pressure of 6240 lb/ft^2 equal to in pounds per square inch (PSI)?

a. 43.3 PSI
b. 433 PSI
c. 898 PSI
d. 898.56 PSI

Objective 11, page 75 — 20. What must exist between different points in a fluid system for liquids or gases to move in that system?

a. a pump
b. temperature stability
c. no resistance
d. pressure difference.

Objective 14, page 75 — 21. A technician usually measures/controls pressure in a fluid system with ________________

a. gages/thermocouplers
b. reducers/valves
c. thermometers/thermostats
d. gages/valves

Objective 1, page 123 — 22. A DC current

a. is produced by an alternator
b. moves back and forth in the wires
c. always moves in one direction
d. both a and b are correct

Objective 2, page 123

23. The most common source of DC voltage is

a. a DC battery
b. a 220 outlet
c. an alternator
d. an automobile battery

Objective 6, page 123

24. Voltage is considered a force-like quantity because it

a. moves electrons through a circuit
b. forces conductors to move
c. is found in electrical circuits
d. all of the above

Objective 7, page 123

25. Which of the following is not a type of voltmeter

a. panel meter
b. ohmmeter
c. digital multimeter
d. oscilloscope

Objective 3, page 123

26. In the electrical circuit with parallel loads shown below when the switch is closed V_B is equal to

a. $V_1 + V_2$
b. $V_1 = V_2$
c. $V_1 - V_2$
d. V_1/V_2

Objective 1, page 161

27. Heat always moves from regions of

a. extreme temperatures
b. lower to higher temperatures
c. higher to lower temperatures
d. low to high energy

Objective 3, page 161

28. Temperature is

a. a vector quantity
b. a measure of energy
c. the presence of heat
d. all of the above

Objective 6, page 161

29. The temperature inside a house is 70° F. Outside the house the house the temperature is 30° F. The temperature difference (ΔT) is

a. $40F^{\circ}$
b. $40^{\circ}F$
c. $100F^{\circ}$
d. $100^{\circ}F$

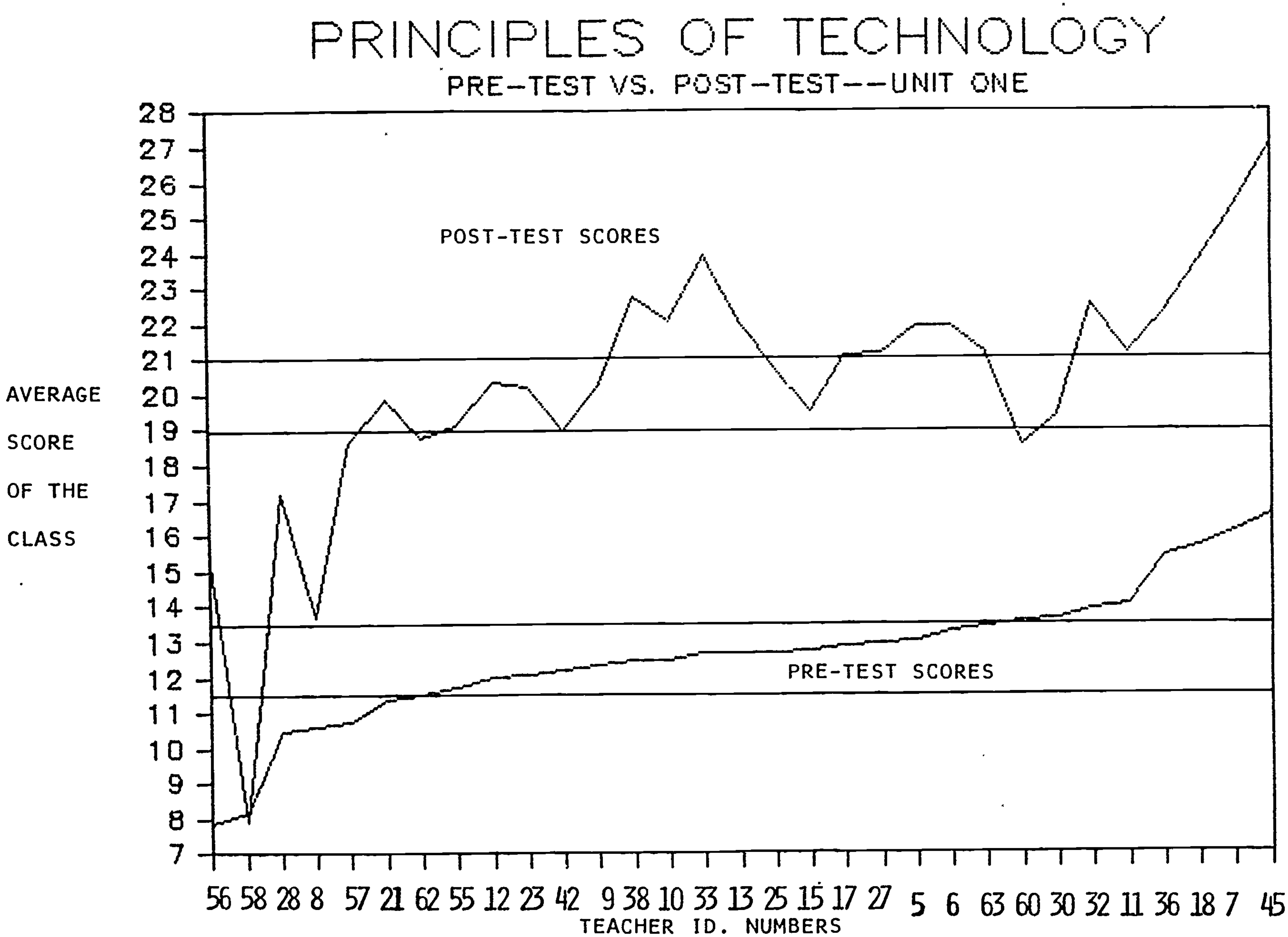
Objective 7, page 161

30. A thermocouple is a device that relates a temperature change to a measurable physical change. The physical change is

a. change in length of solid ·· terial
b. change in electrical property of a material
c. change in ^{o}F as compared to ^{o}C
d. change in ^{o}C as compared to ^{o}F

Appendix C

Mean Scores by Site



PRINCIPLES OF TECHNOLOGY
PRE-TEST VS. POST-TEST--UNIT ONE
AVERAGE SCORE OF THE CLASS
28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7
POST-TEST SCORES
PRE-TEST SCORES
56 58 28 8 57 21 62 55 12 23 42 9 38 10 33 13 25 15 17 27 5 6 63 60 30 32 11 36 18 7 45
TEACHER ID. NUMBERS

26

Appendix D

Pre/Post-Test Frequencies

PRINCIPLES OF TECHNOLOGY
UNIT I: FORCE
STUDENT TEST

Pre	Post	
		1. Force is best defined as
3.9	3.6	a. a scalar quantity
91.8	95.0	*b. a push or pull by one object on another
1.1	1.1	c. something that is measured only in degrees
3.2	0.2	d. a mass
		2. When using the System International (SI) measuring system, mechanical force is measured in
25.5	45.2	*a. newtons
42.2	46.6	b. newtons per square meter (n/m^2)
9.0	1.2	c. pounds
23.1	6.9	d. pounds per square foot (lb/ft^2)
		3. A non-zero net force means that all forces acting on an object
35.6	29.5	a. create a balanced condition
14.3	9.5	b. are in the same line
27.7	32.6	*c. create an unbalanced condition
22.4	28.4	d. cause the object to be in equilibrium
		4. Two teams are in a tug-of-war; each pulls on a rope with opposite forces of 170 pounds. In this tug-of-war, the forces on the rope
26.7	15.5	a. total 340 pounds
4.3	4.1	b. are unbalanced
55.8	73.5	*c. are balanced
12.9	6.9	d. cannot be calculated with the given information

In the following five questions match the words with their correct definitions. On your answer sheet fill in the letter of the definition that corresponds to the numbered word.

% Correct

Pre	Post	
40.9	75.4	5. Scalar (C)
47.6	70.6	6. Weight (D)
50.4	75.0	7. Torque (E)
31.8	60.6	8. Vector (B)
55.2	72.5	9. Mass (A)

A. The total amount of matter contained in an object

B. A physical quantity described by both magnitude and direction

C. A physical quantity described only by magnitude

D. A measure of gravitational pull

E. The product of the force applied and the length of the lever arm

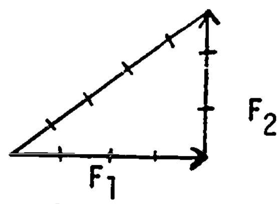
(See back of this page for questions 10-16)

10. A torque wrench has a lever arm of 0.5 meters. A force of 20 newtons is applied to the end of the wrench to tighten a bolt. The torque applied is:

Pre	Post	
31.1	26.5	a. 4 n m
14.2	3.2	b. 20 n m
34.1	56.8	*c. 10 n m
19.4	13.1	d. 100 n m

11. Using the scale of "one division = 10 lb of force" the value of the resultant force of F_1 and F_2 below is

Pre	Post	
18.3	5.5	a. 100 lb
15.2	6.3	b. 140 lb
36.6	17.6	c. 70 lb
29.5	70.5	*d. 50 lb



12. All fluid systems can be classified as either

Pre	Post	
16.7	3.2	a. solid or gas
49.9	15.0	b. hydraulic or liquid
25.3	78.3	*c. hydraulic or pneumatic
8.1	3.5	d. pneumatic or gas

13. The density of a substance is defined as

Pre	Post	
25.3	57.3	*a. the mass of that substance divided by the volume of that substance
20.1	12.2	b. the area of that substance times the mass of that substance
31.2	19.3	c. the mass of that substance times the volume of that substance
23.0	11.2	d. the area of that substance divided by the volume of that substance

14. What must exist between different points in a fluid system for liquids or gases to move in that system?

Pre	Post	
19.2	7.0	a. equal pressure
9.3	2.6	b. temperature stability
15.0	5.6	c. no resistance
56.3	84.5	*d. pressure difference

15. Which of the following best defines buoyant force?

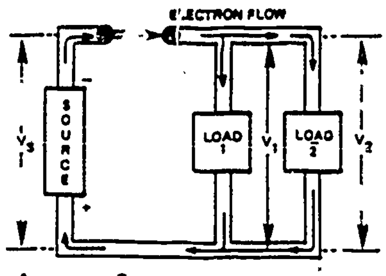
Pre	Post	
16.2	9.0	a. The apparent weight of an object placed in a fluid
44.9	79.6	*b. The upward force on an object equal to the weight of the fluid displaced
22.5	7.9	c. The mass of an object when placed in water
16.0	3.3	d. Any fluid force

16. Pressure in fluids is defined as

Pre	Post	
20.5	28.9	a. force times area
10.9	35.3	*b. force divided by area
46.6	25.0	c. force times volume
21.3	10.8	d. force divided by volume

Pre	Post	
		17. Pressure is a
22.0	22.9	a. vector quantity
25.8	37.9	*b. scalar quantity
27.7	12.1	c. resultant of two vectors
24.4	26.9	d. liquid force
		18. An automobile tire gage reads 30 PSI at sea level. Inside the tire, the trapped air pushes outward on each square inch of tire wall with a force of 44.7 lbs. This 44.7 PSI is
17.3	20.6	a. gage pressure
27.8	20.1	b. atmospheric pressure
13.3	5.5	c. buoyant force
41.5	53.9	*d. absolute pressure
		19. If 1 $ft^2 = 144\ in^2$ what is a pressure of 6240 lb/ft^2 equal to in pounds per square inch (PSI)?
25.0	56.7	*a. 43.3 PSI
24.1	12.2	b. 433 PSI
33.1	18.6	c. 898 PSI
17.4	12.5	d. 898.56 PSI
		20. The density of gold is 19.3 gm/cm^3. What is the specific gravity of gold?
16.7	18.2	a. 19.3 gm
14.6	14.2	b. 19.3 cm^3
11.0	37.2	*c. 19.3
56.7	30.3	d. cannot be computed with the given information
		21. A technician usually measures pressure in a fluid system with ________
18.7	14.6	a. valves
8.6	5.3	b. thermostats
9.0	6.9	c. thermometers
63.4	73.2	*d. gages
		22. A DC current
7.1	1.8	a. is available in a wall socket
10.2	6.9	b. moves back and forth in the wires
55.8	83.5	*c. always moves in one direction
26.6	7.9	d. both a and b are correct
		23. The most common source of DC voltage is
7.1	6.9	a. a toaster
12.9	1.8	b. a 220 outlet
24.7	5.8	c. a home wall socket
54.8	85.4	*d. a DC battery
		24. Voltage is considered a force-like quantity because it
36.6	70.5	*a. moves electrons through a circuit
7.6	2.5	b. moves conductors in circuits
9.1	3.0	c. is found in electrical circuits
46.4	24.0	d. all of the above

Pre	Post	
		25. Which of the following <u>is not</u> a type of voltmeter
16.8	17.4	a. panel meter
22.7	54.4	* b. ohmmeter
18.5	5.3	c. digital multimeter
41.9	22.9	d. oscilloscope
		26. In the electrical circuit with parallel loads shown below when the switch is closed V_s is equal to
27.1	23.3	a. $V_1 + V_2$
40.4	63.5	* b. V_1 and V_2
18.3	9.7	c. $V_1 - V_2$
14.2	3.5	d. V_1/V_2



Pre	Post	
		27. Heat always moves from regions of
11.3	2.3	a. extreme temperatures
30.8	13.4	b. lower to higher temperatures
43.2	81.8	* c. higher to lower temperatures
14.7	2.5	d. low to high energy
		28. Temperature
6.9	10.3	a. is a scalar quantity
21.3	18.8	b. is a measure of molecular motion
23.2	14.2	c. depends on the presence or absence of heat
48.2	56.8	* d. all of the above
		29. The temperature inside a house is $70^{\circ}F$. Outside the house the temperature is $30^{\circ}F$. The temperature difference (ΔT) is
18.8	55.2	* a. $40F^{\circ}$
71.1	38.1	b. $40^{\circ}F$
4.0	2.1	c. $100F^{\circ}$
5.9	4.6	d. $100^{\circ}F$
		30. A thermocouple is a device that relates a temperature change to a measurable physical change. The physical change is
26.5	10.8	a. change in length of solid material
34.1	60.5	* b. change in electrical property of a material
25.7	20.5	c. change in $^{\circ}F$ as compared to $^{\circ}C$
13.7	8.3	d. change in $^{\circ}C$ as compared to $^{\circ}F$

Appendix E

Student Attitude Data

PRINCIPLES OF TECHNOLOGY
STUDENT ATTITUDE QUESTIONNAIRE

Sex: 13 Female 87 Male

Grade: 1 9 15 10 64 11 21 12 Adult = 1

1. Overall, did you like the unit on FORCE?

   18 yes, a lot 14 no, not very much

   62 yes, a little 6 no, not at all

2. What component did you like most in the FORCE unit?

   4 the written material
   21 the video programs
   5 the math labs more than 1 = 9
   43 the hands on labs
   18 no preference

3. What component did you like least in the FORCE unit?

   39 the written material
   9 the video programs
   16 the math labs more than 1 = 9
   2 the hands on labs
   25 no preference

4. Was the material that was covered in the FORCE unit difficult for you to understand?

   8 yes, most of the material was difficult for me to understand
   39 yes, some of the material was difficult for me to understand
   53 no, most of the material was not difficult for me to understand

5. Do you think the material in the FORCE unit is important for you to understand?

   48 yes, very important 7 no, not very important

   41 yes, sort of important 4 no, not at all important

THANK YOU!

Appendix F

Teacher Data and Comments

All numbers in %

PRINCIPLES OF TECHNOLOGY
UNIT I: FORCE
TEACHER QUESTIONNAIRE

N=31 1. Did you teach Principles of Technology on consecutive days for 26 days?

68 yes 32 no

If no, what pattern did you use (for example, 3 days a week)?

See attached comments

N=31 2. How much time per session did you teach?

58 50 minutes or less	7 60-90 minutes
22 50-60 minutes	13 90+ minutes

N=29 3. Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

41 yes 59 no

If yes, which classes did you combine?

See attached comments

N=31 4. Based on your experiences, do you think the 26-day plan of 50-minute class sessions is realistic for the unit on FORCE?

16 yes, definitely	26 no, probably not
55 yes, probably	3 no, definitely not

If no, please explain:

See attached comments

N=31 5. On average, how much time did you spend preparing to teach each class in the unit on FORCE?

20 0-30 minutes	3 90-120 minutes
39 30-60 minutes	3 120-180 minutes
32 60-90 minutes	3 180 or more minutes

Comments:

See attached comments

N=30 6. Overall, did you feel comfortable teaching the material in the unit on FORCE?

44 yes, very comfortable

53 yes, sort of comfortable

3 no, not very comfortable

___ no, not at all comfortable

If no, please specify:

See attached comments

7. What, if anything, caused you the most problems in teaching the unit on FORCE?

See attached comments

N=31 8. How many physics courses did you take in college (undergraduate and graduate)?

20 none

22 1

36 2-4

10 5-7

12 8 or more

N=31 9. How many math courses did you take in college (undergraduate and graduate)?

___ none

3 1

68 2-4

13 5-7

16 8 or more

10. Do you have any other comments, concerns, or suggestions for the unit on FORCE?

See attached comments

The following chart lists each activity for the unit on FORCE down the left column. Since there are no materials specifically for the sub-unit review classes, these classes have not been listed in the chart. For each activity, you should respond to the following questions by circling "yes" or "no":

1) Was the material (readings, labs, or videos) appropriate for your students? Was the material at the right grade level? Was the amount of material appropriate for your students? For any no responses, please use the attached pages to describe your concerns.

2) Were you able to cover the material to your satisfaction in the 50-minute time period? (Since this question doesn't apply to the video, no response options have been provided for the column. Please do respond, however, to the other questions about the video.) For any no responses, please use the attached pages to describe why you could not complete the material and/or what you chose to delete.

3) Were there any errors or inaccuracies in the material? For any yes responses, use the attached pages to specify the errors and recommended corrections.

4) Were there any problems managing the activity? For the labs, were all your students able to rotate through the labs? Did you experience any problems coordinating the activity? For any yes responses, use the attached pages to specify the problems you had and, if possible, suggest changes that you feel would enable you to more easily manage the material.

5) Do you have any suggested modifications for the material? For any yes responses, use the additional pages to specify your suggestions. Include in this section any "teaching tips"--special procedures you used or means you discovered to more easily convey the information to students. Include in this section any comments you may have for the Teacher's Guide.

We recommend that you take a few minutes each day to complete the chart and, most importantly, to write down your comments. If you need more space for comments, use the back of the comments pages and/or attach additional sheets.

1=yes; 2=no

UNIT I: FORCE

	Appropriate for students?	Completed in 50 minutes?	Any errors or inaccuracies?	Any management problems?	Any suggested modifications?
Overview					
Video	1=100 yes no	------------	1=8 2=92 yes no	1=4 2=96 yes no	1=12 2=88 yes no
CO	1=100 yes no	1=93 2=7 yes no	2=100 yes no	1=4 2=96 yes no	1=12 2=88 yes no
Mechanical Systems					
Video	1=93 2=7 yes no	------------	1=7 2=93 yes no	1=11 2=89 yes no	1=28 2=72 yes no
C1	1=100 yes no	1=77 2=23 yes no	2=100 yes no	1=4 2=96 yes no	1=9 2=91 yes no
C2	1=83 2=12 yes no	1=77 2=23 yes no	2=100 yes no	1=5 2=95 yes no	1=14 2=86 yes no
Math Lab	1=81 2=19 yes no	1=67 2=33 yes no	1=8 2=92 yes no	1=15 2=85 yes no	1=30 2=70 yes no
1M1	1=92 2=8 yes no	1=85 2=15 yes no	1=17 2=83 yes no	1=19 2=81 yes no	1=33 2=67 yes no
1M2	1=91 2=9 yes no	1=81 2=19 yes no	1=5 2=95 yes no	1=22 2=78 yes no	1=10 2=90 yes no
Fluid Systems					
Video	1=100 yes no	------------	1=4 2=96 yes no	2=100 yes no	1=25 2=75 yes no
C1	1=92 2=8 yes no	1=79 2=21 yes no	1=20 2=80 yes no	1=4 2=96 yes no	1=13 2=87 yes no
C2	1=96 2=4 yes no	1=71 2=29 yes no	1=25 2=75 yes no	1=12 2=88 yes no	1=23 2=77 yes no
Math Lab	1=85 2=15 yes no	1=75 2=25 yes no	1=4 2=96 yes no	1=15 2=85 yes no	1=22 2=78 yes no
1F1	1=92 2=8 yes no	1=67 2=33 yes no	1=12 2=88 yes no	1=37 2=63 yes no	1=41 2=59 yes no
1F2	1=81 2=19 yes no	1=77 2=23 yes no	1=10 2=90 yes no	1=43 2=57 yes no	1=41 2=59 yes no
Electrical Systems					
Video	1=100 yes no	------------	1=8 2=92 yes no	2=100 yes no	1=17 2=83 yes no
C1	1=100 yes no	1=82 2=18 yes no	1=8 2=92 yes no	2=100 yes no	1=10 2=90 yes no
C2	1=100 yes no	1=82 2=18 yes no	1=12 2=88 yes no	1=4 2=96 yes no	1=5 2=95 yes no
Math Lab	1=85 2=15 yes no	1=82 2=18 yes no	2=100 yes no	1=11 2=89 yes no	1=29 2=71 yes no
1E1	1=96 2=4 yes no	1=82 2=18 yes no	1=4 2=96 yes no	1=12 2=88 yes no	1=20 2=80 yes no
1E2	1=96 2=4 yes no	1=93 2=7 yes no	2=100 yes no	1=4 2=96 yes no	1=19 2=81 yes no

1=yes; 2=no

UNIT I: FORCE

	Appropriate for students?	Completed in 50 minutes?	Any errors or inaccuracies?	Any management problems?	Any suggested modifications?
Thermal Systems					
Video	1=100 yes no	----------	1=4 2=96 yes no	2=100 yes no	1=25 2=75 yes no
C1	1=100 yes no	1=89 2=11 yes no	1=4 2=96 yes no	2=100 yes no	1=16 2=84 yes no
C2	1=96 2=4 yes no	1=89 2=11 yes no	1=4 2=96 yes no	1=4 2=96 yes no	1=12 2=88 yes no
Math Lab	1=93 2=7 yes no	1=78 2=22 yes no	2=100 yes no	1=11 2=89 yes no	1=28 2=72 yes no
1T1	1=96 2=4 yes no	1=68 2=32 yes no	1=4 2=96 yes no	1=24 2=76 yes no	1=17 2=83 yes no
1T2	1=100 yes no	1=71 2=29 yes no	1=4 2=96 yes no	1=20 2=80 yes no	1=17 2=83 yes no
Summary					
Video	1=100 yes no	----------	2=100 yes no	1=5 2=95 yes no	1=8 2=92 yes no

Comments for CO Class

See attached comments

Comments for Videos

Overview Video: See attached comments

Mechanical Systems Video: See attached comments

Fluid Systems Video: See attached comments

Electrical Systems Video: See attached comments

Thermal Systems Video See attached comments

Summary Video: See attached comments

Comments for C1 Classes

Mechanical Systems C1: See attached comments

Fluid System C1: See attached comments

Electrical Systems C1: See attached comments

Thermal Systems C1: See attached comments

Comments for C2 Classes

Mechanical Systems C2: See attached comments

Fluid Systems C2: See attached comments

Electrical Systems C2: See attached comments

Thermal Systems C2: See attached comments

Comments for Math Lab Classes

Mechanical Systems Math Lab: See attached comments

Fluid Systems Math Lab: See attached comments

Electrical Systems Math Lab: See attached comments

Thermal Systems Math Lab: See attached comments

Comments for Lab 1 Classes

Mechanical Systems Lab 1: See attached comments

Fluid Systems Lab 1: See attached comments

Electrical Systems Lab 1: See attached comments

Thermal Systems Lab 1: See attached comments

Comments for Lab 2 Classes

Mechanical Systems Lab 2: See attached comments

Fluid Systems Lab 2: See attached comments

Electrical Systems Lab 2: See attached comments

Thermal Systems Lab 2: See attached comments

Comments for Summary Class

See attached comments

PRINCIPLES OF TECHNOLOGY
UNIT I: FORCE
TEACHER QUESTIONNAIRE RESPONSES

QUESTION 1 COMMENTS

Did you teach Principles of Technology on consecutive days for 26 days? If no, what pattern did you use (for example, 3 days a week)?

1. Four days a week. (#63)
2. We covered the material in 23 days. (#07)
3. Five double periods, alternate weeks. (#30)
4. Two days a week, 1 hour, 50 minutes per day. (#13)
5. Three hours first day, two hours second day. (#23)
6. Extended Mechanical section to 8 days. (#06)
7. The labs were not done because the equipment was late coming in and no surface to set up on. 98% of equipment is here now and demo and lab areas will be in place first week of November. Bad time of year; PSAT, SAT, CTBS, CAT, etc. (#38)
8. Generally with a day or two skips. (#08)
9. Three days a week. (#25)
10. An average of three days a week. (#57)
11. Approximately 4 days. (#28)
12. Except for sick days and conference days. (#15)
13. One or two days per week. (#58)
14. Every other day. (#11)

QUESTION 3 COMMENTS

Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)? If yes, which classes did you combine?

1. Math labs were given as homework or combined with C2. (#07)
2. I combined C1 and C2 in all subunits. (#30)
3. C1-C2 and math, both labs in one day and review. (#13)
4. C1 and C2 in Electrical. (#05)
5. Electrical. (#60)
6. Electrical. (#55)
7. C1 and C2, C1 and L1. (#45)
8. Math department handled math labs, so I was able to spread C1, C2 over three days. (#56)
9. Temperature and electricity. (#57)
10. Different ones at different times. Not in any specific order. (#28)
11. C1 and C2 of Electrical sub-unit. (#15)
12. C1 and C2. (#11)

QUESTION 4 COMMENTS

Based on your experiences, do you think the 26-day plan of 50-minute class sessions is realistic for the unit on FORCE?

1. I found that four days were more than sufficient. This may be a clue to the manner in which my labs were conducted. (#63)

2. If students will do outside class reading, yes. Unless homwork is enforced diligently, plan will not work, i.e., reading assignments. (#17)

3. More time for labs, 1 more day each lab. (#62)

4. Most of the Math Labs (those in Fluid, Eletrical, Thermal) are too short to last a whole class session. Many of the labs do not take up a whole class session i.e., Density of Fluids, L1 in Electricity, L1 and L2 in Thermal. (#37)

5. Vectors needs a day of its own, plus math lab plus lab. (#06)

6. Some days required more lab time. (#55)

7. There needs to be a little more time in C2. For mechanical and fluid sub units. This may correct when I'm able to do the L1 and L2. (#38)

8. If you combine some of the classes like C1 and C2, or C1, C2 and Lab, it would be realistic. (#45)

9. There is just too much material to assimilate, unless you have an exceptional group. (#56)

10. Some material, especially at first, required more than one day. (#08)

QUESTION 5 COMMENTS

On average, how much time did you spend preparing to teach each class in the unit on FORCE?

1. Most time is spent in setting up and obtaining equipment. (#63)

2. With homework connected with checking and recording papers and preparing demonstrations and lab exercises. (#18)

3. Subsequent prep time will be lower. Not a major drawback. (#30)

4. Would need less time next time. (#32)

5. I feel I had an advantage because of my knowledge of physics. (#05)

6. I was spending most of the time to prepare other materials like transparencies or formulas for interested students. (#45)

7. Lab preparation obviously took longer because materials needed to be located, ordered, assembled, etc. (#56)

8. This is not easy to teach without a lot of prep time. (#08)

9. Would like to have more in depth videos and transparencies would hlep in the C1 and C2 parts. (#28)

QUESTION 6 COMMENTS

Overall, did you feel comfortable teaching the material in the unit on FORCE? If no, please specify.

1. Became more comfortable on Subunits 3 and 4 when pace of material slowed. (#30)

2. Only problem I felt was that not every class session was a full 50 minutes. (#37)

3. I was able to handle it well with a little help from our physics teacher and math teacher. This in the form of review and explanation of some points. (#38)

4. But I really had to hurry. (#56)

5. The standards were kind of low for most of the students (like 12th graders), so I was doing a little extra for those who needed it. (#45)

6. Lab equipment was not available. (#25)

QUESTION 7 COMMENTS

What, if anything, caused you the most problems in teaching the unit on FORCE?

1. Being a physics teacher I had trouble staying within the FORCE unit. Many student questions covered material beyond the FORCE unit as presented. (#07)

2. Converting between SI and English units (I'm rusty and students didn't know). (#17)

3. Inaccuracy of scale readings - scales were at an angle to the string and chain giving wrong readings on the force board lab. I used a fish scale as suggested. Most of the force graphs were off as a result. (#18)

4. Early stress of material was very intense. Sub units 3 and 4 were weak on material. Kids tended to be off-balance and to some extent still are. (#30)

5. Too much reading for students. They lost interest. Did not want to read outside of class. (#13)

6. We were unable to do any of the labs except for the first two labs on the mechanical system. At present our funding for the course has been received, but yet the money has not been forthcoming. (#09)

7. All lab equipment not here, subbing, borrowing, etc. (#62)

8. Our equipment shipments from Sargent-Welch have been full of back order. I felt frustrated with the equipment (especially for Fluid). It's been the little things about the equipment that bug me i.e., wrong clamp or wrong tubing, no more banana clips, still waiting and more. Still don't have the pulleys for the first experiment in WORK. (#37)

9. The labs because of lack of equipment. (#05)

10. Equipment delays. Coming up with good examples for each system. (#32)

11. Developing student interest. Create a feeling of concern. (#23)

12. All lab materials were not available or were not adequate. We made the mistake of relying on Sargent-Welch to fulfill a commitment. (#36)

13. The new formulas of physics. (#10)

14. Getting equipment on time for lab section. (#21)

15. Learning how to explain a known concept so the students could understand. Mostly how to manipulate the numbers, I'm really surprising myself. (#38)

16. We didn't have the equipment for the unit in time, so it slowed the pattern. (#60)

17. Preparing lab materials. (#55)

18. For some reason I felt if the videos were shown after the lecture, they would have been more clear and understandable for the students. (#45)

19. Just the pressure to complete it in 26 days, I could not have done it all with the math labs. (#56)

20. Working with vectors. (#08)

21. Time and lack of equipment. (#25)

22. Student acceptance of material covered. (#57)

23. Equipment not sent on time, even though we ordered well before school started. (#28)

24. Lack of equipment (which you have no control over). (#15)

25. Trying to get a good grasp of the subject before the presentation. (#11)

QUESTION 10 COMMENTS

Do you have any other comments, concerns, or suggestions for the unit on FORCE?

1. I feel the labs can be combined and put in a real life setting. An example, I had students take temperature readings of their homes interior and the outside air temperature. They were to take these temperature readings at the same time and place (room) every day for two weeks. From this they not only learned to chart temperature differences, they also saw how the temperatures in the home varied with outside air temperature. (#63)

2. For our students more material or a higher level is needed. (#07)

3. Start teaching conversion techniques between SI and English units at the start. (#17)

4. Too much time available on Thermal unit in C1 and C2 - probably could be combined. (#18)

5. Perhaps strengthen content on Subunits 3 and 4 (Electrical and Thermal) so there is not so significant a difference from 1 and 2 which were very challenging to them. Overall balance was fine, but things did lean heavily towards the front of the month. (#30)

6. I feel there should be additional questions provided at the end of each daily lesson. Also, I felt a lab on determining the densitites of various substances (by weighting and displacement of water for volume) would be useful. Again, as mentioned in the Dallas meeting, the level of the student should be stressed. My classes are mostly 10th grade and approximately half of them have had Algebra 1 or are taking it. Generally the rest are drafters from general math, and many are not suited to the course. (#09)

7. Make the labs more involved. Not necessarily more complex but allow kids to do more discovery type activities. Right now it appears to be just observation and data recording which is not bad. We need more activity in the labs so there's more to observe and more to record. Then the teacher can do a post lab that is sturdy, has more meat to it. I really love the concept of the Math Labs. I would suggest less discussion reading. Put the example in the text but the teacher can show them, put many more problems for the kids to do, but not example type problems. FORCE them to do the problems in class. They won't if you have the process printed out for them. I think the kids find the videos a little light weight. I'm not suggesting concepts in the video. I understand that is my job, however, the videos are really too surface for the kids. They'd like to see more instrumentation and equipment. Right now they see a technician very briefly and generally describing what they do. I know the kids would be more turned on if they saw the sophisticated equipment on the video and saw what it does. Many kinds of instruments should be shown. Then you get responses from the kids like "Decent, wow, awesome, that's what I want to be able to work with." (#37)

8. There was some confusion on my part regarding temperature as a measurement of heat. But I solved it by glossing over that area. Also I

had to strive to incorporate voc-ed equipment - my natural tendency was toward physics labs. (#05)

9. The videos for FORCE are not current "high" tech role models. Could use more pizazz. (#32)

10. The labs should be more invovled and more thought provoking. Some of it is elementary in content. (#36)

11. More student exercises. (#10)

12. Needs more things for students to do in Math Labs (less worked out examples), small progressive steps. (#06)

13. Overall it seems pretty good. (#21)

14. I'm really pleased with C1, C2, math and the demos. The labs look good - I'm looking forward to going back and picking up at least 1 of the labs or combine two when I can. I think it's important to go back and pick up some of the labs. The material is good, text and video, provided that math requisites are met. Selling the program is coming along well. Consider small binders for each unit. They're filling up fast. (#38)

15. I don't think anything should be omitted. In fact some of the sections could be beefed up with demos and labs (for example a specific gravity demo would be nice). Maybe an extra few days could be added or maybe rotational force could be treated as a separate sub-unit. (#55)

16. Overall, I feel the standards were low for some of the students. For example, some trigonometry would have been a help for the students who have had the background, to understand the vector relationships. (#45)

17. The video does not support the teaching as I would like. (#25)

18. I feel you should take the time to go over each lab, many did not come out as planned. (#28)

19. The students seem to enjoy the electrical unit best. Our equipment was slow in getting here, which made it more of a problem. (#58)

COMMENTS FOR CO CLASSES

1. Some time must be used for class housekeeping, bookslips, safety orientation, classroom rules, etc. Our 84 minute first period went as follows: 42 minutes for welcome, business, and pre-test, then a 3 minute break, then 42 minutes for the Overview video and CO class. (#30)

2. This is necessary just to complete pre-test and video. (#05)

3. The first unit of PRINCIPLES OF TECHNOLOGY did not go as smoothly as anticipated. During the first few weeks there was little time for the two teachers to get together for planning, coordinating, and comparing notes. That problem was resolved with the addition of a driver to transport the Papillion, Platteview and Ralston students to class. Now there is sufficient time, before and after class, for the teachers to plan activities. The primary glitch in the management and operation of the class revolved around the lack of or inadequate equipment furnished by the supplier (Sargent-Welch). Some of the equipment necessary for the lab just wasn't there. Some of it wouldn't fit. One concern, expressed by the students, is the distance they must travel to attend class and the amount of their own money needed for transportation. Despite the aforementioned negative aspects, the class is progressing rather well. This can be attributed primarily to the positive attitude of students. In general, the respective schools are well represented by their fine caliber students. Discipline has not been a problem and most students seem excited about the class. Thus far we have had only one attendance problem. In summation, we think the first unit was a success despite the glitches. The content of the course is good. If the logisitcs problem can be resolved, the remaining units should go very well and student interest should remain on a high note. (#36)

4. In our school PRINCPLES OF TECHNOLOGY was not included in our enrollment information. When we started school it became part of our 3 hour block of Machine Shop and welding class. Many of our students have a reading level of 8th grade or below and math levels of 6th grade or below and some have a hard time seeing how this type of information will help them in the future. The material in the overview section does a good job as an overview. We had a local person come in on each section and explain how the system of that unit affected them. Using someone in real life that uses this information has helped a great deal in building interest and we will try to continue to use outside speakers. (#21)

5. The orientations are good and enough time. (#38)

6. Management problems - did not have enough materials for all students. Suggested modification - have materials for all students. (#08)

7. The material was covered very easily. It could be beefed up a bit more. One possibility is to show more actual jobs being done, such as students running a printing press and things that they easily relate to. In the initial video, more jobs were shown, thus relating it to more careers. (#15)

COMMENTS FOR VIDEOS

1. All videos were well received by the students. I particularly like how the video starts them thinking and begin forming questions. (#63)

2. Overview: Good color, sound and examples.

   Summary: Okay, but could use a little more sensationalism. Too redundant. (#17)

3. Mechanical: Pressure created in cooling system of automobile for testing was inaccurate. (#18)

4. Overview: Kids reacted very positively. Some comments on "corwet" and "car-bue-ray-tor" but no negative feedback.

   Mechanical: Students tended to focus on technician's blinking eyes. Things are too new to expect much more than superficial reactions. Their interest was held, and the material apparently absorbed.

   Fluid: Worked very well. Students (and visitors) enjoyed the ending sequence. (#30)

5. All were very appropriate. (#13)

6. All were okay. (#09)

7. All were pretty good. Math videos are over-simplified. (#62)

8. Mechanical: Not deep enough into different kinds of equipment and/or instruments. The kids need to see more to get them interested and maybe hear from more than one type of technician in the mechanical field. (#37)

9. For my students videos were great except math video was too elementary. (#05)

10. Fluid: Fluid examples not too easy to relate to.

    Thermal: Fish freezer not very good for prime focus of video. (#32)

11. Thermal: I think a different illustration would have been better. It's a little hard to relate to removing heat from fish.

    Summary: The summary video did an adequate job of summarizing the material. On the whole, the videos are good learning tools. (#36)

12. All were good. (#06)

13. All videos are very well done. They are short and to the point and do a good job of keeping the students interested. (#21)

14. The videos are good. I will have no management problems when my receiver comes the end of October. (#38)

15. Overview: The mechanic in the film violated a safety rule by putting

his arm down on the carburator, covering the air horn. More explanation needed about examples used. Film too mechanically oriented, not everyone recognizes the systems in a car.

Mechanical: Students could not relate to the hoist in our area, especially in Health occupations. Use of word "ton" instead of "tons."

Fluid: Hydrualic jack lifting car is bending car as it lifts, it is distracting to students.

Electrical: No safety glasses when using a grinder? Wearing jewelry when using electric apparatus?

Thermal: When talking about delta T say "Fahrenheit degrees" not "degrees Fahrenheit."

Summary: Safety violation - beating on a battery with a hammer. (#08)

16. Overview: I think showing the video after the lecture would have had more meaning for the students.

    Mechanical: The same here, IF we give some information like materials on class C1 and C2, then show the relating video. Students would have seen it better.

    Fluid: It was an excellent video.

    Electrical: More information about electronics up to component level would have related the Class C1 and C2 to the real world clearly. (#45)

17. Overview: Too short, should be more involved.

    Electrical: Students enjoyed this unit more. (#58)

18. Overview: Have the beginnings of the segments numbered, so we can just forward to the beginning of each segment. (#15)

19. Fluid: Safety, no eye protection. Not well suited to subject.

    Electrical: Safety, wearing watches, rings...

    Summary: In my case I need the video to support the lab experiences to describe what is supposed to happen. (#25)

20. Overview: The students had difficulty understanding.

    Thermal: This was one of the easier ones to understand. (#11)

COMMENTS FOR C1 CLASSES

1. All demonstrations and discussions presented no problems. In fact, I had to add material because the level of students I have demanded more information. (#63)

2. All were good. (#17)

3. All were okay.

   Fluid: Not enough time to cover material thoroughly. Finished the material in C2. (#18)

4. Mechanical: Very large amount of material to cover. With demo's and illustrations, plus a 5-minute video and time lost by "extended home rooms" C1 extended about 20% longer than planned.

   Fluid: Timing improved. Presentation went better as did student attention and understanding.

   Electrical: Material much "softer." Able to complete C1 in about 20 minutes--excellent for schedule resumption purposes. Good demo using meter.

   Thermal: Short class--thermal bar demo excellent. Much more visible than previous methods. (#30)

5. All were a little too long. Could be cut down. (#13)

6. Mechanical: After discussing resultant forces (pages 15-25) there is need to immediately reinforce these ideas with a set of problems (at least 8-10) dealing with scale drawings, reading a protractor, and then graphically finding the resultant force. Similarly a need exists to have a set (8-10) torque type problems.

   Fluid: While discussing the density of an object it might help to discuss how to find the volume of an irregularly shaped object by displacement of water. This could be related to buoyant force by emphasizing the meaning of water displacement. A set of problems concerning density and specific gravity would be good at this point. (#09)

7. I liked them all. (#37)

8. Mechanical: I took an extra class period for this section so that students could thoroughly understand the material. It worked out to be an extra math lab day.

   Fluid: Again, since there were so many formulas to explain, I took my time on this: taking an additional C3 class.

   Electrical: Here I finished C1 and C2 in 1 day. V in parallel was a little hard to explain without going into Ohm's law.

   Thermal: There was a little confusion on measurement of heat (in calories, not temperature) but I explained this away sufficiently for high school students. (#05)

9. Mechanical: I think the text for both C1 and C2 classes does an excellent job of presenting the material. Each of the systems covered the subject well and were detailed enough to be easily understood. Only a few students had any problem understanding the material that was in the text. (#36)

10. Mechanical: Enclosed is a sample of how to teach vectors with a shoe box. it works super!

    Fluid: Page 84, airplane window - math errors in book.

    Electrical: On page 125 you use the word "electrolyte" without any supporting information. Either don't use it or explain what it is. Page 126 you say "...as if they were flowing out of the negative... into the positive." Should we foster this erroneous concept? (#06)

11. No problems. The reading level of our students has caused some problems, but the material in each unit seems to be okay. (#21)

12. Put diagrams on the same page as first mentioned! (#42)

13. Mechanical: This is okay.

    Fluid: Error on example 1-G. Solution (b) should be 144 inches squared, not 288 inches squared. (#38)

14. Fluid: math error on page 84.

    Thermal: First temperature lab could be more sophisticated. (#55)

15. Mechanical: Not finished in 50-minutes. Had to use additional period to cover vectors and use of protractor. Too much material to cover in 50 minutes. Change class C1 to two classes. More end of class activities. Material on forces acting at an angle should not be covered in the written material without the video and written activities to go with it. For reinforcement the students need all the material at the same time.

    Fluid: Page 84, example 1-G, solution B, 288 inches squared, should be 144 inches squared.

    Electrical: Teaching path says material for C1 ends before "A Simple DC Circuit" while objectives go through page 128, simple circuit. Short hand symbols should also include switch, since it is included in the student exercises.

    Thermal: Objectives should be in the same order as they come in the material. Actually Objective 1-4 only goes to middle of page 164. (#08)

16. Mechanical: I observed the need for more math involvement from some of my students. For example the vector relationships were very demanding. All together it was excellent, very clear, and interesting to students.

    Fluid: I think this section was excellent too. There was a technical mistake on page 84, and an error on page 81 of student copy.

Electrical: The discussion was very good. I think if we add some definitions about current (I) and Resistance (R) then Ohm's Law V=IR, students will be able to understand the votage better.

Thermal: It was excellent. Somehow if we add Conductivity's equation and show how actually we claculate the heat loss or gain. (#45)

17. Mechanical: Time 120 minutes. Need more examples and practice problems.

Fluid: Added demo on specific gravity and bouyant force, etc. Still a tight squeeze time wise.

Electrical: Less time pressure here, more relaxed. Added simple wet cell demonstration and discussion and dissected some batteries. Need exercise for students to learn to read analog type meters. (#56)

18. Electrical: Students enjoyed the work on this unit more than any. (#58)

19. Mechanical: Introduction of the material was acceptable until some of the students begin to question the reasoning of introducing this type of study into their electrical program.

Fluid: Student worksheets would have been helpful at this point. I experienced difficulty in students accepting information as valuable information for future studies.

Thermal: Students were somewhat reluctant to learn temperature differences. (#57)

20. Fluid: I used my hydraulic lessons to cover this area.

Electrical: Okay, good for students just starting with this subject.

Thermal: This unit seems okay for beginning students. I don't know how it will be later on. (#25)

COMMENTS FOR C2 CLASSES

1. Fluid: Examples 1-6, force on an airplane window, page 84. (#07)

2. All good. (#17)

3. Fluid: Still not enough time to cover all concepts thoroughly. (#18)

4. Mechanical: Presentation progressed too rapidly to fit material into time allotment. Class day #3 originally planned as MI and L1 will instead be C1, C2, Review, homework session and M1. This will leave class day as L2 and revelw.

   Fluid: No problem, much lighter material.

   Electrical: Might mention AC schematics used in industrial textbooks. Only give partial schematic and Electrical Wiring kids tend to feel that the complete schematics presented in the book are incorrect. Also "coal car atom" presents inaccurate picture which contracted in other science courses.

   Thermal: Good coverage, no time problem. (#30)

· Embarassing when flow indicator ball sticks, when flow is high. (#62)

6. I liked them all.

   Fluid: On page 84 (the example problem) kids got very frustrated trying to understand why it was set up that way. Explain why A in outward force is doubled.

   Thermal: Could get into the term conductivity more. Page 167, the kids didn't follow the example. They couldn't relate the 5/9ths to the 9/5ths. (#37)

7. Mechanical: Rather simple. (#27)

8. Mechanical: Students liked suction cup - mention in pressure unit.

   Fluid: Answer 6d (student exercises) on page 81, the answer should be 33.2 not 33.92. Answer 6c (page 81) should be 2117 lb/ft squared. There is no consistency with significant digits. (#06)

9. Fluid: Demonstration is wanting. (#42)

10. Mechanical: Need some more time for explanat[illegible]nd board examples.

    Fluid: Error in figure 1-28. Should read P2 gre[illegible]r than P1. Need more time for explanations and board time. (#[illegible])

11. Fluid: Very good discussion. There were 2 technical mistakes. (#45)

12. Fluid: Took more time to go through reading demonstration and student exercises. Page 92, problem 5, letter d is also a correct answer. Problem 6, letter C is actually 2116.8 pound/foot squared. Page 93

problem 11, letter A should be 7.007 psi.

Electrical: Had management problems with the demonstration. Thermocouple question in exercises is confusing. A thermocouple can be made up of two wires of different types. The actual thermocouple is the junction of the two wires.

Thermal: Should talk about temperature difference discussed on page 166 and 167 before it is used on page 165, middle of page, where it says "There are 180 Fahrenheit degrees between the freezing and boiling points." This was very confusing to students as well as teachers. Also, if you are going to use Celsius don't confuse matters by labeling figure 1-41 with Centigrade. (#08)

13. Fluid: chart 1-4 should read 2117 pounds/ft squared. (#15)

14. I experienced my students not wanting to read the material and apply themselves. (#57)

15. Mechanical: top paragraph, page 30, I found this very unclear and had to explain it to the students. (#11)

COMMENTS FOR MATH LAB CLASSES

1. Mechanical: During this lab I found students had difficulty with vectors. Maybe we need to expand that part of the instructional blocks and labs. The remainder of the labs presented no problems, because I used additional examples to explain each. (#63)

2. Mechanical: Not enough material and the level was inadequate for our students in all math labs. Example B, Calculating Mass on page 101. (#07)

3. Mechanical: Need conversion between SI and English systems. Student needs to feel comfortable with both systems and be able to move freely between them.

   Electrical: When are we going to cover powers of ten and mega, kilo, milli, and micro? (#17)

4. Mechanical: Even after instruction the students did not follow through with accurate work - had to spend an extra period to get point across.

   Thermal: Not enough problems. (#18)

5. Mechanical: Seemed appropriate. My management of math labs will change during Fluid Systems when new equipment arrives.

   Fluid: Very simple stuff. Kids got good reinforcement, felt like they learned something. (#30)

6. Mechanical: Math was a little below my students and they were bored doing it. The math in every lab was below their level. (#13)

7. Electrical: It should be emphasized that the graph should be as large as the graph paper being used. Also, that it is not necessary to start the X and Y axes at zero. Therefore, the graph will be as large as possible and values read from the graph will, in general, be more accurate. Part of the math lab should be devoted to reading meter scales for the different ranges (overhead transparencies would be nice). Additional problems needed on page 176. (#09)

8. Love the vidoes and the math lab, math labs were too short, though. (#37)

9. Electrical: Too easy! (#32)

10. Mechanical: The videos are excellent for all math labs. Content of material in the labs is good, but not enough of it. This applies to all Math Labs. (#36)

11. Mechanical: Should be more than 1 period.

    Fluid: Explain that .7854 is pi divided by 4. We had no flow indicator. Put in more practice exercises.

    Electrical: Choice of data was poor for student graph, why not voltage drop verses wire length. (#27)

12. All math labs were very helpful. I appreciate the step by step follow through. (#33)

13. Mechanical: Vector lab needs steps for students to do something i.e., draw a 3 unit vector or "draw vectors acting on a sign, on a car, etc." Thermal: If you use temperature in degrees Fahrenheit = 1.8 (degrees Celsius temperature + 32), why not use temperature degrees Celsius = (temperature degrees Farenheit - 32) divided by 1.8? (#06)

14. The hands on type of math seems to be meaningful to the students. (#21)

15. Mechanical: There is enough time here if you don't have to use some for C2. (#38)

16. Most of the math labs classes were excellent, but apparently not difficult for most of the students. I think we should have had the math lab before the C1 and C2 classes, because if student knows how to convert degrees to radians then it's a lot easier in C2 of WORK in Mechanical Systems. (#45)

17. Mechanical: Took 3 days to complete with videos and teaching students to read a protractor and ruler. Math Lab assumes students have had more than they really have had. Use computer programs for math materials. Some of the math videos were not really applicable to the math lab (i.e., circle). On pagaes 42-43 the figure is confusing. It looks like a fraction.

    Electrical: Should have had a lab like this at first to show how to plot on a graph before vectors or L2 on mechanics lab.

    Thermal: If you use 9/5 in the text you should also use it in the math lab instead of 1.8 for conversion. (#08)

18. Electrical and Thermal seemed to be a bit more difficult for the student. (#58)

19. Page 49, Example F, "a wrench that is 24 feet long?" (#15)

20. Mechanical: When I reached this section about 40% of my students rebelled. They could not see the need for vector relationships. I approached the problem as positively as I could but these same students resented the fact that this material was included as part of their curriculum. Unfortunately, they influenced others in the class and it took several days for the students to accept the fact that this material was to be covered. I probably took it too serious for a first introduction and I was disappointed at the inability of many students transferring information to vector form.

    Fluid: I found many of my students were weak in math skills which made my job harder in trying to develop more exercises for them to work with for practice.

    Electrical: Students were more interested in this topic so they applied more effort. Also we have devoted more time for hands on experiments in the electricity lab.

Thermal: Again I experienced problems with students not accepting the need for this study. (#57)

COMMENTS FOR LAB 1 CLASSES

1. In all the labs I found that equipment used took a lot of time to set up. Additionally, I feel we need labs that incorporate apparatus that the students are familiar with. Demonstrate the difference between a vented tank and unvented. This can be done with straw submerged in liquid. Place your finger on the top and remove the straw from the liquid. Now you can ask "What kept the fluid in the straw?" Simple, but it starts a lot of discussion. (#63)

2. Mechanical: Used the Sargent-Welch force boards instead of the suggested equipment.

   Fluid: Specific gravity using hydrometers was not effective using some of the suggested liquids.

   Electrical: Error in problem 2, part D, page 148. (#07)

3. All were good.

   Fluid: Would have been good if we had equipment. (#17)

4. Mechanical: Scale readings are inaccurate because of angle that the fish weighing scales are to the rope and chain. Also measuring with the protractor from a horizontal position depends on the accuracy of a student's eyes.

   Fluid: The hydrometers will not measure specific gravity less than 1.1, therefore, cannot measure the suggested liquids, e.g., alcohol, oil, anti freeze, pop. Suggest: one hydrometer that will measure alcohol, one that will measure antifreeze, one that will measure battery acid. (#18)

5. Mechanical: Could use water instead of sand--my room looks like a beach and the custodian is bemoaning his floorwax. Nylon cord doesn't hold a tie, recommend cotton line instead.

   Fluid: The densities of the materials you suggested for use do not fall within the range of the equipment you suggested to measure with. Only sulfuric acid solutions gave measurable results and my impression is that it is too dangerous a material to be used as a high school density experiment.

   Electrical: First evidence of "elite-ism" as kids familiar with meter reading from shop tended to rush those who had never used them before.

   Thermal: Worked well - always wanted to do this type of lab and never had the equipment before. (#30)

6. Mechanical: As this was the first lab, students were okay, but soon got bored. No challenge, after about 5 minutes they started to play.

   Fluid: As this is a farming community most students already understood this concept. Did not require all the time allocated for this section.

Electrical: My students were up on this area to begin with, again did not use all the time allotted.

Thermal: Very good. (#13)

7. Mechanical: With all due respect I found the kids had a hard time working with the force board from Sargeant-Welch. As a first experiment having to convert newtons to pounds was not successful for the kids and they had a hard time physically manipulating the protractor and the force board. I also noticed that the graph paper provided in the lab already had your sample data in vector form on the graph. I feel it could have been better if that was done as an example then provide a blank graph to do their own data. Then they'd have the experience of seeing if their resultant was equal to the 20 lb. force.

   Fluid: Density lab was good. I used 3 different concentrations of corn syrup and it work nicely. I found the kids were done in a flash - it took 20 minutes tops. Should have been longer.

   Electrical: I'm not an electronics teacher but in my opinion they were too basic and short. Kids need to be busy or believe me they'll find something to do and it's not going to be school work.

   Thermal: Loved the calibration of thermometer experiment except it also didn't take a full class session. The thermometers Sargent-Welch sent us were not the same length so we had a hard time making this work. We had to use 250 ml beakers for our ice bath and hot water bath cause we only got 6 liter beakers from Sargent-Welch. Therefore couldn't really submerge liter beakers. I also liked the thermocouple experiment. (#37)

8. Fluid: Suitable liquids to test were difficult to find. Note needed to instructors that both hydrometers are to be battery type. (#32)

9. Mechanical: To one degree or another all labs resulted in some disappointment. The mechanical systems lab offered some confusion because the text discussed pounds and the equipment measured only newtons. A different type of force board may have been better.

   Fluid: Good concept but could have been longer. Again, we couldn't seem to get Sargent-Welch equipment to work properly.

   Electrical: This would have been more interesting if we could have progressed to something a little more complex. Improvising was in order and is easy for someone experienced in electronics. The VOM takes more time to learn than was indicated in the text.

   Thermal: Frustration again because of equipment. There was a little confusion on what we were attempting in the calibration process. (#36)

10. Fluid: Suggest use of liquid other than such a dangerous acid. One student was burned. (#27)

11. Fluid: The hydrometer that we ordered through Sargent-Welch didn't work out very well. They were battery acid testers and we couldn't get a

reading on all our fluids. (#33)

12. Mechanical: Neat vector board idea but add instruction to compare valves need to support some more at different angles.

    Electrical: Eliminate voltage at outlet.

    Thermal: Modified lab: Took temperature readings for heat loss in three containers (glass, metal, styrofoam) over 15 minute period. Used pre-heated water, plotted results and compared. (#06)

13. The lab set up has been very difficult - for the instructor this first year time sometimes just does not let us set up to our best advantage. The material is interesting for most students and seems to keep student interest a lot higher. (#21)

14. Fluid: Battery testers were difficult to read. Two broke (the floats) very quickly and easily.

    Thermal: Needed more time. (#42)

15. Thermal: Needs to be made more sophisticated. (#55)

16. Fluid: Didn't do. (#60)

17. Electrical: I think we should have had some componenets like resistors and capacitors or conductors. Experimenting with the actual component instead of element of bulb makes a lot of difference. (#45)

18. Mechanical: Errors - page 57, figure 4, angle AB should be 75 degrees. Have modified force board to be less complicated. Used bricks for weights and other things that cannot be explained. Use of symbols such as Fa, Fb, etc, was confusing to some students.

    Fluid: We used one hydrometer per station and rotated students to each station thus eliminating the need to rinse the hydrometer each time. We also had a problem finding a hydrometer that would read 1.09 to 1.33 but finally found some in health occupations class.

    Electrical: To save on expenses for each lab station have one set of equipment and circulate students from one lab station to the next. (#08)

19. Mechanical: Needs a thorough preview day before to save time on lab day.

    Fluid: Needs thorough preview day before so it can be completed in one period. Did as demo because of fragility and cost of hydrometers.

    Electrical: Easy in one period. Biggest problem was reading VOM's. (#56)

20. Mechanical: Approximately 50% of the students had problems transferring information from vector boards to drawings. Some of the scales were off balance, which made it more difficult for students to understand.

Fluid: I was about to pull my hair out with lack of interest and abuse of weights and springs. My management skills on this experiment was not at its best due to lack of student interest. I had to improvise with plastic hose nailed to a board in the form of a U-tube. At this point, I divided students into groups of three and let them give a demonstration to the other students in class.

Thermal: A good experiment. We ended up taking a couple of days extra to allow for time factor involved in heating to boiling point. (#57)

21. Very weak labs. (#25)

22. Mechanical: We were unable to use the force boards indicated in program and had to substitute.

    Fluid: Had to borrow materials from auto shop because my order wasn't complete at the time.

    Electrical: The students had trouble using the VOM and we had to modify part of the lab to get it to work. (#11)

COMMENTS FOR LAB 2 CLASSES

1. Time for set up and clean up plus what was mentioned in Lab. (#63)

2. Thermal: Excellent, but how does this compare to a regular thermocouple used in industry? (#17)

3. Fluid: Vacuum/pressure pumps do not read pressure on gauge as experiments ask for (will create pressure, but cannot be read).

   Thermal: Okay, students have enough time to convert degrees celsius to degrees Fahrenheit for more practice using math. (#18)

4. Mechanical: Went well. Good results in class: not too difficult for 40 minutes.

   Fluid: Equipment did not arrive. We will try to test the lab out-of-order when it does.

   Electrical: Meters that beep drive me crazy. Kids had to tweet those things to distraction.

   Thermal: Results surprisingly close to accepted values even in low heat environments. (#30)

5. All labs were too simple, could not keep student interest up. Only graphing them would be of interest. No challenge. (#13)

6. Mechanical: We couldn't do the experiment because Sargent-Welch back ordered the spring holders and spring. We dry labbed it but it looked like it was a very nicely written lab.

   Thermal: I liked the thermocouple experiment but again it didn't take a full class session. Also Sargent-Welch back ordered the banana plugs, we still don't have them. (#37)

7. Fluid: I deleted this lab because I felt working with Hg on an open system was too much for my students. You need to re-examine this lab. (#05)

8. Fluid: Vacuum pump suggested by Sargent-Welch incapable of doing experiment. (#32)

9. Mechanical: Spring holder didn't arrive, this lab a disappointment.

   Fluid: Discussed in Lab 1. I'm sorry to say this lab was mostly a failure. Sargent-Welch equipment was inadequate.

   Electrical: I made an interesting experiment but needs something with a little more complexity.

   Thermal: I thought the thermocouple lab went smoothly after making our own leads. The students seemed to learn a lot from this lab. Few had known what a thermocouple was before this. Again the lab was a little too short. (#36)

10. Fluid: We had no hand pump that would hold pressure--therefore the

concept was shown and taught, but the lab, per se, was not done. Hg has too many dangers to have multiple manometers set up in class. (#27)

11. Fluid: Our equipment for this lab has yet to arrive, we spent the time working through the lab in a discussion. (#33)

12. Mecl anical: Did not do - used day for additional vector work.

    Fluid: We also used sphygomomanometer and stethoscope - higher interest. Used atmospheric pressure to collapse can.

    Thermal: Computer lab: programmed computer to convert between celsius and Fahrenheit scales. Converted previous days' data. Did not have thermocouple available for studen+.. (#06)

13. Flui:. No proper equipment. Had to run as a demonstration. Data tables should be on the same sheet.

    Electrical: Have source voltage read with switch closed. (#42)

14. Fluid: Didn't do.

    Thermal: Didn't do. (#60)

15. Mechanical: Appropriate terms like delta, L0, L1, were not understood by students. 50-minutes measured springs and viewed video on graphing. First period, graphed and finished up on second day. Management problems, brake return spring does not give that much. Use screen door springs.

    Fluid: Used only vacuum pump and only one lab set up to save money. Worked just fine.

    Electrical: Connected two wires together at point "D" on parallel circuit so change to series circuit was simplified by only loosening two screws.

    Thermal: Reading on surface of hot plate exceeded readings available on chart. Also had to modify apparatus because we never received banana nuts from Sargent-Welch. (#08)

16. Fluid: Did not have manometers to do this lab. (#15)

17. Mechanical: The students did not accept this experiment with great enthusiasm. There was continuous abuse of springs and weights. I feel that the experiment is a good one but the problems I have encountered with maintaining student interest has been difficult in my Electricity program.

    Fluid: I experienced difficulty with students playing around with mercury and adapting devices to equipment for experiment.

    Electrical: Good experiment. Excellent acceptance by students.

    Thermal: Good experiment. More time involved for heating. (#57)

18. Fluid: Useless lab for showing pressure and forces.

    Electrical: Went well. Bought all equipment from Radio Shack. (#25)

19. Fluid: We were unable to run this lab because of late shipment, no manometers. We used tubing and water to show what happens when you have a pressure difference. (#11)

COMMENTS FOR SUMMARY CLASS

1. I think this is a very important class! It helps to tie it all together. "Unification" principle of science fields needs to be emphasized even more. Class is beginning to show external signs of understanding that all fields of science have a prime mover, something being moved, and something to overcome in order to move. Good, good, good! (#17)

2. Mechanical: If a test is given, there is not time for follow-up the next day. Fluid Systems Review: Not enough time for a thorough review and a test also. There is a lot of information and formulas in this unit. If a test is given, not enough time for follow-up afterward. Not enough time for a thorough test. (#18)

3. Not too shabby, so far! (#62)

4. This program, to this date, has not been funded. I have taught Unit 1, and feel I have presented, and the students have achieved the goals set forth in the plan.

   I have had to use about 25% more time than allotted. Instead of the lab demonstrations, I used normal demonstration procedures from my mechanics classes.

   The largest part of all labs were spent in discussion type meetings and demonstrations on the black board.

   This may have been beneficial due to the caliber of students I have this year. No student was screened and due to new policy, I received students from 10th to 12th grades. In this group, I have 2 12th graders not working toward a diploma, classified as alternative students.

   With the situation as it is, I still feel the program will be successful and beneficial to my students.

   Their attitude is good (after explaining the benefits they will receive).

   The results are true and I feel we have achieved. (#23)

5. I hope all of you at AIT and CORD understand that my comments are sincere and made with all due respect to the extraordinary effort you've put forth. I like PRINCIPLES OF TECHNOLOGY. (#37)

6. There was a marked difference in pre- and post-test scores. (#05)

7. More student exercises. (#10)

8. The summary could have included a listing of the formulas that were introduced in the sub-units and also showing how each one is worked. The glossary was very valuable and very much appreciated. (#33)

9. We reviewed most concepts. (#06)

10. The summary was good. I was able to go back and review each objective after the video and the discussion. (#38)

11. Most of my problems dealt with not having the equipment. I was not able to do the following labs: Fluid 1, Thermal 1, Fluid 2. I was also unable to demonstrate 1 DM and 1DT successfully because of equipment. (#60)

12. On test, question #26 is a bad question, when you quibble between "+" and "And." (#08)

13. We're running about one month late because of safety classes and other start up problems. I could have used more math assist tapes. (#25)

14. Students performed better and appeared to accept the fact that there is valuable material here for them to learn. Unfortunately many of the students did not take interest in the material and did poorly on the examination. Many of the students reent the amount of material there is to read. I personally feel that the program as a whole is very good and if students applied themselves they could gain from these experiences. I have tried to do my best but with the negative attitude of the students not wanting to integrate into their electrical curriculum has made it very difficult for me. On the next section on WORK I hope to help change those attitudes to a positive one. (#57)

15. Overall all the students enjoyed it. We had a few problems getting started, with equipment and lab set-ups. But we are catching up now. (#58)

PRINCIPLES OF TECHNOLOGY

UNIT 2: WORK

PILOT TEST FINDINGS

AGENCY FOR INSTRUCTIONAL TECHNOLOGY

CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

March 1, 1985

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Introduction

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 34 state 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. Each unit consists of a student manual, a teacher's guide, hands-on laboratories, and video programs. The prospectus for the project was issued in June of 1983; the initial development work began in November of 1983.

An important part of the developmental process is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working, and 2) to identify specific problems with the materials. Each consortium agency has designated 2 sites in its state/province as pilot test sites. All pilot test teachers were oriented to the *Principles of Technology* course and the pilot test procedures at one of two meetings in Dallas, Texas, held in the summer of 1984.

This report details the findings of the Unit 2, WORK, pilot test. The report makes several comparisons of the Unit 2 findings with Unit 1 findings, which are contained in a separate report (see "Unit 1: FORCE - Pilot Test Findings," December 18, 1984).

Pilot Test Procedures

Unit 2 pilot test materials were mailed to the teachers in mid-September, 1984. These materials consisted of:

1) Pre/posttests (see Appendix B).

2) Computerized scoring sheets for the pre/posttests.

3) Student attitude questionnaires (see Appendix D).

4) Teacher questionnaires (see Appendix E).

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the posttest and the student attitude questionnaires. All unit 2 evaluation materials were then mailed back to AIT. Data contained in this report include all material received by January, 1985.

Limitations of the Methodology

There are two major limiting factors that must be considered when interpreting the findings: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered, including:

* Lack of matched control groups.

The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in terms of time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

* The pretest/posttest format.

The same test was used for both the pre and posttest. The effect that memory of the pretest might have on posttest performance was another concern. The research design addressed this concern in three ways:

1) Students were not given the correct answers to the pretest. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

3) A correlated t-test was used to analyze the pre/posttest data. This technique helps to partial out any variance that might result from an intruding correlation--in this case memory.

* The pre/posttest as an instrument (See section on development of the instrument, page 6).

The test cannot measure all objectives. Therefore objectives had to be sampled. Also, the items do not always <u>directly</u> match the intended objectives. The test was a cognitive test. Many of the objectives, (particularly the lab objectives) are psychomotor objectives. Each of these factors must be considered when assessing the validity of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results, including:

* Equipment problems.

  Several teachers reported problems in securing necessary lab equipment.

* Student characteristics.

  At this time the project does not have adequate data to describe the students in the pilot test, although there seems to be considerable variability in the kinds of students in the course. Attempts have been made to collect these data, which should be available for subsequent units.

* Teaching pattern.

  There appears to be considerable variability in terms of length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess the impact of the various conditions on the outcomes.

So, both research design and external constraints must be considered when interpreting the results. It's important to remember that the overall pilot test was designed primarily as a formative evaluation to improve the materials, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

Sample

The sample included 417 students in 24 sites. Relevant teacher characteristics include:

* Physics background

  There was a wide range in the teachers' physics background: 18% reported no college physics courses; 4% reported 1 college physics course; 48% reported 2-4 college physics courses; 15% reported 5-7 and 15% reported 8 or more college physics courses.

* Mathematics background

  Almost all teachers (96%) have had 2 or more college mathematics courses; several (30%) have had 5 or more college mathematics courses.

* Teaching pattern

  Most (63%) taught *Principles of Technology* on consecutive days.
  Most (84%) taught sessions that were 60 minutes or less.
  Several (41%) indicated they had combined some classes into one session.

* Preparation time

  Over half (63%) indicated they spent 60 minutes or less preparing to teach each unit on WORK.

Student characteristics included:

* Grade†

  10 = [illegible]5% 11 = 62% 12 = 22%

* Sex

  Male = 84% Female = 16%

Thus, even with fewer sites than were included in the Unit 1 report, the student and teacher demographics were essentially the same for Unit 2.

† Due to missing data, the pre/posttest student demographics don't match the student attitude demographics.

Pre/Posttest as an Instrument

To understand the results, one must first understand the characteristics of the test as a measurement instrument, including the process by which the test was developed and what statistical analyses reveal about the reliability and validity of the instrument.

Over 60 test questions were initiated at CORD by the content specialists. In a collaborative process between evaluators and content specialists these questions were pruned and revised to the eventual 33 items. Each item is tied, as directly as possible, to a specific objective from Unit 2. As some reviewers have pointed out, the item/objective match is not always exact. This is a valid criticism, but it's impossible to directly match items to objectives because of the way the objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and often approximations of objectives are as good as cognitive test developers can do. With only 33 items (targeted number of items that can comfortably be tested in the available time), not all objectives could be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were determined based on the relative importance of the concepts. (Appendix B lists the objective each item is intended to address below the item.)

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?). The reliability (Spearman-Brown test of internal consistency) of this instrument is .72, which is acceptable by most standards. Validity is a bit more complicated to judge. A factor analysis of the instrument indicated

almost all items related to discrete factors. This is expected, because each item is tied to a separate objective. Readers are encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?
2) Is a sufficient range of objectives addressed?
3) Overall, is the instrument a fair measure of Unit 2 instruction?

Pre/Posttest Results

A variety of analyses of the pre/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 33 items. The findings included:

Mean differences - The overall pretest mean was 13.6. The overall posttest mean was 17.6. This increase was statistically significant (correlated t-test) at the .01 level.

However, when compared to Unit 1, both the percentage of increases (65% for Unit 1; 29% for Unit 2) and the percentage correct on the posttest (69% for Unit 1; 53% for Unit 2) are less for Unit 2 This probably indicates that either the Unit 2 material was more difficult, the test was more difficult, or both. Because the test is directly tied to the objectives, one might surmise that students found Unit 2 more difficult than Unit 1.

In examining Unit 1 data, the project team established criteria for acceptable performance. These criteria included either:

1) 70%+ correct on an item or

2) Doubling of pretest score on the posttest.

In examining the Unit 2 items against these criteria we find:

70%+ or doubling of percent correct - 1, 2, 4, 6, 7, 8, 9, 11, 13, 14 (69%--close enough!), 20, 21, 22, 23, 27, 32, 33

Less than 70% and no doubling of percent correct - 3, 5, 10, 12, 15, 16, 17, 18, 19, 24, 25, 26, 28, 29, 30, 31

As with Unit 1, it will be helpful to examine the content of the items on which students' performance did not meet the acceptability criteria. First, let's examine the items according to subunits.

Mechanical - Two of seven items did not meet acceptability criteria.
Fluid - Two of seven items did not meet acceptability criteria.
Electrical - Five of seven items did not meet acceptability criteria.

Thus, students performed the poorest on the electrical subunit. In examining the items for the electrical subunit, 3 items (30, 31, 33) dealt with mathematics--either manipulating a formula (30 and 31) or

recalling a formula (33). It's probably not too surprising that students performed poorly on these items, since they've exhibited an on-going weakness with the math items. Probably more cause for concern is the poor performance on three items (27, 28, 29) dealing with the key terms of the subunit--joules, amperes, and volts.

Poor performance was also registered on the items (15, 16, 17, 18) covering English and SI torque/work units. (Two teachers also indicated these were confusing concepts.)

Finally, poor performance was registered on several mathematical items (5, 10, 21, 24, 30). In seeking explanations for this, two possibilities seem to exist (remember, students are typically given the formulas to use in solving the problems):

1) Students might not know how to manipulate the equations.
2) Since the formulas use scientific notation, students might not remember what the scientific symbols indicate.

Whatever the reasons, the decision from Unit 1 to increase both the remedial and advanced math content received additional support from these data.

Pre/Post Results by Site

The attached graph (Appendix C) indicates the pre/posttest mean scores by site. Twenty-two sites showed statistically significant increases; 4 sites showed no statistically significant gains. It's important to note that student numbers in each class has a major impact on statistical significance; the smaller the class size, the greater the gain must be to become statistically significant. Keeping this in mind may help to understand the significance of these data.

Pre/Post Test by Selected Variables

The impact of several variables on students' performance was examined, including:

1) Students' characteristics.
   a) sex
   b) grade

2) Teaching pattern.
   a) consecutive days
   b) length of class periods
   c) combined activities

3) Teacher background.
   a) physics background
   b) mathematics background

These variables were analyzed with an analysis of covariance, which controlled for pretest scores. Table 1 examines the results of this analysis; all means reported in Table 1 are for the posttest.

As Table 1 indicates, the student variables, sex and grade, had little impact on posttest scores. However, the teaching pattern and teacher characteristics each had statistically significant impact on student scores. These results were consistent with results for Unit 1.

Table 1

Results of Analyses of Main Effects

Main Effect	Level of Significance	Subset(n)	Mean Score
Sex	.59	Boys (349)	17.60
		Girls (48)	17.65
Grade *	.09	Grade 11 (52)	18.04
		Grade 12 (244)	17.27
Teaching on Consecutive Days	.01	Yes (284)	18.10
		No (133)	16.42
Minutes per Class	.04	LT 50 (216)	17.77
		50-60 (86)	18.53
		60-90 (29)	17.83
		90+ (86)	15.98
Combining Sessions	.01	Yes (88)	19.70
		No (329)	16.99
Teacher's Physics Background	.01	No Classes (103)	16.17
		1 Class (80)	18.44
		2-4 Classes (134)	17.72
		5-7 Classes (40)	16.97
		7+ Classes (60)	18.82
Teacher's Mathematics Background	.01	No Classes (0)	--
		1 Class (1)	13.44
		2-4 Classes (292)	17.55
		5-7 Classes (47)	17.60
		7+ Classes (60)	18.82

* 55 students did not indicate grade. Most of these were in one class which is predominantly tenth graders.

Student Attitude Results

The student attitude findings (Appendix D) indicated:

- Most students (76%) liked the WORK unit either a lot (14%) or a little (62%).
- The most appealing components were the hands on labs (37%) and the video programs (21%).
- The least appealing components were the written material (30%) and the math labs (21%).
- Half (50%) indicated that some of the material was difficult for them to understand.
- Most (87%) indicated they thought the material was very (34%) or sort of (53%) important to understand.

These findings were very similar to the student attitude findings for Unit 1.

Teacher Results

Questionnaires were returned from 27 teachers. Appendix E lists all the teachers' comments. Key teacher findings included:

* Time

  Most (84%) indicated the 20-day plan of 50-minute class sessions is probably realistic for the unit on WORK. Those who reported that there was not enough time tended to indicate that the hands on labs required more than the allocated 50 minutes.

* Teacher Comfort

  Almost all teachers (92%) indicated that they felt comfortable teaching the unit on WORK.

* Student Readings

  The majority (62%) indicated that their students probably did not do the assigned readings at home. Since much of the content is contained in the readings, this is a particularly troubling finding.

* Teacher's Guide

  Most (88%) indicated that the Teacher's Guide provided them with enough information to implement the unit.

Problems

The areas in which teachers reported having problems with Unit I included:

- labs, either getting the equipment, setting up the equipment, or problems with specific labs (13 teachers);
- terms in the electrical subunit (3). Student test scores support this as a problem area;
- "English to metric" (2);
- symbol use (1);
- school schedule (1).

Conclusions

Overall, the Unit 2 data were fairly consistent with the data for Unit 1. Unit 2 data indicated that:

1) Siginificant learning gains took place in almost all classes.

2) Students performed most poorly on items dealing with mathematics and the electrical subunit. Three teachers also indicated that the terms in the electrical subunit caused students problems.

3) Students continued to indicate positive attitudes about the material.

4) Teachers' comments indicated continued problems with the labs.

5) Teachers' comments included several specific recommendations, which should be examined carefully.

Unit 2 data support many of the decisions the project team made based on Unit 1 data, particularly the decision to increase the amount of both remedial and advanced mathematics.

Appendix A

Cooperating Agencies

Appendix B

Pre/Posttest Frequencies and Objectives

All numbers in %
Objectives listed below item

PRINCIPLES OF TECHNOLOGY
UNIT 2: WORK
STUDENT TEST

Pre	Post	
		1. According to the technical definition of work, work in a mechanical system is done:
21	4	a. anytime force is exerted
52	87	*b. when force causes an object to move
1	1	c. when the forces are in balance
25	8	d. all of the above
		O-1
		2. By the technical definition of work, which of the activities below is <u>not</u> considered work?
9	4	a. moving an I-beam
59	92	*b. holding an engine suspended with a rope hoist
19	2	c. moving water with a pump
13	2	d. drilling a hole with an electric drill
		O-2
		3. In the unifying equation for work, which of the following quantities is a force or forcelike quantity?
14	12	a. volume
16	13	b. charge
50	65	*c. voltage
20	10	d. coulomb
		O-1
		4. Work is equal to force _____ distance moved.
16	1	a. plus
3	1	b. minus
70	96	*c. times
11	2	d. divided by
		O-2
		5. A forty-five degree (45°) angle is equal to
31	44	*a. $\pi/4$ radians
21	18	b. π radians
29	17	c. 2π radians
19	21	d. $\pi/2$ radians
		M-6

In the following <u>four</u> questions indicate whether or not work is being done by placing "a" or "b" on your answer sheet, according to the legend below:

a. Work being done
b. Work not being done

Pre	Post	
54	91 b	6. Parking brake holding car on steep hill O-1
81	95 a	7. Elevator moving from second floor to first floor O-1
80	95 b	8. Elevator at rest at second floor before passengers exit O-1
46	78 a	9. Parachutist in free fall O-1

(See back of this page for questions 10-19)

Pre Post

10. How much work is done by a helmsman on a ship who applies 60 lb of force to turn the ship's wheel 2 revolutions when the wheel has a 3-foot radius? (Hint: Use formula $W = T \times \theta$, θ = Angle in radians)

48 47 a. 360 ft•lb
23 13 b. 720 ft•lb
16 13 c. 1130 ft•lb
13 27 *d. 2260 ft•lb

M-8

11. The formula $\left(\frac{\text{output work}}{\text{input work}} \times 100\right)$ describes

21 4 a. mechanical work
59 89 *b. % efficiency
9 3 c. angle in radians
12 3 d. electrical work

M-5

12. When calculating work done by a force, distance object moves is measured

11 3 a. when net forces are zero
35 40 b. as long as the object being acted on moves
32 47 *c. only while force is applied
23 10 d. none of the above

M-1

13. A force of 90 newtons is required to move a load. How much work is done in moving the load 10 meters?

18 7 a. 9 N•m
11 2 b. 100 N•m
7 2 c. 450 N•m
64 89 *d. 900 N•m

M-2

14. Efficiency of any machine is a comparison of

24 10 a. force output to force input of the machine
11 3 b. distance output to distance input of the machine
36 69 *c. work output by the machine to work input on the machine
29 18 d. both a and b

M-5

In the following four questions, match the units on the right with the correct definition on the left. On your answer sheet fill in the letter of the unit that corresponds to the numbered definition.

a=41 b=46 c=9 d=4
46 53 15. English system torque unit a=39 b=53 c=6 d=3 a. ft lb
M-10 a=10 b=13 c=49 d=28
49 45 16. SI torque unit a= 4 b= 9 c=45 d=43 b. lb ft
M-10 a=41 b=37 c=10 d=11
41 53 17. English system work unit a=53 b=35 c= 7 d= 6 c. N m
M-10 a= 7 b=11 c=35 d=47
35 60 18. SI work unit a= 5 b= 5 c=60 d=30 d. N/m

M-10

19. In fluid systems work is equal to

33 32 a. pressure difference x fluid volume moved
20 16 b. pressure x change in volume or volume displaced
33 46 *c. both a and b
13 5 d. neither a nor b

F-2

Pre	Post	
		Each fluid system listed below can be classified as either an open fluid system or a closed fluid system. For each system indicate the type of system with an "a" (closed fluid system) or "b" (open fluid system) on your answer sheet.
61	81 b	20. Auto fuel system
		F-1
69	88 a	21. Auto brake system
		F-1
67	88 b	22. Fire department pumper truck
		F-1
68	89 a	23. Hydraulic jack
		F-1
		24. If weight density of water is 62.4 lb/ft^3, how much work is done in filling a 200-ft^3 tank located 50 ft above the water? (ΔP = 3120 lb/ft^2)
15	8	a. 2,000 lb/ft
17	11	b. 10,000 ft·lb
38	55	*c. 624,000 ft·lb
30	26	d. 624.000 ft/lb
		F-5
		25. The type of work done by a hydraulic cylinder piston when it moves a load is:
26	36	*a. mechanical work
63	60	b. fluid work
5	2	c. electrical work
6	1	d. thermal work
		M-11
		26. In an electric motor-operated pump, the efficiency of the pump is a comparison o
21	14	a. force output of the pump to force input of the pump
31	46	*b. fluid work done by the pump to electrical work done on the motor
20	13	c. pressure output of the pump to pressure input on the pump
29	27	d. both a and c
		F-L3
		27. The unit of electrical work is the
24	14	a. ampere
24	21	b. coulomb
19	49	*c. joule
34	17	d. volt
		E-1
		28. The rate of movement of electrical charge is measured in
37	52	*a. amperes
17	23	b. coulombs
11	10	c. joules
35	14	d. volts
		E-3
		29. The forcelike quantity that moves electrical charge to produce work is measured
18	15	a. amperes
23	15	b. coulombs
16	13	c. joules
42	58	*d. volts
		E-1

(See back of this page for questions 30-33)

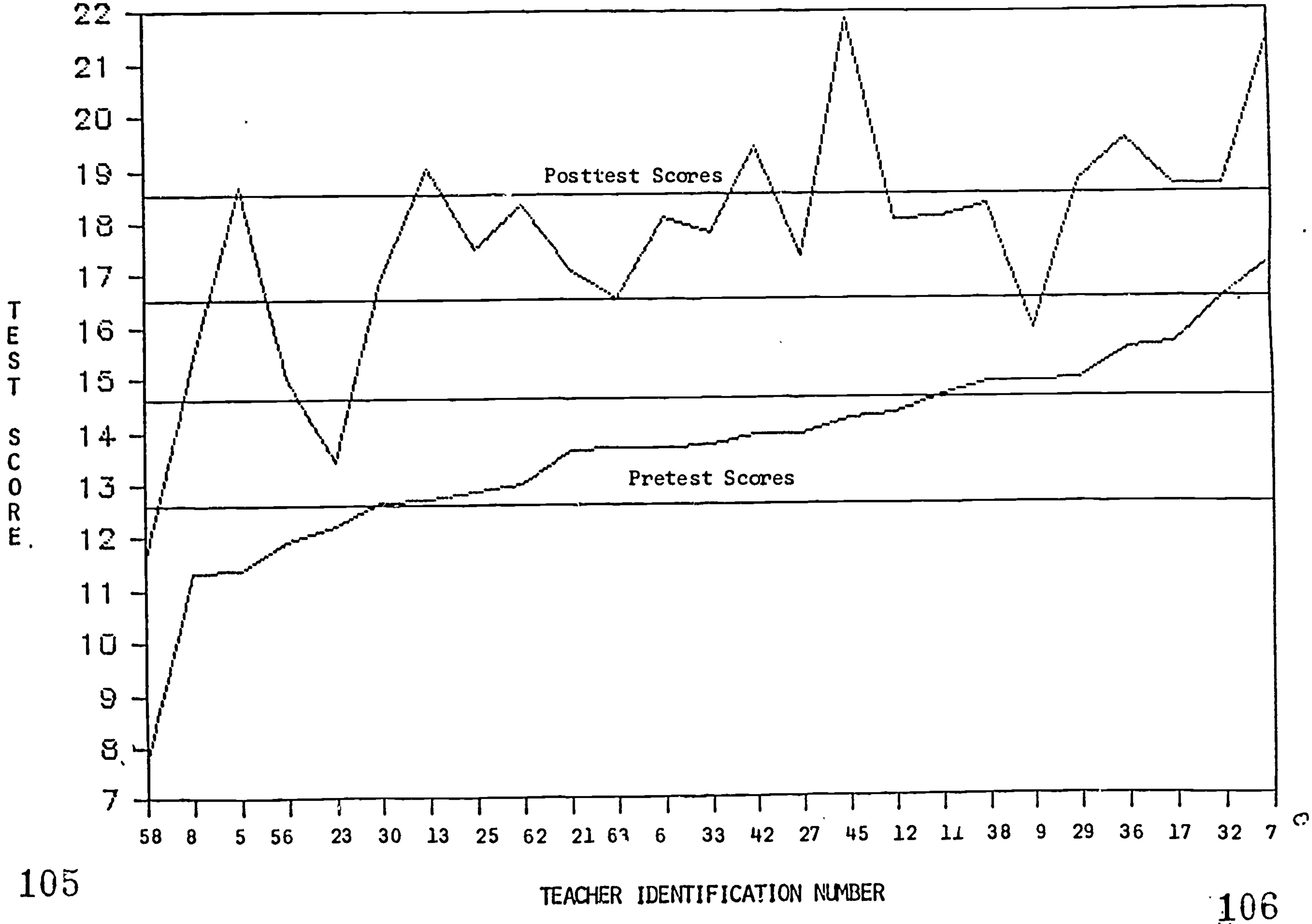
Pre	Post	
		30. A battery-powered windshield wiper motor is activated for 10 seconds and draws a current of 5 amperes at a voltage of 12 volts. Find the total amount of charge moved. ($q = I \times t$)
11	5	a. 0.5 coulombs
35	24	b. 60 coulombs
36	56	*c. 50 coulombs
18	14	d. 120 coulombs
		E-2
		31. A 12-volt battery can store 8000 coulombs of electrical charge. If the battery is "dead," how much work must be done to recharge the battery to a potential difference of 6 volts? ($W = V \times q$)
12	6	a. 72 joules
20	9	b. 1333 joules
48	59	*c. 48000 joules
20	27	d. 96000 joules
		E-2
		32. For an electrical device to be 100% efficient
25	8	a. the work out would be greater than the work in
12	8	b. the work out would be less than the work in
52	76	*c. the work out would be the same as the work in
11	8	d. the electrical device could have no moving parts
		E-7
		33. Which of the following equations correctly defines electrical work?
27	14	a. $W = F \times d$
32	66	*b. $W = (\Delta V) \times q$
20	5	c. $W = (\Delta P) \times h$
21	15	d. $W = (\Delta V) \times I$
		E-1

Appendix C

Mean Scores by Site

P.T. UNIT TWO

PRE-TEST POST-TEST RESULTS



Appendix D

Student Attitude Data

N=417

All numbers in %

PRINCIPLES OF TECHNOLOGY
STUDENT ATTITUDE QUESTIONNAIRE

Sex: 16 Female 84 Male

Grade: .2 9 15 10 62 11 22 12 Adult=1

1. Overall, did you like the unit on WORK?

   14 yes, a lot
   24 no, not very much
   62 yes, a little
   5 no, not at all

2. What component did you like most in the WORK unit?

   4 the written material
   21 the video programs
   5 the math labs
   37 the hands on labs
   22 no preference

   more than 1 = 11

3. What componenet did you like least in the WORK unit?

   30 the written material
   4 the video programs
   21 the math labs
   2 the hands on labs
   34 no preference

   more than 1 = 9

4. Was the material that was covered in the WORK unit difficult for you to understand?

   8 yes, most of the material was difficult for me to understand
   50 yes, some of the material was difficult for me to understand
   42 no, most of the material was not difficult for me to understand

5. Do you think the material in the WORK unit is important for you to understand?

   34 yes, very important
   7 no, not very important
   53 yes, sort of important
   5 no, not at all important

THANK YOU!

Appendix E

Teacher Data and Comments

PRINCIPLES OF TECHNOLOGY
UNIT II: WORK
TEACHER QUESTIONNAIRE

n=27 1. Did you teach Unit II: WORK on consecutive days for 20 days?

63 yes 37 no

If no, what pattern did you use (for example, 3 days a week)?

See attached comments

n=26 2. How much time per session did you teach?

50 50 minutes or less 8 60-90 minutes

34 50-60 minutes 8 90+ minutes

n=27 3. Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

41 yes 59 no

yes, which classes did you combine?

See attached comments

n=26 4. Based on your experiences, do you think the 20-day plan of 50-minute class sessions is realistic for the unit on WORK?

26 yes, definitely 12 no, probably not

58 yes, probably 4 no, definitely not

If no, please explain:

See attached comments

n=27 5. On average, how much time did you spend preparing to teach each class in the unit on WORK?

22 0-30 minutes 8 90-120 minutes

41 30-60 minutes 3 120-180 minutes

26 60-90 minutes 0 180 or more minutes

Comments:

See attached comments

n=27 6. Do you think most of your students did the assigned readings at home?

7 definitely 30 probably 59 probably not 3 definitely not

Comments:

See attached comments

n=27 7. Overall, did you feel comfortable teaching the materials in the unit on WORK?

62 yes, very comfortable

4 no, not very comfortable

30 yes, sort of comfortable

4 no, not at all comfortable

If no, please specify:

See attached comments

8. What, if anything, caused you the most problems in teaching the unit on WORK?

See attached comments

n=26 9. Do you feel the Teacher's Guide material provided you with enough information to help you successfully implement the unit?

46 definitely 42 probably 8 probably not 4 definitely not

If no, what should be added to the guide to make it more useful?

See attached comments

n=27 10. How many physics courses did you take in college (undergraduate and graduate)?

18 none

15 5-7

4 1

15 8 or more

48 2-4

n=27 11. How many math courses did you take in college (undergraduate and graduate)?

___ none

11 5-7

4 1

18 8 or more

67 2-4

12. Do you have any other comments, concerns, or suggestions for the unit on WORK?

See attached comments

The following chart lists each activity for the unit on WORK down the left column. Since there are no materials specifically for the sub-unit review classes, these classes have not been listed in the chart. For each activity, you should respond to the following questions by circling "yes" or "no":

1) Was the material (readings, labs, or videos) appropriate for your students? Was the material at the right grade level? Was the amount of material appropriate for your students? For any no responses, please use the attached pages to describe your concerns.

2) Were you able to cover the material to your satisfaction in the 50-minute time period? (Since this question doesn't apply to the video, no response options have been provided for the column. Please do respond, however, to the other questions about the video.) For any no responses, please use the attached pages to describe why you could not complete the material and/or what you chose to delete.

3) Were there any errors or inaccuracies in the material? For any yes responses, use the attached pages to specify the errors and recommended corrections.

4) Were there any problems managing the activity? For the labs, were all your students able to rotate through the labs? Did you experience any problems coordinating the activity? For any yes responses, use the attached pages to specify the problems you had and, if possible, suggest changes that you feel would enable you to more easily manage the material.

5) Do you have any suggested modifications for the material? For any yes responses, use the additional pages to specify your suggestions. Include in this section any "teaching tips"--special procedures you used or means you discovered to more easily convey the information to students. Include in this section any comments you may have for the Teacher's Guide.

We recommend that you take a few minutes each day to complete the chart and, most importantly, to write down your comments. If you need more space for comments, use the back of the comments pages and/or attach additional sheets.

UNIT II: WORK

	Appropriate for students?			Completed in 50 minutes?			Any errors or inaccuracies?			Any management problems?			Any suggested modifications?		
	yes	N	no	yes	N	no	yes	N	no	yes	N	no	yes	N	no
Overview															
Video	100	25			------------		4	23	96		24	100	10	21	90
CO	100	21		95	22	5		20	100		21	100	5	19	95
Mechanical Systems															
Video	100	26			------------			23	100	4	23	96	10	21	90
C1	100	26		88	25	12	4	23	96		23	100	10	21	90
C2	96	26	4	84	25	15	5	23	95	9	23	91	19	21	81
Math Lab	88	25	12	80	24	20		23	100	14	22	86	36	22	64
1M1	88	24	12	76	25	24	5	21	95	30	23	70	33	21	67
1M2	91	23	9	72	25	28	14	22	86	25	24	75	52	21	48
Fluid Systems															
Video	100	26			------------			24	100		23	100	11	19	89
C1	100	26		84	25	16		24	100		23	100	15	20	86
C2	96	26	4	80	25	20	17	24	83	9	23	91	20	20	80
Math Lab	88	24	12	79	24	21	4	24	96	9	22	91	33	18	67
1F1	91	21	9	72	25	28	4	23	96	50	22	50	42	19	58
1F2	86	21	14	68	25	32	4	23	96	36	22	64	32	19	68
Electrical Systems															
Video	100	26			------------		4	23	96	4	24	96	14	21	86
C1	100	26		84	25	16		23	100	4	24	96	14	21	86
C2	100	26		84	25	16		23	100	4	24	96	14	21	86
Math Lab	88	25	12	83	24	17	4	22	96	12	24	88	29	21	71
1E1	92	24	8	68	25	32		22	100	42	24	38	33	21	67
1E2	91	23	9	80	24	20	13	23	87	21	24	79	29	21	71

	Appropriate for students?	Completed in 50 minutes?	Any errors or inaccuracies?	Any management problems?	Any suggested modifications?
Summary					
Video	100 yes 24 no	----------	5 yes 22 95 no	yes 21 100 no	17 yes 23 83 no

Comments for CO Class

See attached comments

Comments for Videos

Overview Video: See attached comments

Mechanical Systems Video: See attached comments

Fluid Systems Video: See attached comments

Electrical Systems Video: See attached comments

Summary Video: See attached comments

Comments for C1 Classes

Mechanical Systems C1: See attached comments

Fluid Systems C1: See attached comments

Electrical Systems C1: See attached comments

Comments for C2 Classes

Mechanical Systems C2: See attached comments

Fluid Systems C2: See attached comments

Electrical Systems C2: See attached comments

Comments for Math Lab Classes

Mechanical Systems Math Lab: See attached comments

Fluid Systems Math Lab: See attached comments

Electrical Systems Math Lab: See attached comments

Comments for Lab 1 Classes

Mechanical Systems Lab 1: See attached comments

Fluid Systems Lab 1: See attached comments

Electrical Systems Lab 1: See attached comments

Comments for Lab 2 Classes

Mechanical Systems Lab 2: See attached comments

Fluid Systems Lab 2: See attached comments

Electrical Systems Lab 2: See attached comments

Comments for Summary Class

See attached comments

PRINCIPLES OF TECHNOLOGY
UNIT II: WORK
TEACHER QUESTIONNAIRE

QUESTION 1 COMMENTS

Did you teach Unit II: WORK on consecutive days for 20 days?

1. Two days a week, 2 hours a day. (#13)
2. Additional material was added, and the math labs were done as homework. (#07)
3. For 24 days. (#32)
4. Two and three days a week. (#58)
5. We skipped weekends. Actually lost three days mid-unit to school site. (#06)
6. 4 days a week. (#63)
7. Week of double periods, week off. (#30)
8. Used standard pattern but had too many interruptions. (#60)
9. 95 minutes every other day. (#11)
10. 3 days a week. (#25)
11. I taught on consecutive days but it took more than 20 days. (#38)
12. We skipped several days because of deer season, parent-teacher conferences, etc. (#08)

QUESTION 3 COMMENTS

Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

1. C1, C2 Electrical. (#07)

2. C1 and C2. (#46)

3. C1 and C2. (#05)

4. Usually C0 and C1 on one day. Math and L1 on 2nd day. L2 and Summary on 3rd day. Bookkeeping and quiz on 4th day. (#30)

5. Most. (#55)

6. Electrical C1 and C2. (#60)

7. Combination of C1 and C2 and a demo. (#11)

8. Teach in straight time but don't break up lessons. (#25)

QUESTION 4 COMMENTS

Based on your experiences, do you think the 20-day plan of 50-minute class sessions is realistic for the unit on WORK?

1. Labs take too much time. (#62)

2. You do not have time to get set-up and then teach or for students to set-up their lab. (#58)

3. More work on the math is needed - extra problems, review, practice. (#27)

4. I like students to be involved in set-up. This requires as much as 20 minutes, but a valuable experience. (#06)

5. I'm going to try to combine the two discussion days - do the demonstration and math lab on 1 day and see if I can get a little more time for the labs. (#38)

QUESTION 5 COMMENTS

On average, how much time did you spend preparing to teach each class in the unit on WORK?

1. Labs took longer if you count set-up time. (#56)

2. Depending on available materials. (#06)

3. This time includes the set-up and take-down of labs. (#36)

QUESTION 6 COMMENTS

Do you think most of your students did the assigned readings at home?

1. My students do the readings in class as we meet 3 hours a day. (#17)
2. We read the material in class. (#09)
3. 60% probably, 40% probably not. (#42)
4. I have 10 students and I think at least 6 of them did the assignments. (#46)
5. During study hall. (#62)
6. They don't have enough "accountability" exercises - questions, problems, etc. at each day's block. (#06)
7. Daily checks on reading at start of period have been initiated - short written quizzes. (#27)
8. We did some of the assigned reading in class. (#58)
9. Some did and some didn't, but more chose not to read at home. I tried reading time in class (that's how I got behind). (#32)
10. It's been difficult to get them to read at home, when they take notes in class. (#05)
11. Based on test results, my impression was that it is time for an emotional rejuvenation. (#30)
12. There is too much introduction in the labs for the kids to read. I suggest that it move into C1 and C2. (#37)
13. It's hard to get them to read the assignment, I'm going to start quizzing. (#11)
14. It seems that few if any of us are having much luck getting our students to read. (#38)
15. Students will not do it. (#08)

QUESTION 7 COMMENTS

Overall, did you feel comfortable teaching the materials in the unit on WORK?

1. Some of the material I was not familiar with. (#58)

2. Format is now begining to feel comfortable. (#30)

3. I am a forestry teacher, I did not enjoy physics when I took it in college and still do not. (#08)

QUESTION 8 COMMENTS

What, if anything, caused you the most problems in teaching the unit on WORK?

1. Labs. (#13)
2. Symbol use. (#62)
3. Vague labs. (#42)
4. Once I spent the time reviewing the material I had no problems. Shortage of lab equipment. (#33)
5. Lack of sub-unit tests. (#09)
6. The joule. I had to review. (#17)
7. Limited materials for unit on fluids (messy for labs). (#06)
8. Labs. (#56)
9. Repetition of demonstrations as labs. (#27)
10. Some of the terms in the electrical systems. (#58)
11. Electrical WORK, the efficiency always seemed to be too low. (#32)
12. You used scientific notation and did not take time to explain how you use it (I stopped and explained it). (#05)
13. Supplies and lab set-ups. Running papers. (#55)
14. Work Done by a Winch lab. Text illustration on lab set-up was vague and directions left much room for misinterpretation. (#30)
15. Labs, equipment set-up is elaborate for the short period spent on task. (#63)
16. Joules, coulombs, and where they would be used in a work situation. (#11)
17. School schedule. (#60)
18. Lab 2F1, this experiment proved to be unsatisfactory. Three beakers were broken while attempting this lab. Balloons were also broken. Equipment not safisfactory for the experiment. (#36)
19. The lab in Electrical WORK and on Work Done by a Motor. (#08)
20. There is just not enough time to set-up and complete the labs and put up the equipment in a 50-minute period. (#38)
21. Going back and forth from English to metric. (#25)
22. Metric and math problems. (#10)

QUESTION 9 COMMENTS

Do you feel the Teacher's Guide material provided you with enough information to help you successfully implement the unit?

1. Lab directions could be more concise. (#07)

2. Should give example answers on lab experiments. (#13)

3. Subunit tests. (#09)

4. Appendix on special equipment much too brief. Need suggestions as to supply (local) or substitute labs. (#06)

5. Reiterate comments on FORCE unit. (#30)

6. More specifics on setting up the lab experiments. (#37)

7. When the book is finalized we need an index. (#38)

QUESTION 12 COMMENTS

Do you have any other comments, concerns, or suggestions for the unit on WORK?

1. Experiments should be a little more explanatory. The one on Torque using fishing reel was very inconclusive. (#13)

2. I still do not have all of the Sargent-Welch equipment to do all the labs. They promised and did not fulfill. I also, by virtue of teaching an Electronics I and II class, El ctricity I and II classes, plus a State evaluation, VICA and sundry other requirements do not have time to fill this form out. Sorry about that. (#62)

3. I think this unit was excellent, the information was complete enough, yet easy to understand. There is one point about the labs: I think if we provide the experiment in video and show it to the students it would be a great help to them. (#46)

4. Lab E2 on solenoids. Should be more structured, the slower students need more direction. (#42)

5. Math skills and substituting in formulas and isolating was excellent. More aids in that order would be appreciated. (#33)

6. Subunit tests, additional questions and problems. We still have not received funding for the lab portion of this course. Consequently we have not been doing the labs. (#09)

7. I missed having something in thermal to work with. No suggestions at this time. (#17)

8. I feel you should give some sample problems for teachers to use, so that you can give the students extra problem solving. I have enough knowledge to manage, but some teachers might appreciate this extra help. (#05)

9. Everything has gone fine up to the point where we got involved in Electrical WORK. Then we bogged down. The kids had trouble understandng that area. (#32)

10. Variety for demonstrations and labs is needed. Use 2 different set-ups to better develop the ideas and concepts. (#27)

11. Definitely need a list of optional labs. We were given $16,000 for salary and materials (we team teach), not enough money for blanket order, not enough lead time to specifically order things we don't wish to assemble. To qualify for science credit activities must be hands on, not demonstration. (#06)

12. More prep time needed for instructor teaching this program to set-up labs. (#55)

13. There were a number of locally generated problems with completing the WORK unit: Thanksgiving day rallies, class fund-raisers.... Much of the time, especially during the latter part of the unit,

class attendance was very spotty. In addition, since we have now approached Thanksgiving recess with a deliberately unselected group, several students are beginning to demonstrate motivational problems. (#30)

14. Math Labs should be much longer and more invovled. They really are too much an easy single concept idea. "Math Application" math labs would be helpful. Is it possible to have math labs on video like you did for Unit 1? Include "fun" demonstrations. We need excitement. Trust me, these are kids, they are a captive audience. Remember this is high school and they are not in high school by choice (as college). We need to motivate by exciting them about technology. Please help us create excitement. (#37)

15. The only possible objection I would have is that some of the classes were hard to constructively use a full 50 minutes. I've got five different preparations in my position and it makes it tough to do justice to the prep for this class. I wish my administration had as much commitment to the program as I do. (#60)

16. Labs tend to be too short. More activity should be planned and incorporated in each lab. It is better to have too much activity than not enough. Some of the Math Labs can be completed in about ten minutes. We must supplement these labs with teacher prepared exercises. That takes more time for class preparation. High school students need someting to get them going. More lab activity of the right kind can get them motivated. (#36)

17. Some labs were way too complicated for our teachers and students. We did not appreciate the material used as dividers on Unit 3. Enclosed please find an example. (#08)

COMMENTS FOR CO CLASS

1. We need more testimony from on the job people about why they have to know technical principles. (#17)

2. Very beneficial. Gave us a chance to look at the relationship of all the systems and how they can work together. (#33)

3. Nice class, worked well. Kids interested and follow well. (#30)

4. I had difficulty presenting this material in the manner that I would like. This seems to be a recurring problem. (#11)

5. More discussion following objectives. (#08)

6. We are using as many outside people in the local industry as possible, to come and speak to both classes anywhere from 10 minutes to an hour on how that unit we're on affects them in their work. Our class consists of machine shop and welding students and if at all possible I have people from a completely different line of work. During the FORCE unit we had the head of Dodge City water works talk about the water system (Fluid). On Electrical unit 2, had a young female Med. Tech. from the local hospital talk about some of her equipment. Thermal brought a local Heating and Air Conditioning repairman. The local Farmland Rep. talked to us about "density" in his product (fertilizer). On the WORK unit I could not come up with a speaker. On Unit 2 Rate, I had the local Police Department come to talk to us about ballistics, the local Fire Department will have one of their Engineers speak to us about their Fluid roles, etc. Our own Auto Mechanics instructor will speak to us about electrical rates in the auto mechanics trade. Using local people, that many of the students know, to describe their use of the material we're looking at, seems to help a great deal. At least it should show the students that many people in all types of work use this type of material and find it very important. (#21)

COMMENTS FOR VIDEOS

1. Mechanical: Good teaching concepts. (#07)

2. In general I think if the videos were a little more detailed they would have a better result, students like them. Also, if we give some of the lecture first, then show the videos, or we show them during the C1 and C2 classes, they are going to make more sense to the students. (#46)

3. Overview: good introduction although it moves rather fast. We had to back up several times to get all the formulas, students wanted to write them down.

   Mechanical: good to see some technical applications using computers. Seem to take its time and explain things a little better. (#33)

4. The videos give good variety to everyday learning. All good! I like testimony by people as to why they need to know principles. I like the humor. I do not believe the videos should address specific principles only. They should be broad and address generalizations of technology. Let the students search for the specifics. (#17)

5. Overview: The students seemed to feel the videos are getting more professional. (#05)

6. Electrical: Scientific notation should be added at this point.

   Summary: Bridge raising is not "work" it is torque. (#27)

7. All videos were well done. I do feel that a little more explanation and examples in each would enhance their effectiveness. (#63)

8. I have no complaints with any of the videos. Overall, they are of good quality and address the subject well. However, for high school students, the video might be more detailed, this applies to all videos. (#36)

9. Overview: Work for the girl going up the stairs and the high jumper would only be equal if they had the same mass. Also it would only be equal if they traveled the same distance. The video shows they are equal even though it may state the opposite. (#60)

10. My comment is the same throughout. The kids are finding them to be too much the same. The kids would like the videos to be a little bit deeper, interesting, etc. (#37)

11. Mechanical: Management problem; videocassette only had Overview on it, so students did not see video until review time.

    Electrical: Students cannot identify with a trolley bus. Pronunciation of coulomb? Distraction of front view of van with electric car then back view of pick-up truck. Why 6 volt batteries instead of 12 volt batteries in electric car?

Summary: Review more of what will be on test. (#08)

12. The videos are fine - the comments by the students are all positive, time and content are very good. We need a briefing video for registration next year. (#38)

13. Probably a car lift being used might show distance moved, etc. (#25)

14. Videos are all well done and seem to keep the student's interest. (#21)

COMMENTS FOR C1 CLASS

1. All were good. (#13)

2. All were good. (#17)

3. They were excellent. (#46)

4. Electrical: Tried reading time in class, didn't finish in 50 minutes. (#32)

5. We had time so we did not push to get through. The students enjoyed the labs, so we used the extra time to let them work on experiments. We have 2 1/2 hour class periods. We tie the technical class in with our machine shop class. It seems to be working well so far. (#58)

6. Mechanical: Example 2C should read similar to question #18 on page 23, with the engine block weighing 540 pounds and being lifted one foot.

7. Fluid: C1 and C2 took less than 80 minutes. Needs more meat, and the demo seems to be of little value.

   Electrical: Add motor demo to explain very basics of motors. Also can preview lab and do demo today instead of C2. (#56)

8. Electrical: For electrical, the students wanted to know the relationship between newton-meters and joules, and the relationship to energy. I had to explain it in terms of joules/coulomb= 1 volt (they seemed to understand that better). I only took one period for lecture on this and used the other days for extra math. (#05)

9. All covered the material adequately. (#63)

10. Mechanical: Well done, especially the section on radians. Radians gave them the most trouble.

    Fluid: We need simpler explanations of Delta P and Delta V. We just tell them atm. pressure is involved, or it is the volume displaced by the cylinder and they can't picture it in their minds. It's an abstract idea if you've never seen a hydraulic cylinder, or even if you have. I suggest demonstration of showing a Delta P and Delta V. May you can help us come up with some that would be fun for the kids to watch. I'm going to be honest with you - I'm at a loss when I try to come up with these things because I teach science and not voc. ed. I need to use some really neat demos that the kids would already have familiarity with that I could make fun for them. I need help with relevant examples of hydraulics etc. Please listen to me - that is what is lacking; the "fun" aspect of this course. I'm not saying I'm not creative but this is my 1st year teaching these applicable, vocational examples and I'm not well versed in this stuff yet. So maybe you can help us teachers be creative. (#37)

11. I believe that the discussions, demos, and math lab can be done in

- 2 - 2 1/2 days releasing some more time for labs. We need it. I'll know when I get into RATE. (#38)

12. Electrical: Students did not understand scientific notation. (#08)

13. We make and use a lot of overheads for all classes and labs. (#21)

COMMENTS FOR C2 CLASS

1. Excellent. (#46)

2. Fluid: page 57 the given answer is incorrect, it should be 0.00012 meters cubed. (#33)

3. All were good. (#17)

4. Electrical: Tried reading time in class again. (#32)

5. Electrical: Demo, solenoids and relays and some basic coils to show how magnetic field is produced and how a solenoid works. (#56)

6. Mechanical: Demonstration information page A-6 last line of #4 pi=1.57, should be Theta=1.57. (#18)

7. Fluid: We replaced RV pump with an aquarium pump and the end of a drill pump. (#06)

8. Mechanical: Math lab should preceed this lesson.

   Fluid: Lab and math take too long. Should be 2 lesson periods. Several additional math problems should be added for practice. (#27)

9. Mechanical: I think distinguishing between torque and work with lb•ft and ft•lb is confusing.

   Fluid: Page 57, step 3, example 2G, there is a decimal error in Delta V. (#38)

10. Mechanical: Students did not understand radians. Ft•lb and lb•ft are the same and should be used only one way. This is confusing to students.

    Fluid: Demo has an error in calculating Delta P.

    Electrical: Demo caused some frustration for me. I do not have an electrical background and I blew several fuses in meters before getting them set correctly. I did not know how many amps the motor would pull. (#08)

11. More student work exercises. (#10)

COMMENTS FOR MATH LAB CLASSES

1. Math labs are not demanding for our students. (#07)

2. Good exercise for the mind. Should help students feel more comfortable with math and build math strength. (#17)

3. Fluid: good exercises. (#33)

4. In general if we categorize the students in terms of their grade, it wouldn't be correct. Because I have some students (3 out of 10) who don't understand the basic mathematics like addition and subtraction, so the math lab is not really a big help to them. I also have some students (7 out of 10) who know more math than they need for this course and the math lab is completely a waste of time for them. Anyway I think if we have the math labs before the C1 and C2 classes, it would be more help to the students. (#46)

5. Mechanical: Should come before C2.

   Fluid: This should be included in Unit 1.

   Electrical: We use only digital VOM's - not appropriate for our purposes. (#27)

6. Electrical: Too easy. (#32)

7. Fluid: There is an error on page T-66 in step 3; it should read 62.8 ftlb/6.28 Rad. (#18)

8. Mechanical: We finished most of our math labs in less than 50 minutes. Also I feel you should have taken time to explain scientific notation and how to work with it. I did explain but other teachers might have had a hard time.

   Fluid: In this lab, you should give practice problems using weight density and height. Stress the units for pressure and how these cancel to get foot-pounds. You need to stress the units.

   Electrical: I used 2 days for this math and added problems for extra (needed) work. The math lab here should have been more problem solving; rather than reading the scales only. (#05)

9. All were very good. I feel inclusion of more problems would make this an even more valuable learning tool. (#63)

10. The three math labs in this unit were exceedingly well received. There should be more carry-over from class to math lab to test, however. (#30)

11. Mechanical: Radians are always hard to explain. The students without good math backgrounds had trouble with this.

    Electrical: It's hard to show where an application of parts of this lab apply. For instance, joules and coulombs, where do you use these calculations in industry or where would a technician use these

units? (#11)

12. There is not enough to them. First of all, they require too much preliminary reading by the kids which they do not do. Second, the math itself is too "single concept." We need math application problems and make them at least 40 minutes. (#37)

13. The concepts are okay, but the labs need to be longer. (#36)

14. Mechanical: Students still do not understand radians.

    Electrical: Why wasn't this lab done before we ever saw a meter? (#08)

15. Math labs seem to be hard for our students but I think these types of math labs will and are helping the students, not only in our class but in some of the other classes in high school. (#21)

16. Need more student work. (#10)

COMMENTS FOR LAB 1 CLASSES

1. Mechanical: Spring scales are not accurate force measuring devices. Another weight hanger would work better. (#07)

2. Mechanical: Experiments were not very well defined and the teacher's manual should have an example worked out. Students reversed the scale and all readings came out over 100% - with all experiments coming out the same. I had trouble convincing them of the difference.

   Fluid: Had trouble with water in the classroom. Another system could be used. Students seem to believe water in a classroom is for play. Math in experiments was worth doing.

   Electrical: Was too basic in information - had trouble with motor not stopping for measurements. Motor's inertia kept going after switch opened. (#13)

3. Mechanical: muddled directions. No clear picture of actual set-up.

   Fluid: balloon doesn't work that well. (#43)

4. For classes L1 and L2 I think if we can demonstrate the lab in videos before they start doing it, they will take more advantage of it. (#46)

5. Electrical: the pulley for the motor did not have a deep enough V therefore the cord sent would only wrap a few times then the pulley was loaded and the rope would slip to the shaft. (#33)

6. Mechanical: Good.

   Fluid: Piston experiment is difficult but possible. Problems are: 1) blowing balloon up to correct size; 2) finding a disc to fill a beaker size close enough.

   Electrical: excellent. (#17)

7. Fluid: In this lab, we had a heck of a time managing the balloon. It was not fully explained whether the balloon was supposed to be tied or not.

   Electrical: We had to improvise on the motor part (we did not have a motor to use). So I made up another lab to see the effects of electrical work. (#03)

8. Mechanical: Front system was 2 different block and tackle set-ups.

   Fluid: Why use 0.7854 for area when calculators have pi? On page 72; nice idea but not enough movement to show concept. (#06)

9. Mechanical: Not enough to do. Need more pulley set-ups or different weights.

Fluid: Need more trials. Apparatus works okay, but something a little less physics like would be nice.

Electrical: Worked well. Efficiency comes out very low. Students enjoyed lab.

10. Fluid: I do not believe this experiment will work with the weights given and the balloons supplied. We had to add a lot more weight to get any results. Many students have to be reminded to convert cm and mm to meters to work the results of the experiment. (#13)

11. Electrical: Set-up trouble, due to unusual power supply requirement. 12v DC and 10 Amps? (#32)

12. Fluid: Several different sizes of beaker-balloon combinations should be used.

Electrical: Repetitions of demos. Why go into efficiency? (#27)

13. All labs are very good. The problem in the regular high school is that time between classes is a problem in setting up labs. (#53)

14. Mechanical: Standard pulley lab. Please note amount of string to use for teachers' use in setting-up lab in future editions.

Fluid: Piston lab worked fairly well after balloon was properly inflated. Some teams used up to 3 balloons.

Electrical: Excellent lab! Some improvement should be made in the teacher instructions: 1) specify the weight to be raised; 2) tape slotted weight to weight hangers to prevent "flyaway masses;" 3) specify a method of attaching line to motor shaft and keeping assembly straight. (#30)

15. Mechanical: This lab needs more activity. What we had was good - we just need more of it. The equipment we had left a little to be desired and consequently, the job did not go as smoothly as we anticipated.

Fluid: The equipment was troublesome. Three beakers were broken due to poor design of the equipment. This was another experiment that resulted in disappointment. Perhaps something other than the piston and balloon should be devised.

Electrical: We did not have the proper ammeter for this lab. Fortunately we have an ammmeter in the power supply. It took a number of trial runs before satisfactory results were maintained. (#36)

16. Fluid: It would be better to use a different lab than the one used in the teacher demonstration. We went through and studied the figures during the C2 section and as a result the class wasn't as motivated as in the other labs. (#60)

17. Mechanical: I found the management of this lab a problem. We could not achieve the desired results. The kids were confused.

Reading the spring balance appears unreliable to me because it's very hard to pull with constant force. Pulling on the spring balance seems to be the source of error. The pulleys should have worked better. These kids find pulleys, cord and spring balance okay, but I know they'd have liked a second part to this lab that was fun and exciting. The lab doesn't capture their enthusiasm to start with and then the attitude is just let's hurry up and get this thing done, and they didn't take the proper measurements, because the calculations are not interesting to them. You see all they think they are doing is taking measurements so they can calculate. Well, calculating isn't fun, so the lab needs more.

Fluid: I liked the lab and the kids did. Here are a couple of things we need to do to fine tune this. First, we must make sure we use a container that is an accurate volumetric measure. You say fill with 3 gallons, well did you ever wonder how we were going to measure the 3 gallons? You should have. Second, the fluid conversion of gallons to feet cubed should definitely be typed into the student experiment. Third, this may not be important, however why are we using a motor with bare tips on the ends? It would appear to me that even though we are not using a lot of voltage that this should be a no no especially since this lab brings with it spilled water often. Safety is part of what we should be teaching in P/T.

Electrical: This lab was exactly like the demo. I also would like to suggest that you include for the teachers a discussion that you might have to adjust the voltage being used in order to get the desired results. Please give the teachers hints and tips on how to achieve the results we want. We need them badly. The motor we have is a high speed motor. That's what we were sent. (#37)

18. Electrical: We had problems setting up the meters into the circuit as shown. We ended up using the readings taken from the power supply meters. (#11)

19. Mechanical: Appropriate for students - students did not understand pulley systems. Students not understanding pulleys could not assemble pulley systems. Assemble pulley systems and rotate students through systems.

Fluid: Experiment showed such a small amount of movement it was very difficult to measure. Students cannot read rule. Use an air pump with outlet closed off and measure weight applied to it and movement.

Electrical: Lab set-up was too complicated for students and teachers without electrical background. (#03)

20. Mechanical: Teachers unfamiliar with single pulley systems and light weights need to be warned that they are working so close to 100% efficiency that unless students are extremely accurate they will come up with 100% + efficiency.

Fluid: Using the glass beaker as a cylinder is a mistake. We need

a clear plastic cylinder. We may need to rethink the entire lab. (#38)

21. We are still having a hard time finding and getting any equipment for our lab. However, the equipment has been ordered for 2 labs which we are really excited about and will be making good use of 2nd semester. We have gone fairly well using what we have plus making a large mount of overheads, charts and worksheets. (#21)

22. We have not received any lab equipment as of now. (#10)

COMMENTS FOR LAB 2 CLASS

1. Mechanical: Equipment concept is very poor. The equipment was provided through Sargent-Welch. (#07)

2. Mechanical: Kit bought from Sargent-Welch was very difficult to operate. Fishing reel will not release for getting a true reading.

   Eletrical: Solenoid a fair experiment but plunger moved too fast for accurate reading. Voltage and current were hard to read on meter. Most just guessed. (#13)

3. Mechanical: Problems with winch slipping and math values don't come out right. Difficult for students to understand. Setting up lab is a total challenge. (#17)

4. Fluid: Ran into a problem. We had to find HP of motor that was sent - tabled information and completed later. (#30)

5. Mechanical: Muddled directions. Set-up not clearly understood.

   Fluid: When teach care and use of power supply?

   Electrical: Don't make this "discovery type" lab. Slower students need more direction. (#42)

6. Mechanical: Wheel and axle (modified lever) can be used to replace reel (cuts down cost and time for modification).

   Fluid: This is a repetition of the demonstration - change one or the other. Water spillage is a problem.

   Electrical: The linear movement of the plunger automatically gives the scale reading. 5/8" motion can give only 1 reading on the linear scale of the spring scale. Changes in the reading are too fast to detect. Variable power supply negates the need for a rheostate (bare wire danger reduced). What is stopwatch for? Conclusion 1 - poor. Students not expected to know integral calculus. (#27)

7. Elecrical: Solenoid hard to find, washing machine solenoid didn't work at 12V. (#32)

8. Electrical: Except for the questions this is a rather fruitless experiment. (#18)

9. Mechanical: Worked fine. Tough building apparatus. Observed by 12 people from PA State Department of Education, they thought lab was too long with the theory.

   Fluid: Did as a demo. Too much mess for a group lab. Efficiency of pump and motor very low.

10. Mechanical: Replaced with wheel and axle.

    Fluid: Not enough time to introduce H.P. and do lab properly.

Electrical: Spring balance measures how far solenoid pulls, not how hard.

11. Mechanical: In 2M2, the explanations for the set-ups, that was provided for the teacher's preparation of the lab, was not detailed enough. In other words, you need to give teachers better explanations on how to set-up the labs, especially since many of us are improvising where equipment is concerned. (#05)

12. Mechanical: Kids found it difficult to decipher set-up diagram. Next time, I will set up one lab station as a reference. By the time students completed set up, string kept pulling out of disk on fishing reel. Not an effective investigation, although the idea itself was good and it made a good demo.

Fluid: Leave pump on table next to power supply. Use two long hose connections to move water. The efficiency lost by the increased pull over the longer distance is outweighed by the safety gained by keeping the electrical connection at the pump away from the water. One of the wettest and noisiest of labs I have ever encountered, but very cost-effective.

Electrical: Include lab objectives on Data Sheet after the 3 conclusions. Request supplies to inclue "lead shot" for the inside of solenoid shaft. (#30)

13. Mechanical: This one was valueless to me. The winch apparatus sent by Sargent-Welch made by lab spec doesn't work. You try it. Also, we the teachers shouldn't have to figure out and monkey with the equipment to get the labs to work. Please send specific instructions on operation of all these pieces of equipment.

Fluid: In the duration of the piston cylinder balloon lab, Carolina Sylvestri almost totally released all of her Italian emotion - I couldn't believe it and I still don't. Would you please do me a favor and secure for yourselves (all of you) a piston set-up from Sargent-Welch. I will not dignify this set-up by commenting on it. If I do my blood will begin to boil again and I'm gonna get angry all over again.

Electrical: A great lab. Did you think you'd never hear that from me? The fact that it was a discovery lab was worderful. Please make like this with added suggestions of additional things to do to enhance the discovery aspect. (#37)

14. Mechanical: Poor design of equipment almost caused this lab to fail. The pulley was too long and the filament line proved to be awkward to work with. The pulley also had to be counter-bored before it could be used. Equipment continues to be a frustration.

Fluid: This experiment went rather well but the lab needed more activity. There was not enough for 50 minutes. Some adoption filled up the lab. Students get bored very fast then mischief

starts. We need activity.

Electrical: This lab went along pretty well. Results were as expected but again adaptations and supplementary activity was added to fill in the time. The students liked this lab, but it's a shame there wasn't more. (#36)

15. The idea of using a fishing reel for a winch is very good. However the pulley that was built for the reel was unsatisfactory. I had to turn one out of hardwood, drill and counterbore it so that the reel handle attaching screw would work. Then no problem.

Fluid: Good lab. I put brass fittings on some of the bucket bottoms so that they can be easily hooked into the pump systems. (#38)

COMMENTS FOR SUMMARY CLASS

1. Summary was fair. Had to do a lot of ad libbing to fill in on tape. Overall was very useful. (#13)

2. The terms were very beneficial. (#33)

3. Went well. Test results disappointing but opportunity presented to reinforce course objectives and importance. (#30)

4. I feel a culminating exercise should be given. This exercise should include a written and practical exercise. Through this I feel the student will see the big picture or as educators say "experience the aha syndrome." (#53)

5. We have just received our money. Equipment is presently being ordered. (#10)

PRINCIPLES OF TECHNOLOGY Staff and Consortium Members

Jim Shea

Units 2: WORK and Unit 3: RATE Pilot Test Findings May 7, 1985

Enclosed are copies of Unit 2: WORK and Unit 3: RATE Pilot Test Findings. The Unit 4 report should be ready by the first part of June. Preliminary data for Uhits 5 and 6 will be discussed at the meeting in Dallas.

If you have any questions, feel free to contact Bill Johnston at AIT.

cc

PRINCIPLES OF TECHNOLOGY

UNIT 3: RATE

PILOT TEST FINDINGS

AGENCY FOR INSTRUCTIONAL TECHNOLOGY

CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

APRIL 29, 1985

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Introduction

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 34 state 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. Each unit consists of a student manual, a teacher's guide, hands-on laboratories, and video programs. The prospectus for the project was issued in June of 1983; the initial development work began in November of 1983.

An important part of the developmental process is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working, and 2) to identify specific problems with the materials. Each consortium agency has designated two sites in its state or province as pilot test sites. All pilot test teachers were oriented to the *Principles of Technology* course and to the pilot test procedures at one of two meetings held in Dallas the summer of 1984.

This report details the findings of the pilot test on Unit 3: RATE. The report makes some comparisons of these findings with those for Units 1 and 2, which are contained in separate reports (see "Unit 1: FORCE - Pilot Test Findings," December 18, 1984 and "Unit 2: WORK - Pilot Test Findings," March 1, 1985).

Pilot Test Procedures

Unit 3 pilot test materials were mailed to the teachers in mid-October, 1984. These materials consisted of:

1) Pre/posttests (see Appendix B).
2) Computerized scoring sheets for the pre/posttests.
3) Student attitude questionnaires (see Appendix D).
4) Teacher questionnaires (see Appendix E).

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the same test as a posttest and the student attitude questionnaires. All Unit 3 evaluation materials were then mailed back to AIT. Data contained in this report include all material received by February, 1985.

Limitations of the Methodology

Two major limiting factors must be considered when the findings are interpreted: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered, including:

* Lack of matched control groups.

The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in terms of time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

* The pretest/posttest format.

The same test was used for both the pre and posttest. The effect that memory of the pretest might have on posttest performance was another concern. The research design addressed this concern in three ways:

1) Students were not given the correct answers to the pretest. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

3) A correlated t-test was used to analyze the pre/posttest data. This technique helps to partial out any variance that might result from an intruding correlation -- in this case memory.

* The pre/posttest as an instrument (See section on development of the instrument, page 7).

The test cannot measure all objectives. Therefore objectives had to be samples. Also, the items do not always directly match the intended objectives. The test was a cognitive test. Many of the objectives, (particularly the lab objectives) are psychomotor objectives. One must consider each of these factors when assessing the valdity of the instrument. It's important to remember, however, that the test

is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results, including:

* Equipment problems.

  Several teachers reported problems in securing necessary lab equipment.

* Student characteristics.

  At this time the project does not have adequate data to describe the students in the pilot test, although there seems to be considerable variability in the kinds of students in the course. Attempts have been made to collect these data, which should be available for subsequent units.

* Teaching pattern.

  There appears to be considerable variability in the length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess the impact of the various conditions on the outcomes.

So, both research design and external constraints must be considered when the results are interpreted. It's important to remember that the overall pilot test was designed primarily as a formative evaluation to improve the materials, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

Sample

The sample included 397 students in 22 sites. Student characteristics included:

* Grade†

  10 = 17%   11 = 65%   12 = 22%

* Sex

  Male = 87%   Female = 13%

Teacher characteristics included:

* Physics background.

  There was a wide range in the teachers' physics background: 18% reported no college physics courses; 4% reported 1 college physics course; 48% reported 2-4 college physics courses; 15% reported 5-7, and 15% reported 8 or more college physics courses.

* Mathematics background.

  Almost all teachers (96%) have had 2 or more college mathematics courses; several (30%) have had 5 or more college mathematics courses.

* Teaching pattern.

  About half (48%) taught *Principles of Technology* on consecutive days.
  Most (84%) taught sessions that were 60 minutes or shorter.
  Almost half (48%) indicated that they had combined several classes into one session.

* Preparation time.

  Over half (76%) indicated they spent 60 minutes or less preparing to teach each unit on RATE.

Thus, even with fewer sites than were included in the Units 1 and 2 reports, the student and teacher demographics were similar for Unit 3, except that fewer teachers taught Unit 3 (48%) on consecutive days than taught Unit 1 (68%) or Unit 2 (63%) on consecutive days. This change may be the result of school schedules around the holidays or it may indicate that some teachers are integrating *Principles of Tech-*

† Due to missing data, the pre/posttest student demographics don't match the student attitude demographics.

nology with other material. Judgment must be reserved until data from subsequent units arrive.

Pre/Posttest as an Instrument

To understand the results, one must first understand the characteristics of the test as a measurement instrument, including the process by which the test was developed and what statistical analyses reveal about the reliability and validity of the instrument.

Over 50 test questions were inititated at CORD by the content specialists. In a collaborative process between evaluators and content specialists these questions were pruned and revised to the eventual 30 items. Each item is tied as directly as possible to a specific objective from Unit 3. As some reviewers have pointed out, the item/objective match is not always exact. This is a valid criticism, but it's impossible to directly match items to objectives because of the way the objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and that approximations of objectives are often the best that cognitive test developers can do. With only 30 items (the number that can comfortably be tested in the available time), not all objectives could be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were determined based on the relative importance of the concepts. (Appendix B lists the objective each item is intended to address above the item.)

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?). The reliability (Spearman-Brown test of internal consistency) of this instrument is .82, which is acceptable by most standards. Validity is a bit more complicated to judge. A factor analysis of the instrument indicated that almost all items were related to discrete factors. This is ex-

pected, because each item is tied to a sepa·ate objective. Readers are encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?
2) Is a sufficient range of objectives addressed?
3) Overall, is the instrument a fair measure of Unit 3 instruction?

Pre/Posttest Results

A variety of analyses of the pre/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 30 items. The findings included:

Mean differences - The overall pretest mean was 14.9. The overall posttest mean was 19.4. This increase was statistically significant (correlated t-test) at the .01 level.

This statistically significant learning gain is consistent with gains after Units 1 and 2. Table 1 examines pretest/posttest scores for the 3 units.

Table 1

Unit	Number Items	Pretest Mean	Mean Posttest
1	30	12.5	20.07
2	33	13.6	17.6
3	30	14.9	19.4

The project team has established criteria for acceptable performance on an item. These criteria included either:

1) 70%+ correct on an item or

2) doubling of pretest score on the posttest.

In examining the Unit 3 items against these criteria we find:

70% or doubling of percentage correct - 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 16, 22, 23

Less than 70% and no doubling of percentage correct - 8, 14, 15, 17, 18, 19, 20, 21, 24, 25, 26, 27, 28, 29, 30

It will be helpful to examine the content of the items on which students' performance did not meet acceptability criteria. First, let's examine the items according to subunits.

Mechanical - One of six items did not meet the criteria.

Fluid - One of three items did not meet the criteria.
Electrical - Three of five items did not meet the criteria.
Thermal - All six items failed to meet the criteria.

Thus, students performed least well on the electrical and thermal subunit items.

Students performed poorly on the same kinds of items as those that gave them difficulty after Units 1 and 2. These items included:

1) Selected terms. The various terms in the electrical and thermal subunits were particularly confusing to students.

2) SI/English units.

3) Mathematical items.

Pre/Posttest by Selected Variables

The impact of several variables on students' performance was examined, including:

1) Student characteristics.
   a) sex
   b) grade

2) Teaching pattern.
   a) consecutive days
   b) length of class periods
   c) combined activities

3) Teacher background.
   a) physics background
   b) mathematics background

These variables were analyzed with an analysis of covariance, which controlled for pretest scores. Table 2 examines the results of this analysis; all means reported in Table 2 are for the posttest.

Table two indicates that sex and grade had a statistically significant impact on the posttest scores. Because this is the first unit to show significant differences on these variables, an additional analysis was conducted. When one class was removed, the sex and grade variables were no longer significant, as they were not in the findings for Units 1 and 2. The class that was removed from the analysis has more tenth graders and more females than any other class in the pilot test. This difference accounts for the variance.

Both teaching pattern and teacher characteristics had a statistically significant impact on the student scores. This too is consistent with the findings for the first two units.

Table 2

Main Effect	Level of Significance	Subset	Mean Score
Sex	.01	Boys (305)	20.00
		Girls (56)	17.32
Grade	.02	10th (53)	17.79
		11th (226)	19.90
		12th (74)	20.64
Teaching on Consecutive Days	.05	yes (290)	19.24
		no (107)	20.19
Minutes per Class	.01	LT 50 (239)	18.63
		50-60 (64)	20.25
		60-90 (29)	18.24
		90+ (65)	2.48
Combining Sessions	.01	yes (110)	21.46
		no (287)	18.74
Teacher's Physics Background	.01	No classes (52)	21.50
		1 class (89)	19.47
		2-4 classes (136)	19.78
		5-7 classes (53)	16.11
		7+ classes (67)	20.06
Teacher's Mathematics Background	.30	No classes (0)	----
		1 class (0)	----
		2-4 classes (256)	19.98
		5-7 classes (65)	19.88
		7+ classes (76)	20.24

Pre/Posttest Results by Site

The attached graph (Appendix C) indicates the pre/posttest results by site. Seventeen sites showed statistically significant (.01 level) increases; five sites showed no statistically significant gains. Of the first three units, Unit 3 had the most sites (5) with no statistically significant gains.

Student Attitude Findings

The student attitude findings (Appendix D) indicated:

- The majority of students (62%) liked the RATE unit either a lot (9%) or a little (53%). However, Unit 3 was the least appealing of the first three units (80% indicated they liked Unit 1; 76% indicated they liked Unit 2).

- The most appealing components were the hands-on labs (40%) and the video programs (23%). This fact is consistent with the findings for Units 1 and 2.

- The least appealing components were the mathematics labs (26%) and the written material (25%). Again, these percentages were very consistent with those for Units 1 and 2.

- Over half said some (44%) or most (18%) of the material was difficult for them to understand. The percentage of students who indicated that most of the material was difficult for them to understand (18%) was more than double what it was for Units 1 (8%) and 2 (8%).

- Students indicated that the mathematics labs (31%) and the written material (22%) were the most difficult components for them to understand.

- Students indicated that the video programs (45%) and the hands-on labs (19%) were the least difficult for them to understand.

- Most students (77%) said they thought the material in the RATE unit was important for them to understand; this was fewer than those who said Unit 1 material was important (88%) and Unit 2 material was important (87%).

Thus, although the differences weren't pronounced, student attitudes tended to be less positive toward Unit 3 than toward Units 1 and 2. Students tended to like it less, find it more difficult, and see the material as less important than Units 1 and 2.

Teacher Results

Questionnaires were received from 25 teachers. Appendix E lists the detailed teacher comments and should be carefully examined. The teacher findings included:

* Teacher comfort.

  Almost all teachers (92%) indicated they felt comfortable teaching the material in the RATE unit.

* Time.

  Most (75%) indicated that the 6-day plan of 50-minute class per subunit is a realistic time allotment. Some teachers indicated some of the hands-on labs required more than 50 minutes.

* Student reading.

  Many (67%) indicated most of their students may not be doing the assigned readings at home. This is a disturbing finding.

* Unit 3 compared to Units 1 and 2.

  The majority of teachers (68%) indicated that Unit 3 was about the same as Units 1 and 2; several (24%) thought it was better than the first two units.

* Problems.

  To the question, "What, if anything, caused you the most problems in teaching the unit on RATE?" twenty-three teachers responded. The problems reported included:

  - Hands-on labs (13 teachers)
  - Mathematics labs (3 teachers)
  - SI/English units (1 teacher)

Overall, these findings were consistent with those for Units 1 and 2.

Conclusions

It is important to remember that the entire pilot test is designed as a formative evaluation; the results are being used to make revisions in the materials. Certainly the data contain much information that the developers can use to make revisions. Some of the key findings included:

1) Overall, a statistically significant learning gain took place. However, five classes showed no statistically significant gains, which was the largest number (so far in the pilot test) showing no significant gains.

2) Students performed most poorly on test items dealing with the Electrical and Thermal subunits, mathematics, and SI/English units.

3) Student attitudes were generally positive, although not as positive as they were about the first two units.

4) Teachers were fairly positive about the unit.

5) Teachers' comments indicated that the most problems were encountered with the hands-on labs, which have been an ongoing concern.

6) Many specific recommendations for changes were contained in the teachers' comments.

Over the first three units, some consistent patterns have begun to emerge in the data. This report has attempted to identify the trends and to point out variations in the Unit 3 findings from the patterns that appeared earlier.

Appendix A

List of Cooperating Agencies

Cooperating Agencies

Alaska Department of Education

ACCESS NETWORK

Arizona Department of Education

Arkansas State Department of Education
Vocational and Technical Education Division

California Department of Education
Division of Vocational Education

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
Occupational and Postsecondary 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 Spe. .al Intermediate School District 916

Mississippi State Department of Education
Vocational-Techn..cal Division

Nebraska Department of Education
Division of Vocational Education

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

TVOntario

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

Utah State Office of Education

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

Virginia Department of Education
Vocational and Adult 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

Pre/Posttest Frequencies and Objectives

PRINCIPLES OF TECHNOLOGY
UNIT III: RATE
STUDENT TEST

Pre	Post		
			O-1
		1.	In the unifying definition for rate, rate is the relationship between
12	7		a. forcelike quantity and distance
50	18		b. work and elapsed time
35	75		*c. displacementlike quantity and elapsed time
4	--		d. voltage and charge

O-1

In the left column are rates that may or may not exist in one of the energy systems described in the right column. On your answer sheet fill in the letter of the energy system that corresponds to the numbered rate.

Pre	Post				
60	85	B 2.	Mass flow (m/t)	A.	Rate in mechanical energy systems
79	93	C 3.	Current (q/t)	B.	Rate in fluid energy systems
57	85	A 4.	Acceleration (v/t)	C.	Rate in electrical energy systems
77	93	D 5.	Heat flow per elapsed time ('/t)	D.	Rate in thermal energy systems
				E.	Is not a rate in an energy system
74	92	E 6.	Postal rate (cents/ounce)		
50	75	A 7.	Angular speed (θ/t)		

Pre	Post		
			O-2
		8.	When using the International System of units (SI), mechanical rate is measured in
22	19		a. newton meters (N•m)
26	16		b. newtons per second (N/s)
14	9		c. feet per second (ft/s)
38	57		*d. meters per second (m/s)
			M-2
		9.	Linear speed is
67	87		*a. distance an object travels along a line in a unit of time
6	2		b. always expressed in SI units
18	8		c. must include magnitude and direction
10	4		d. measured in radians per second
			M-2
		10.	Which of the following is a linear rate?
6	2		a. helicopter blades in flight
8	3		b. hands moving on a clock
55	80		*c. a jet airplane accelerating down a runway
31	16		d. all of the above

(see back of page for questions 11-18)

Pre	Post	
		M-5
		11. Which of the following involves an <u>angular rate</u>?
10	4	a. helicopter blades in flight
14	7	b. ferris wheel
20	8	c. hands moving on a clock
55	82	*d. all of the above
		M-4
		12. An increase in linear speed during an elapsed time is described as
8	3	a. an average speed
79	93	*b. an acceleration
7	2	c. a deceleration
6	2	d. a new linear speed
		M-5
		13. Angular speed is
9	3	a. always expressed in SI units
59	74	*b. measured in radians per unit of time
16	10	c. distance an object travels along a line in a unit of time
17	13	d. a vector quantity
		M-7
		14. When changed to radians per second, 4RPM's is equal to (Note: Remember that 1 minute = 60 seconds and 2π radians = 360°)
15	10	a. 0.210 rad/sec
27	49	*b. 0.418 rad/sec
35	26	c. 0.636 rad/sec
22	15	d. 1.272 rad/sec
		O-2
		15. A unit of rate associated with a fluid system is
39	40	a. gallons per minute
10	3	b. kilograms per second
19	5	c. cubic feet per minute
31	52	*d. all of the above
		F-1
		16. Volume flow rate is
70	89	*a. volume moved per unit of time
14	5	b. determined by the length of the pipe
9	3	c. always expressed in SI units
7	4	d. a linear rate
		F-2
		17. A car air conditioner pumps 5 kg of freon gas through the system in 3 minutes. The mass flow rate of the freon gas is
13	13	a. .60 kg/min
29	52	*b. 1.67 kg/min
45	28	c. 15 kg/min
12	7	d. not enough information given to calculate
		O-2
		18. One coulomb per second is a unit of
29	26	a. electrical charge
18	10	b. electrical voltage
44	62	*c. electrical current
[illegible]	2	d. electrical resistance

An AC current changes direction at the rate of 120 times per second. Use this information to answer questions 19 and 20.

E-3

19. The frequency of the current is

Pre	Post	
19	15	a. 1/120 cycles per second
12	8	b. 1/60 cycles per second
44	38	c. 120 cycles per second
25	39	*d. 60 cycles per second

E-4

20. The period of the current is

Pre	Post	
44	40	a. 1/120 seconds
21	33	*b. 1/60 seconds
18	13	c. 120 seconds
17	14	d. 60 seconds

E-5

21. When an ammeter is placed in a circuit to measure current through a resistor, it is placed in __________ with the resistor

Pre	Post	
49	67	*a. series
33	28	b. parallel
9	2	c. at right angles
9	3	d. none of the above

E-4

22. The term 60 Hz is an electrical

Pre	Post	
10	6	a. period
67	80	*b. frequency
8	6	c. event
15	8	d. amplitude

E-1

23. Rate in an electrical system is

Pre	Post	
52	69	*a. how fast charge flows through a conductor in a unit of time
16	16	b. electrical current in coulombs
10	3	c. only measured in DC current
22	14	d. all of the above

T-1

24. Heat flow rate is

Pre	Post	
12	7	a. calories per second
21	13	b. BTUs per minute
36	15	c. heat energy per unit of time
31	66	*d. all of the above

T-2

25. In the English system, heat flow rate is stated in

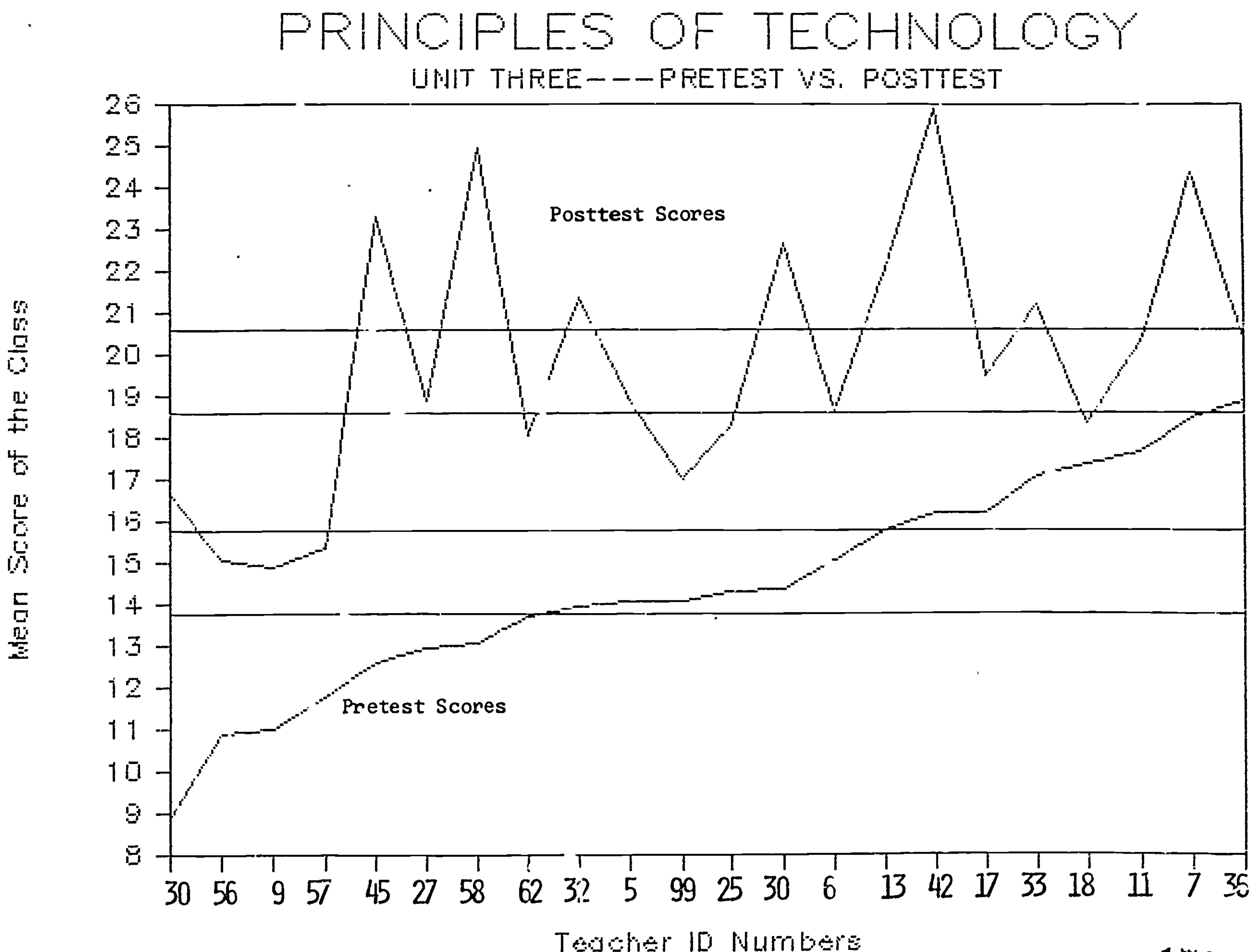
Pre	Post	
26	16	a. calories/second
15	5	b. joules/second
44	66	*c. BTUs/hour
15	14	d. all of the above

(see back of page for questions 26-30)

Pre	Post	
		T-4
		26. The amount of heat energy required to raise the temperature of a given body one degree is
22	14	a. latent heat
26	26	*b. heat capacity
39	43	c. specific heat
12	17	d. sensible heat
		T-4
		27. How many units of heat energy are required to raise a urit mass a unit temperature difference defines
29	19	a. latent heat
31	28	b. heat capacity
27	40	*c. specific heat
12	13	d. sensible heat
		T-6
		28. The heat capacity of 10 pounds of water is
26	30	a. 10 cal/C°
17	8	b. 1 BTU/F°
27	21	c. 10 BTU/hr
30	41	*d. 10 BTU/F°
		T-7
		29. The calories per second of heat energy flowing through a window pane does not depend on
12	6	a. thickness of glass
42	66	*b. weight of the glass
24	8	c. surface area of the glass
22	21	d. type of glass
		T-5
		30. Water at 90°C to steam at 100°C is
20	22	a. latent heat
14	12	b. sensible heat
41	51	*c. both latent and sensible heat
24	15	d. specific heat

Appendix C

Mean Scores by Site



PRINCIPLES OF TECHNOLOGY
UNIT THREE---PRETEST VS. POSTTEST
Posttest Scores
Pretest Scores
Mean Score of the Class
26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8
30 56 9 57 45 27 58 62 32 5 99 25 30 6 13 42 17 33 18 11 7 36
Teacher ID Numbers

Appendix D

Student Attitude Data

Due to rounding, all numbers do not equal 100%

n=375

all numbers in %

PRINCIPLES OF TECHNOLOGY
UNIT 3: RATE
STUDENT ATTITUDE QUESTIONNAIRE

Sex: 13 Female 87 Male

Grade: ___ 9 12 10 65 11 22 12

1. Overall, did you like the unit on RATE?

   9 yes, a lot
   53 yes, a little
   26 no, not very much
   12 no, not at all

2. What component did you like most in the RATE unit?

   4 the written material
   23 the video programs
   3 the math labs
   40 the hands on labs
   25 no preference
   more than 1=5

3. What component did you like least in the RATE unit?

   25 the written material
   7 the video programs
   26 the math labs
   5 the hands on labs
   29 no preference
   more than 1=8

4. Overall, was the material that was covered in the RATE unit difficult for you to understand?

   18 yes, most of the material was difficult for me to understand
   44 yes, some of the material was difficult for me to understand
   38 no, most of the material was not difficult for me to understand

5. Which component of the RATE unit was the most difficult for you to understand?

   22 the written material
   2 the video programs
   31 the math labs
   5 the hands on labs
   32 no component was particularly difficult
   more than 1=8

6. Which component of the RATE unit was the least difficult for you to understand?

   8 the written material
   45 the video programs
   8 the math labs
   19 the hands on labs
   15 all components were equally difficult
   more than 1=5

7. Do you think the material in the RATE unit is important for you to understand?

   29 yes, very important
   48 yes, sort of important
   1[illegible] no, not very important
   11 no, not at all important

8. Do you have any comments about the RATE unit?

THANK YOU!

Appendix E

Teacher Data and Comments

PRINCIPLES OF TECHNOLOGY
UNIT III: RATE
TEACHER QUESTIONNAIRE

1. What did you like most about the RATE unit?

   See attached comments

2. What did you like least about the RATE unit?

   See attached comments

n=25 3. Overall, how would you compare the RATE unit to units 1 and 2?

   24 better 68 about the same 8 worse

   If worse, why?

   See attached comments

n=25 4. In terms of their overall impact (instructional effectiveness, student interest, manageability) rank each of the components of the RATE unit using the following scale:

   A = Excellent
   B = Good
   C = So-so
   D = Poor
   E = Terrible

   Place the letter, corresponding to your ranking, next to each component.

A=40;B=44;C=16 student handbook A=12;B=52 C=32;D=4 hands on labs
A=52;B=44;C=4 videos A=12;B=60;C=28 teacher's guide
A=12;B=28;C=24;D=12 E=4 math labs

   Please explain any C, D, or E rankings and/or list any other comments you have about the components:

   See attached comments

n=24 5. Which of your students seem to be the most successful in the PRINCIPLES OF TECHNOLOGY course?

   63 above average 37 average ___ below average

n=24 6. Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for the subunits?

29 yes, definitely — 20 no, probably not

46 yes, probably — 4 no, definitely not

If no, please explain:

See attached comments

n=25 7. On average, how much time did you spend preparing to teach each class in the unit on RATE?

16 0-30 minutes — 16 91-120 minutes
56 31-60 minutes — 4 121-180 minutes
8 61-90 minutes — ___ 181 or more minutes

Comments:

See attached comments

n=25 8. Overall, did you feel comfortable teaching the materials in the unit on RATE?

64 yes, very comfortable — 8 no, not very comfortable
28 yes, sort of comfortable — ___ no, not at all comfortable

If no, please specify:

See attached comments

n=24 9. Do you think most of your students did the assigned readings at home?

4 definitely 29 probably 54 probably not 13 definitely not

Comments:

See attached comments

10. What, if anything, caused you the most problems in teaching the unit on RATE?

See attached comments

n=23 11. Do you feel the Teacher's Guide material provided you with enough information to help you successfully implement the unit?

39 definitely 44 probably 14 probably not 4 definitely not

If no, what should be added to the guide to make it more useful?

See attached comments

n=25 12. Did you teach Unit III: RATE on consecutive days for 26 days?

48 yes 52 no

If no, what pattern did you use (for example, 3 days a week)?

See attached comments

n=25 13. How much time per session did you teach?

64 50 minutes or less
20 51-60 minutes
4 61-90 minutes
12 91+ minutes

n=23 14. Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

48 yes 52 no

If yes, which classes did you combine?

See attached comments

n=25 15. How many physics courses did you take in college (undergraduate and graduate)?

12 none
16 1
44 2-4
4 5-7
24 8 or more

n=24 16. How many math courses did you take in college (undergraduate and graduate)?

___ none
4 1
67 2-4
8 5-7
21 8 or more

17. Do you have any other comments, concerns, or suggestions for the unit on RATE?

See attached comments

The following chart lists each activity for the unit on RATE down the left column. Since there are no materials specifically for the sub-unit review classes, these classes have not been listed in the chart. For each activity, you should respond to the following questions by circling "yes" or "no":

1) Was the material (readings, labs, or videos) appropriate for your students? Was the material at the right grade level? Was the amount of material appropriate for your students? For any no responses, please use the attached pages to describe your concerns.

2) Were you able to cover the material to your satisfaction in the 50-minute time period? (Since this question doesn't apply to the video, no response options have been provided for the column. Please do respond, however, to the other questions about the video.) For any no responses, please use the attached pages to describe why you could not complete the material and/or what you chose to delete.

3) Were there any errors or inaccuracies in the material? For any yes responses, use the attached pages to specify the errors and recommended corrections.

4) Were there any problems managing the activity? For the labs, were all your students able to rotate through the labs? Did you experience any problems coordinating the labs? Did you experience any problems setting up or tearing down the labs? Did you experience any problems coordinating the activity? For any yes responses, use the attached pages to specify the problems you had and, if possible, suggest changes that you feel would enable you to more easily manage the material.

5) Do you have any suggested modifications for the material? For any yes responses, use the additional pages to specify your suggestions. Include in this section any "teaching tips" - special procedures you used or means you discovered to more easily convey the information to students. Include in this section any comments you may have for the Teacher's Guide.

We recommend that you take a few minutes each day to complete the chart and, most importantly, to write down your comments. If you need more space for comments, use the back of the comments pages and/or attach additional sheets.

UNIT III: RATE	Appropriate for students?	Completed in 50 minutes?	Any errors or inaccuracies?	Any management problems?	Any suggested modifications?
Overview					
Video	100 yes 22 no	---------	yes 20 no 100	100 yes 21 no 100	yes 20 no 100
CO	100 yes 22 no	90 yes 20 no 10	100 yes 19 no 100	100 yes 20 no 100	yes 19 no 100
Mechanical Systems					
Video	100 yes 22 no	--------	100 yes 19 no 100	100 yes 19 no 100	10 yes 19 no 90
C1	100 yes 22 no	100 yes 18 no	100 yes 19 no 100	5 yes 19 no 95	10 yes 19 no 90
C2	100 yes 22 no	100 yes 19 no	15 yes 20 no 85	yes 19 no 100	10 yes 19 no 90
Math Lab	36 yes 21 no 15	85 yes 19 no 15	100 yes 20 no 100	5 yes 20 no 95	35 yes 20 no 65
3M1	75 yes 20 no 25	76 yes 17 no 24	5 yes 20 no 95	52 yes 21 no 48	39 yes 18 no 61
3M2	95 yes 20 no 5	100 yes 20 no	100 yes 19 no 100	37 yes 19 no 63	17 yes 18 no 83
Fluid Systems					
Video	100 yes 22 no	---------	10 yes 20 no 90	yes 19 no 100	21 yes 19 no 79
C1	100 yes 22 no	100 yes 20 no	20 yes 20 no 80	yes 19 no 100	21 yes 19 no 79
C2	100 yes 22 no	95 yes 20 no 5	10 yes 20 no 90	yes 19 no 100	10 yes 19 no 90
Math Lab	14 yes 22 no 86	90 yes 19 no 10	5 yes 20 no 95	5 yes 20 no 95	33 yes 21 no 67
3F1	86 yes 21 no 14	90 yes 19 no 10	21 yes 19 no 79	48 yes 21 no 52	37 yes 19 no 63
3F2	88 yes 16 no 12	50 yes 14 no 50	27 yes 15 no 73	69 yes 16 no 31	40 yes 15 no 60
Electrical Systems					
Video	100 yes 21 no	---------	yes 19 no 100	yes 19 no 100	5 yes 19 no 95
C1	100 yes 21 no	100 yes 19 no	yes 19 no 100	yes 19 no 100	5 yes 18 no 95
C2	100 yes 21 no	100 yes 19 no	yes 19 no 100	5 yes 19 no 95	5 yes 18 no 95
Math Lab	86 yes 21 no 14	100 yes 17 no	16 yes 19 no 84	10 yes 19 no 90	20 yes 20 no 80
3E1	96 yes 21 no 4	95 yes 18 no 5	yes 19 no 100	5 yes 19 no 95	5 yes 19 no 95
3E2	90 yes 21 no 10	95 yes 18 no 5	yes 19 no 100	15 yes 19 no 85	5 yes 19 no 95

	Appropriate for students?			Completed in 50 minutes?			Any errors or inaccuracies?			Any management problems?			Any suggested modifications?		
	yes		no	yes		no	yes		no	yes		no	yes		no
Thermal Systems															
Video	100	21			--------			19	100		19	100	10	19	90
C1	100	21		100	19			19	100		19	100	16	19	84
C2	100	20		100	18		17	18	83	5	18	95	17	18	83
Math Lab	76	21	24	90	19	10	26	19	74	5	19	95	42	19	58
3T1	85	20	15	70	17	30	18	17	82	53	19	47	33	18	67
3T2	90	20	10	83	18	17	5	18	95	11	18	89	22	18	78
Summary															
Video	100	21			--------		10	20	90		21	100	5	21	95

Comments for Overview Class

See attached comments

Comments for Videos

Overview Video: See attached comments

Mechanical Systems Video: See attached comments

Fluid Systems Video: See attached comments

Electrical Systems Video: See attached comments

Thermal Systems Video: See attached comments

Summary Video: See attached comments

Comments for C1 Classes

Mechanical Systems C1: See attached comments

Fluid Systems C1: See attached comments

Electrical Systems C1: See attached comments

Thermal Systems C1: See attached comments

Comments for C2 Classes

Mechanical Systems C2: See attached comments

Fluid Systems C2: See attached comments

Electrical Systems C2: See attached comments

Thermal Systems C2: See attached comments

Comments for Math Lab Classes

Mechanical Systems Math Lab: See attached comments

Fluid Systems Math Lab: See attached comments

Electrical Systems Math Lab: See attached comments

Thermal Systems Math Lab: See attached comments

Comments for Lab 1 Classes

Mechanical Systems Lab 1: See attached comments

Fluid Systems Lab 1: See attached comments

Electrical Systems Lab 1: See attached comments

Thermal Systems Lab 1: See attached comments

Comments for Lab 2 Classes

Mechanical Systems Lab 2: See attached comments

Fluid Systems Lab 2: See attached comments

Electrical Systems Lab 2: See attached comments

Thermal Systems Lab 2: See attached comments

Comments for Summary Class

See attached comments

PRINCIPLES OF TECHNOLOGY
UNIT III: RATE
TEACHER QUESTIONNAIRE

QUESTION 1 COMMENTS

What did you like most about the RATE unit?

1. Video and math labs. (#13)
2. Videos and labs. (#33)
3. Videos were most interesting and had as much content as print material. Print material direct and to the point. (#30)
4. Fluid labs. (#62)
5. Electricity portion on oscilloscopes. (#10)
6. Formulas in content area. (#05)
7. The labs all went well. (#32)
8. RATE in Electrical system was most interesting, both in theory and laboratory. (#45)
9. Intro of equipment, strobe and oscilloscope. (#06)
10. I liked the examples used. Because NASA is part of our community I feel the students understood the examples given much better. (#63)
11. Text material. (#07)
12. Easier to track than previous units. (#55)
13. "Measuring liquid flow rate in a channel." (#17)
14. Had better labs and more even flow. (#25)
15. The videos were well done. Strobe lab was interesting and well received. (#56)
16. The kids seem more interested in this unit. (#37)
17. The labs. On the whole they were a success. We need more. (#36)
18. Lab exercises--they were very good. (#58)
19. The unit was well put together--it tied all systems together in a good way. (#60)
20. Getting a chance to get my hands on an oscilloscope. (#08)
21. Students understood the idea of velocity and enjoy calculating problems concerning speed of automobiles. (#40)

22. Easy to teach. Allowed great flexability for lab variations. (#55)

23. The unit was just really good, labs were great. (#38)

QUESTION 2 COMMENTS

What did you like least about the RATE unit?

1. Written material. (#13)
2. The fluid labs were extremely difficult. (#33)
3. Labs were very time-consuming to set-up and conduct. (#30)
4. Thermal labs. (#62)
5. Thermal. (#10)
6. Not enough problems relating to the many formulas given. (#05)
7. The teacher notes, not enough info on some. (#32)
8. Experiment of measuring gas flow rate with orifice. (#45)
9. Vague directions and drawings for lab set-ups. (#42)
10. Velocity-acceleration lab could be much better. Pneumatic labs remain difficult to set up. (#06)
11. There weren't any glaring short comings. (#63)
12. Labs that didn't work as described. (#07)
13. 3T1, we couldn't get system to stabilize. (#17)
14. Seemingly unrelated math labs and lack of use of true scientific notation. (#18)
15. Electrical. (#25)
16. Lab 3M1, 3F2, 3T1. (#56)
17. It continued a lot of concepts that these students were unfamiliar with. So many different units, etc. (#37)
18. Math labs. The symbols were hard for the students to grasp. (#58)
19. I need more time to get the labs done ahead of time. (#60)
20. The lack of information in the unit on the use of an oscilloscope. (#08)
21. Electrical RATE labs were weak. (#55)
22. We need to move the power of 10 out of math labs and practice thermal problems. (#38)

22. Easy to teach. Allowed great flexability for lab variations. (#55)

23. The unit was just really good, labs were great. (#38)

QUESTION 4 COMMENTS

In terms of their overall impact (instructional effectiveness, student interest, manageability) rank each of the components of the RATE unit using the following scale:

A = Excellent
B = Good
C = So-so
D = Poor
E = Terrible

Place the letter, corresponding to your ranking, next to each component. Please explain any C, D, or E rankings, and/or list any other comments you have about the components.

1. Student handbook and hands on lab seem to be going into a physics lab. Should be more to the real world. (#13)

2. The labs in the Fluid unit were very difficult for me. (#33)

3. As an example, the two Fluid RATE labs required me to mop an entire floor after the students left. 3F2 required 90 minutes for the best students to complete and 4 hours for me to assemble. Could be the time of year as well. Kids didn't seem to react as well to this unit. We may be deeply into the plugging along phase now. (#30)

4. Video-errors. Comparison of high jumper with woman on steps not the same rise nor weight, yet video implies equality. The "comedy" portions should be dropped. (#10)

5. 3M1 is too difficult to buy and store. A 3 speed drill press would have worked just as well. Student handbook seems to be too difficult for students to understand.

6. Teacher guide not enough detail. (#32)

7. I think experimental value of this unit was excellent. Increase in quantity of the experiments in Electrical subunit (scope) is great. (#45)

8. Vague directions, inaccuracies. (#42)

9. Math labs need more for students to do. Some hands-on lab equipment impossible. We substitute for most (inadequate funding for up front purchase). (#06)

10. Part of the teacher's guide was incomplete, several answer sheets were omitted. (#63)

11. Lab equipment did not work as it should. (#07)

12. Some math labs do not pertain to text or labs. Some labs did not work the way they were supposed to (3F2 and 3T1). (#13)

13. I felt some labs, especially in the Fluid and Thermal subunits amounted

QUESTION 3 COMMENTS

Overall, how would you compare the RATE unit to units 1 and 2? If worse, why?

1. Probably the most challenging thus far. Took more preparation. (#33)

2. Text material easier, some lab material much more difficult. (#30)

3. Many students found it harder and the labs were more difficult to explain and set up. (#05)

4. Bad, faulty or non-existent equipment. Vague directions. A little too sophisticated for my students. (#42)

5. The students are getting the feel of the sequence. (#06)

6. About the same as Unit 2, but not as good as Unit 1. (#18)

7. Maybe a little better. (#03)

QUESTION 6 COMMENTS

Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for the subunit? If no, please explain.

1. Some units need more time. Students may need more time with the labs. Teacher needs more time to explain labs, plus students need time to accomplish. (#33)

2. It is possible that some labs can be modified to be completed in one period with increased familiarity with the equipment. (#30)

3. Need longer periods for labs. (#62)

4. Not enough time. (#09)

5. Some lessons require more than 1 period, 1 to do and at least part of one to evaluate the work. (#10)

6. From a science point of view lab work should precede book work in some cases. (#06)

7. Some labs may require more time if everything does not go as planned. (#07)

8. Some beefing up of the math concepts needs to be implemented. Some more difficult problems for the better students. (#18)

9. I could have used an extra day or even two in both Mechanical and Thermal subunits. (#56)

10. C1 and C2 often need to be stretched out to C3. (#37)

11. I think more labs should be implemented. (#36)

12. I do not use the 50-minute class sessions. (#58)

13. Slower students need more individual attention and time to do math calculation. (#40)

14. Not enough time for labs. (#38)

to a lot of work for limited objectives and some of the procedures are stilted and don't necessarily do what they advertise. (#56)

14. The teacher's guide is incomplete. I believe you assume we know everything. The math labs are too short and repetitive, the kids have no interest or motivation. (#37)

15. Could use more content in math labs. Student handbook should explain procedures, etc. in more detail. (#36)

16. The symbols in the math labs were hard for the students to understand. (#58)

17. Some of the math labs were not useful to the succeeding sections. Show some of the calculations on the math labs. Also a sample lab result would have been useful. (#60)

18. Teacher's guide had too many mistakes and left out many answers. Math labs do not relate to the material being covered in the unit. (#08)

19. All math la s are of such a format as to be depressing to look at by students. I substituted about every lab. (#55)

QUESTION 8 COMMENTS

Overall, did you feel comfortable teaching the materials in the unit on RATE?

1. We had problems getting some of the labs operating. Dewar flasks, no DP-DT switches, orifice, readings didn't follow chart. (#33)

2. I do not feel comfortable yet with the lab components. (#30)

3. We've been unable to do the labs due to lack of funding. However, second sememster we should be able to do some labs because the money finally arrived. (#09)

4. I often feel that we should go into more depth and must restrain myself. (#56)

5. I'm not a physics teacher. (#08)

QUESTION 7 COMMENTS

On average, how much time did you spend preparing to teach each class in the unit on RATE?

1. Class material was not difficult but required preparation. Lab material on fluids. (#30)

2. Setting up labs very time consuming. (#62)

3. The material for me is easy to explain. Labs and lab equipment is where I spent most of my time. (#05)

4. Lab prep is a pain in the ass. (#06)

5. My problems in preparation was developing lab equipment. Although we have most of the equipment it is spread out over the system. (#63)

6. Some labs in this unit took a great deal of preparation. Also, it was very difficult to re-set up some labs (Fluid and Thermal) when P/T was taught in consecutive classes. (#56)

7. Math is a subject that I enjoy and am involved in teaching math at the high school level. (#40)

QUESTION 10 COMMENTS

What, if anything, caused you the most problems in teaching the unit on RATE?

1. Lab units, could not get interest going. Was told the same thing could be done in a physics lab. (#13)

2. Fluid labs. (#33)

3. Fluid lab set-up time. Unavailable equipment in Mechanical labs prevented. (#30)

4. Thermal lab. (#62)

5. Low caliber of students. (#09)

6. Lack of materials for labs and demonstrations. This is due to no prior knowledge of needed materials which left us short. (#10)

7. Labs and lab equipment. (#05)

8. Getting students to do homework. (#32)

9. Equipment and vague directions. (#42)

10. Lab equipment needs. (#63)

11. Lab materials. (#07)

12. Material handling. (#55)

13. I had no particular trouble and the students seemed to do well. (#17)

14. Too much time available on most of the math labs and seemingly unrelated math to either the labs or text. (#18)

15. The Electrical unit used equipment that was not explained before the unit. Need unit on how to use oscilloscope before doing the Electrical lab. (#25)

16. Changing units, kid's are driving me nuts. Trying to follow the schedule when kids are not doing the proper preparation. (#56)

17. The math lab timing--I wrote a supplemental math lab which I have done for almost each suunit. (#37)

18. Math. (#58)

19. Lab equipment. (#60)

20. Working with the oscilloscope, I had never even touched one before. The pre/posttests are too difficult for our students. (#08)

21. Math calculations on the electrical subunit; Current = charge transferred/elapsed time. (#40)

QUESTION 9 COMMENTS

Do you think most of your students did the assigned readings at home?

1. Material is not real interesting to read. On some areas, (Electrical) students read, but on others they were not too interested. (#13)

2. About 13 out of 18. (#33)

3. Despite exhortations to the contrary, their questions during lab classes lead me to doubt that they are doing a great deal at home. (#30)

4. Too lazy and found material in handbook difficult. (#05)

5. This is definitely the hardest part of teaching PRINCIPLES OF TECHNOLOGY. (#32)

6. Exercises at end of the discussions were excellent. (#45)

7. I feel the readings should have a glossary of terms. Some units require students to look up the various terms if they are to fully understand the material. (#63)

8. I have them read in class because I have them 3 hours per day, 5 days per week. (#17)

9. When the assignments (homework) were greater as they were in FORCE, the students were more committed and put forth more effort. (#18)

10. Getting kids (most people for that matter) is a struggle. (#37)

11. We did all readings in class. (#58)

12. Students will not do reading at home. (#03)

13. Some of the slower students came to class not as well prepared as I had hoped they would be. (#40)

14. There is no way that is going to happen. (#55)

QUESTION 11 COMMENTS

Do you feel the Teacher's Guide material provided you with enough information to help you successfully implement the unit? If no, what should be added to the guide to make it more useful?

1. Fluid, I needed to know hcw many cubed centimeters in a liter. (#33)

2. More sample problems for math labs. I used physics problems for practice in content area. (#05)

3. Demo ideas for oscilloscope. (#06)

4. More information on lab i.e., results to be expected, etc., so teachers might need more background information on the materials. (#07)

5. Some areas I had to look up in other books (might be my fault, though). (#17)

6. It would be helpful to have answers to the oscilloscope problems. (#18)

7. Step by step lab instructions. (#25)

8. Include explanation on some of the sample problems. Include more on what should happen and be very specific in the labs. (#37)

9. Instructions can be more detailed and comprehensive. (#36)

10. A sample of each lab--sample data to help students know if labs are working. (#60)

11. More background material would have been helpful. I've spent a lot of time trying to find reasons that things are like they are stated in the book. (#08)

22. Not enough time for labs. (#38)

23. The labs would have due to materials, but substituted labs helped and were no problem. (#55)

QUESTION 14 COMMENTS

. Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)? If yes, which classes did you combine?

1. C1 and C2 and then Math Lab and labs. (#13)

2. C0, C1, and C2 in one day, M1 and L1 on day 2, L2 and Summary with quiz on day 3. This seems to be a comfortable schedule for the double period alternate week. (#30)

3. L1 and L2 general background. (#10)

4. Labs on Mechanical, Fluid (it is almost impossible for me to set up 2 labs a week). (#05)

5. Math lab and C1, C1 and C2. (#45)

6. Most C1 and C2 classes were covered in 1 to 1 1/2 days so that additional material could be introduced. Math Labs were introduced as homework. (#07)

7. I'm still teaching C1, C2 and lab prep in first 3 days (sometimes 4 days). (#56)

8. We combined as many as possible. (#58)

9. 0 and C1, Review and Test. (#60)

10. I try and group two classroom lectures every time, thus home reading is required. (#40)

11. L1 and L2 with split class. (#38)

12. Except for math labs which are integrated into labs and other classes. (#55)

QUESTION 12 COMMENTS

Did you teach Unit III: RATE on consecutive days for 26 days? If no, what pattern did you use (for example, 3 days a week)?

1. 2 days a week, 2 hours a day. (#13)

2. Double periods during alternate weeks. (#30)

3. This unit ran 30 days - holidays caused schedule changes. Several lessons took 2 days. (#10)

4. Consecutive days except for winter break and now review for finals. (#05)

5. Thirty consecutive days. (#32)

6. During this period I was selected to attend a course taught within our system plus the holiday break caused a long delay before the unit could be completed. (#63)

7. We added about one week. We spread the unit on RATE out so that we could stall for time before unit 4 (equipment lists were not available so that orders could be made). Enrichment material was given. (#07)

8. Interrupted normal pattern for one week, so I could get lab equipment in. (#17)

9. Yes, except for all the interruptions. (#18)

10. Every other day. (#25)

11. More like 30 days. (#56)

12. We had about a 4 day stop to do semester breaks for all of the different schools. (#37)

13. Two or three days a week. (#58)

14. We had skips because of Christmas and semester tests and snow. (#08)

15. As my time schedule must correspond to my Machine Shop class, I use 1 1/2 periods of a two hour block per week, with home assignments. (#40)

16. It took 33 days, however, due to additional lab activities teacher added. (#55)

17. Had to use more time for labs. (#38)

COMMENTS FOR OVERVIEW CLASS

1. Kids see the point of studying rates very well. Print material very good. (#30)

2. Did not finish Overview as students had quite a few comments and questions. This video really got the students thinking. A few had the attitude of so-what, why do I need to know that? Explanation went into the next session. Had students answer their own questions about need to know as an outside assignment. Worked out well, but was time consuming. (#13)

3. Overall it was excellent but think a little more material on Electrical subunit would have been good. I believe a 10-15 minute lecture before the videos and students would have enjoyed it better. (#45)

4. Overview materials could be a little more comprehensive but was considered adequate. Instructor experiences and knowledge played a key role in the success. (#35)

5. Good unit in the sense that students understand velocity, angular velocity, volume flow rate, mass flow rate, and heat flow rate. Electrical systems present an understanding concept as how do you see or feel change transfer. (#40)

QUESTION 17 COMMENTS

Do you have any other comments, concerns, or suggestions for the unit on RATE?

1. I feel we need to take a look at some of the labs. Also need to work through the labs for next year when (if) we get together. (#33)

2. Videos seem to have improved. Print material continues in quality, but kids do not like reading and tend to resist. Math labs are drawing rave reviews (perhaps because they give a positive reinforcement), but the overall impression of the applications labs is not as strong as it could be. Some seem to be untested or poorly tested, OR, real kids can find very strange ways of interpreting the labs. Perhaps a teacher's manual addition of "post-lab" suggestions helping us to stress with the kids what the lab activity was to show, might be useful. It seems to me as well that some of the labs are being intentionally complicated to make use of equipment used for other labs. This may help in demonstrating increased cost-effectiveness to school committees, but it doesn't endear the program to the teachers who have to set up 6 lab stations before class. (#30)

3. The student test does not coincide with the unit content, in that the unit places strong emphasis on mathematics, while the test contains only a very limited amount of mathematics. I suggest that revised forms of the test indicate the same emphasis as the unit content, or that the math emphasis is reduced. (#10)

4. This unit was excellent, students seemed to like it very much, especially subunit on Electrical RATE. (#45)

5. I feel adamant about the need for more student accountability. Questions at end of each reading assignment, questions following labs, etc. (#06)

6. The students were more interested when the assignments required more time on their art, like the unit on FORCE. (#18)

7. Instructions can be geared more to the high school student who has little technical knowledge. (#36)

8. Good unit. Students enjoyed the Mechanical system. (#40)

9. The teachers and the students are getting sick of the music at the beginning of each video with the P/T logo! (#08)

10. Electrical RATE labs weak. Conveyor belt and washer lab a little trite. (#55)

14. Mechanical: Students on most part could relate to the drag races and their rate.

Fluid: On measurement of flow rate at dam the bottom will not be the same in all places, should have explained that you took an average. (#08)

15. Overview: We really got into the dragsters and computed all types of rates for students' cars. (#55)

COMMENTS FOR VIDEOS

1. Mechanical: Superlative, I learned a lot.

   Fluid: Guy in the lake deserved extra money.

   Thermal: Obviously the best done overall video unit. Tended not to be as light in tone as the others in the RATE unit. Recommend that you keep the kicker at the end of the video. Very effective using young or young-looking technicians. Kids can relate better to them. (#30)

2. Overview: Very good. Created a lot of questions and required a lot of explanation. Took class away from lecture and put it in question and answer type class.

   Mechanical: Very interesting. Formulas are given but I believe it would be a great advantage if the formulas were used and a problem solved. (#13)

3. Fluid: The material on the rate measurement of the river is not acceptable. Water changes depth radically just beyond experimenter, therefore multiple depth measurements are needed to find x-sec area. Width is not a direct measurement, this could be done by surveying. Water velocity varies. Fastest in top middle and slowest at edges.

   Summary: The sequence on the high jumper and woman climbing stairs implies equality of heights - impossible - woman has gone up many normal rise steps. (#10)

4. Electrical: It was good but more real world examples on this section would have been useful. (#45)

5. All continue to be helpful. Students continue to enjoy. (#06)

6. I would like to sum up the effectiveness of the videos in one statement: If they are improved upon there will be no need for an instructor. According to M. Hunter theory and teaching methods it's all there. Keep up the good work. (#63)

7. Videos are better. (#07)

8. Mechanical: Measuring flow in channel was cute, but kids were quick to point out inaccuracies. (#56)

9. Electrical: This video didn't back up the lab much. (#25)

10. I miss the humor episodes with respect to the videos. The students miss the humor episodes and particularly the old movie shots. (#17)

11. All were good. (#36)

12. Students enjoyed all the videos. Could go into a little more detail. (#58)

13. All were good. (#40)

10. Mechanical: Less bulk-more principles.

    Fluid: Example 3-F on page 43, the answer is incorrect. Should be 41.67 gal/min. (#08)

11. Mechanical: Excellent job.

    Fluid: Easy.

    Electrical: Hard to instruct.

    Thermal: Good. (#40)

12. Fluid: Page 43, example 3-F, Qv = 41.67 gal/m, not 83 gal/m. (#38)

COMMENTS FOR C1 CLASS

1. Mechanical: Formulas come too fast and heavy. Should have more examples per formula or a little more explanation. (#13)

2. Mechanical: Students seem more at home with vectors at second exposure.

   Fluid: What a short subunit.

   Electrical: Class worked well, no problems.

   Thermal: Might we assume that R-values (as in insulation) are going to show up in the RESISTANCE unit? Might be worth citing here, at least in Teacher's pages. By the way, what's celotex?

3. Mechanical: My strobe is not calibrated in cps, scale is 0-100.

   Fluid: The procedure for part 2 of the demo is confusing as written. This is a standard measurement and I suggest that it be written as such. What is meant by "Fill the beaker" (Part 2, direction 3)?

   Thermal: Page 110, diagram illustrating vibrational motion would be helpful. (#10)

4. Fluid: Error on page 43, example 3-F. Answer should be 41.66 gal/min. Error on page 48, question 10, answer should be either A or D since 1.66 rounded off equal 1.7 kg/min. (#42)

5. Mechanical: It was excellent, I think it couldn't have been easier explained, graphs and discussing were great.

   Fluid: It was very good. Students had no problems of understanding the concepts. The unifying concept and equations were a great help.

   Electrical: It was great but I think because of the importance of this section we could have had a little more material. Students were loving it.

   Thermal: It had an excellent practical vein for the students. They could actually feel the need for understanding of this section. (#45)

6. Electrical: Page 83, #8, frequency is a measure of how often events take place. Use of repeat implies first action does not count. (#06)

7. Fluid: Mistake in math page 43, example 3-F; 41.6 gal/min, not 33 gal/min. (#18)

8. Fluid: This system seems to be the most difficult by far for the kids. Part of the problem is with cubic values. We need a simple presentation that is inclusive. I know that will be hard to do. (#37)

9. Instructor knowledge and experiences helped in making all four systems more interesting to the students. (#36)

8. Example 3F has wrong answer. Should be 41.67, not 83. (#60)

COMMENTS FOR C2 CLASSES

1. Mechanical: Good chance to review torque.

   Thermal: Cheaper and as effective: melting of ice. Lots of waiting time here. Recommend setting this one up after C2, starting it on the next class, conducting M1 while it heats and stabilizes, and completing the post-lab and write-up at the end of the math lab. This one is not what you would call an earth shaking discovery lab. (#30)

2. Thermal: Errors on page 116, example 3-N, 70 degrees Celsius should be 70 Celsius degrees. Page 117 same example. Demo took far too much time to complete. (#42)

3. Mechanical: Check page 17, 5th line down. According to my physics book (college) "General Physics," clockwise rotation is minus, counterclockwise rotacion is +. Please inform; otherwise okay. (#05)

4. Mechanical: There is a technical mistake on page 19 question #2c, where it is asked to identify the linear or rotational rate. Some of the students were confused because of drill's linear and rotational speed, and I believe question could have been more clear.

   Fluid: Students understood and liked this subunit.

   Electrical: I think this section was the most important part of the unit and students payed special attention to it.

   Thermal: On page 116 at the end of the example 3-M, BTU should be BTUs. On page 120, example 8, specific heat of water was written as 1 cal/gm/celsius degree, while it should be 1 cal/gm celsius degree. (#45)

5. Mechanical: In my opinion example 3C needs to be changed using one revolution in one second. Should be changed to more than 1 revolution and more than 1 second. In both 3C and 3D the number of steps used to illustrate Rev/min---Rads/sec is confusing. I shortened the procedure with success.

   Thermal: Error in student exercise #8C, should be 1.00 cal/gm·°C. (#38)

6. Strobe not calibrated - we got the idea. Could you insert comment on timing light (auto) here? (#06)

7. Fluid: On student exercise #7 could be volume or mass because ounces is a measure of both volume and mass. Page 48, #10 answer A is correct if you round off.

   Electrical: Demo - it was difficult to use the oscilloscope, because I had never used one before.

   Thermal: Page 111, example 3N should be 70 °C. Also had a problem with demo. Nail never fell during class on steel bar. (#08)

calculations. I feel the math lab should be a practice of the sample calculations in the text. Again, I have written supplemental material. (#37)

9. Very good and each example is easily understood. In fact, all labs are great, but we are not fully equipped to complete all labs. (#63)

10. Thermal: It seems incongruous that in previous reading assignments, scientific notation is talked about and then in the math lab, the method is not followed; e.g. page 125. On page T-125 there are two answers that are incorrect. It seems that all of the math labs need beefing up with similar problems to those in the text and those in the practical labs. (#18)

11. Some power of 10 unit answers are incorrect. (#33)

12. Math labs are getting better. (#07)

13. Thermal: Power answers are negative. (#55)

14. Some problems did occur in the math classes. The symbols seem to give the most probems. (#58)

15. Mechancal: Average and above average students had no problems.

Fluid: No problem.

Electrical: Explain, but what do you use for a visual example?

Thermal: Good. (#40)

16. I have commented on this to CORD evaluation: lb-in vs psi. Metric or English, one or the other. Powers of 10 at this time? Why? (#62)

17. Mechanical: They will not be interested in doing power of 10 notation with a calculator in hand, but they were willing to see how to write the numbers.

Fluid: Addition, subtraction, multiplication and addition, power of 10 or not, will be done by calculator as far as the kids are concerned.

Electrical: Recommend adding some time for students to turn on oscilloscopes and play with them in addition to reading scales.

Thermal: Kids had no problem changing the units. Good as an extra help session for those who need it. (#30)

18. Electrical: No answers were provided for student problems.

Thermal: T-125, errors, 19.1×10^{-6} should be $.191 \times 10^{-6}$, 0.0191×10^{-9} should be 191×10^{-9}, 136,000 Kj should be 136,000 kj. (#42)

19. Mechanical: It was accurate and students (some) like it. But for

COMMENTS FOR MATH LAB CLASSES

1. Fluid: Adding and subtracting of exponential numbers are not necessarily easier than adding or subtracting decimal numbers for most students. The only real savings is in multiplying and dividing. (#60)

2. Mechanical: This should have been introduced back in Electrical WORK.

   Electrical: No answers were provided in teacher's edition. I was not sure of my answers and it caused many problems.

   Thermal: Problems 1 and 2 on page 124 were already worked in student curriculum. (#08)

3. Need more for students to have an active role, so give a hundred problems, we can select which ones we want. (#06)

4. Mechanical: I really think more practice on the math associated with the subunit is needed. I don't know where power of 10 and scientific notation would be done. Does it really need to be at this time?

   Fluid: Why not practice the math used in C1 and C2? If it is necessary to review power of 10 numbers and scientific notation why not in the day or two at the end of work, since thermal is not there.

   Electrical: Good. We need more that apply directly to C1, C2, L1 and L2.

   Thermal: Devote problems in thermal RATE, maybe a specific subunit. Fourth one in WORK on power of 10 and scientific notation. (#33)

5. We have bagged the math labs entirely, integrating math concepts as needed into labs, lab wrap-ups and lectures. (#55)

6. Mechanical: This lab took 2 days.

   Fluid: This is probably a 2 period activity for most students.

   Electrical: Troughs are not at consistent depression level, trough not as wide as crest portion. Trough and crest portions not consistent in width in problem 2. Grid drawing is absolutely erroneous. This is too good a math lab to have this much error. (#10)

7. Most of the math labs continue to require supplementation by the instructors. This applies to all systems. (#36)

8. Mechanical: Too short. Also, we need to explain math more succinctly.

   Fluid: It would be better if the problems were applied to a situation. The kids find these exercises as repetitive.

   Thermal: It appears to me it was too short and ignored the math

most of the students it was not interesting. They wanted some more advanced material.

Electrical: On page T-87, voltage reading of a multimeter was calculated as 1.414 of peak to peak voltage of scope, while it's not 1.414 and it is .318. (#45)

20. Mechanical: Okay but not enough problems relating to the many formulas given in the content area.

Flud: Inappropriate for content material. The way it was explained was confusing.

Thermal: Again, had to supplement lab with physics problem on $H= mc\Delta T$ and Qh lost = Qh gained. Need to have more guided practice problems. (#05)

COMMENTS FOR LAB 1 CLASSES

1. Mechanical: Appropriate but the equipment listed could not be purchased or stored (from my district). Variable speed drill press would have sufficed.

   Fluid: Okay, but had to do only 1 lab. Impossible to conduct 2 labs per week. (#05)

2. Electrical: We could have used more experiments like this part. The rest were excellent. (#45)

3. Mechanical: Our "so-called" conveyor belt apparatus has never appeared. We do have some pulleys, clamps, and tubing sent to us under the cover of conveyor belt apparatus, but what is to be done with them is beyond my ken. This lab not done.

   Fluid: Poor! Poor! Poor! Directions unclear. S-W equipment leaked, hoses kinked, bobber stuck to sides of trough, flow control valves not dependable, etc. However, the stopwathces worked well and the water did flow...and flow.

   Thermal: S-W sent us 115 volt 660 watt heaters. Naturally they provided no heat with 12 volts D.C. Directions on room temperature measurement and calculations were confusing. DMM's from S-W were inaccurate with temperatures at 25 degrees. (#42)

4. Mechanical: Equipment never arrived, unable to complete.

   Fluid: I have never instructed a messier lab. Recommend elimination of power supply and pump. Replace with siphon or carbuoy with faucet tap. Lab is terribly complcated for my kids and I am not convinced the point was made.

   Electrical: Nice, simple, well-written 40 minute lab. Requires teacher to be specific on meter settings.

   Thermal: Used lots and lots of thermocouple wire in making connections. Is there a better way? (#30)

5. Who has a sink in their voc-ed classroom? (#62)

6. All the labs were very instructional and the students enjoyed them very much. (#58)

7. Mechanical: Equipment was not available (did not do).

   Fluid: Hose provided for the lab would not fit flow control valve. Students had a hard time understanding cross section area calculations and what was taking place. Troughs leaked.

   Electrical: Very good, students enjoyed using the oscilloscope.

   Thermal: The lab would not work using the procedures in the text. Work using AC at 28 volts and preheating the flask for 2 hours. Could be done using two calorimeter cups and an aluminum bar.

(#07)

8. Fluid: Answers on page T-56 are messed up, at least that's the con- conclusion we made.

   Thermal: No double SP-DT switch available. (#33)

9. Mechanical: Page T-32 part 2, 0.2 oz should be 0.23 oz.

   Thermal: This is one of those experiments that take longer than 50 minutes to complete. A 60-75 watt light bult would have been a lot quicker, but of course, not as safe with the present apparatus. We had to double the voltage reading on the power supply to get anything at all worthwhile out of this experiment. (#18)

10. Mechanical: Could not do. S-W did not send us materials for this lab. We are now having a conveyor belt made for us.

    Fluid: Interesting lab, the calculations were difficult. We need to explain to the kids in an understandable way how the X-section area is determined. It would be helpful to the teacher if you would include a direct explanation of how the apparatus relates to a dam.

    Thermal: Good lab! The kids thought the connecting was difficult and I agree for these kids and teacher who didn't know a lot about electronics. (#32)

11. Mechanical: We couldn't do this lab because we lacked the equipment. Perhaps another concept would generate more enthusiasm for students and instructors.

    Fluid: This lab could also contain more activity for the students. The set-up requires the most time. From there it is sort of down hill. Students got a little messy towards the end of the lab because of boredom.

    Electrical: This lab also needs more activity.

    Thermal: The thermal labs were fine but take a technical mind to set up properly on the first one. It worked fine however, and accomplished goals. (#36)

12. Mechanical: Due to materials requirements, it was necessary to construct conveyor systems for this lab. This was a very time consuming job, as there were no dimensions or specific suggestions for the work.

    Fluid: Calculations sheet is confusing.

    Thermal: Not done. DeWar flask and Type E thermocouple not available. (#10)

13. Mechanical: We bagged 3M1 and did linear rate, vibration, oscillation, deceleration instead.

Fluid: We measured flow rate of nearby creek and flow rates of 4 different pumps each at 3 different heights, instead of 2 as lab suggested.

Thermal: We again substituted a lab, in this case for the DeWar lab. We melted ice to steam and graphed sensible and latent heat, as well as adding another lab, we graphed a lot here. (#55)

14. Mechanical: There were no conveyor belts on the initial list and none available at the vendor. I made one and demonstrated the procedure. Worked well, but I need to know if they will be available or if I need to start gathering parts to make 5 more.

    Fluid: Just barely enough time, real close. Wrong connection for pump.

    Electrical: Just enough time.

    Thermal: Got to have more time. (#38)

15. I substituted for every lab but Electrical. (#06)

16. Mechanical: Figure out less expensive conveyor mechanism. Conveyor mechanism we used would not hold items on it.

    Fluid: Did not receive materials so I improvised a lab. On page 59 the use of T and t for time should be one or the other. Also the use of l for both length and liters was confusing.

    Thermal: Error on page 136 in Table 2. Temperature difference across cylinder, or temperature change, should be Celsius degrees. We used a coffee can instead of an expensive DeWar flask and experiment still worked. A lot of these experiments could be done more cheaply. (#08)

17. Mechanical: Didn't have conveyor belts.

    Fluid: Good lab.

    Electrical: Okay.

    Thermal: Our equipment didn't work. (#60)

18. Mechanical: Lab was too simple, it took too much time and money to set-up experiment. Students understood process before we started.

    Fluid: Lab too complicated, could not get system to function properly - gave up on it. Used pneumatic Robot arm instead. Students could not understand why P/T lab understood the speed control on robot's arm. (#13)

19. Thermal: The heat source seems too slow for 50-minute class, or results are too small to calculate early. (#32)

20. Mechanical: Good I guess. I did not have conveyor belt apparatus.

Flud: Good.

Electrical: Good.

Thermal: A good lab but has one problem. Finding a point of stabilization i.e , page 135 (step 4) is next to impossible. (#17)

21. Mechanical: I didn't care for this lab. I think there are many other ways to measure a constant velocity.

Fluid: The kids liked this lab but the weir was not really used. I would have liked to include a measurement using a weir even though a larger channel would be required.

Electrical: Biggest problem was kids blowing fuses on meters.

Thermal: Much time was devoted to using the formula for heat flow rate. Yet in the lab it was barely mentioned. I felt that indicating that the heat added by the element will all be transferred through the Al. was misleading. Only about 20% of heat goes through Al, the rest is lost. This could be discussed and maybe demonstrated. The average kid couldn't set-up this lab and get results in 50 minutes. (#56)

COMMENTS FOR LAB 2 CLASSES

1. Mechanical: Great, kids loved it.

   Fluid: Far too much trouble setting up for what you get out of it. I can't imagine doing this with groups of 4 kids each.

   Electrical: Great! Kids did well. I even gave a practical test and my poorest students came out on top.

   Thermal: When you're doing several consecutive classes it takes a lot of boiling water. (#56)

2. Mechanical: Good.

   Fluid: An excellent lab. 3F2 takes longer set up than most labs. Suggest set up one day and lab the next. Otherwise students rush too much, failing to pick up important points. (#17)

3. Fluid: Data did not seem to substantiate table data. Orifice size probably in error. (#32)

4. Mechanical: Did not perform this as it was too expensive. We used a timing light on an automobile and got the same results. Students could put this to a practical use. (#13)

5. Mechanical: Our strobe was too hard to calibrate. It was hard to read the strobe setting.

   Fluid: We didn't get our apparatus to work.

   Electrical: Students enjoyed this one.

   Thermal: We didn't have everything for the lab. (#60)

6. Mechanical: Did lab late because of delay in receiving strobe.

   Fluid: Did not do because it was too complicated to even understand for the teacher. Simplify it.

   Electrical: For a person that has never touched an oscilloscope before, this lab was extremely difficult to set up.

   Thermal: This was one of the most down to earth practical labs we have had. The students were able to see more about what was going on in this lab than any of the others we have had. Why can't more of the labs be this practical? (#08)

7. Mechanical: Used strobe as demo.

   Fluid: Rate of flow of siphon hoses with different cross sections.

   Electrical: Used suggested lab as demo. (#06)

8. Mechanical: Very difficult to index FPS on the strobe by students. It seems like there ought to be a positive stop to index the

strobe.

Fluid: Not enough time to set up equipment or do the lab. Time is a problem. Wrong orifice for chart. Collection column is 17" not 19". Error in set up instructions - recommended pressure for tank too high. Pressure regulation too sensitive and no instructions.

Electrical: Not enough time for things as new as oscilloscope.

Thermal: Got to have more time. (#38)

9. Mechanical: We have just 1 strobe and it is not calibrated. I took an extra day with class to calibrate the scope in order to do the lab.

   Fluid: Orifice tube was not available. No cross section area or diameter for orifice was given. New instructions came out too late. This type of lab set-up is too complex for students to set-up and do in one period. (#10)

   Thermal: Type E thermocouples not available, used thermometers. (#10)

10. Mechanical: This lab generated more enthusiasm and was more fun as well as educational for the student. Howver, there wasn't enough content for continued activity.

    Fluid: We couldn't do this lab because we lacked the equipment. It appears a little complicated for a one day lab.

    Electrical: This lab was the most successful by far. It generated a lot of interest among the students. I think the majority of them liked working with the equipment.

    Thermal: A good lab demonstrating heat transfer and insulating properties. (#36)

11. Mechanical: Good experiment, kids enjoyed it and it went smoothly.

    Fluid: Did not have manometers, didn't do.

    Electrical: This lab was by far the most interesting for the kids. The fact that they could operate a difficult looking instrument did wonders for their self image and motivation. My only suggestion would be to add at the end an unknown wave from an applicable source that they would have to determine period, amplitude and frequency for.

    Thermal: Very good lab but it's almost too easy for the kids. How about at the end after we have pooled the data - we have the kids calculate the rate of heat flow or to be more exact a rate of T/Time for each lab station. Then they should compare the rates to the rate of the control and a pretty good discussion follows. I tried this and was pleased. (#37)

12. Fluid: Nothing but disaster. Our orifice diameter is half the

size indicated. Calibration Tables A and B are worthless for a .025" orifice. Therefore, Data Table 2 is of no value in verifying Data Table 3 or vice versa. Because of the mistake we have probably learned more about the orifice and flow control than we were supposed to.

Thermal: We used 3 50-minute periods to cover the 2 labs in order to thoroughly cover the concept. (#18)

13. Fluid: Confusing. (#33)

14. Fluid: Pressure regulators and orifice assembly were not satisfactory. Very hard to control air pressure without blowing the water from the manometers. Bad experience for students.

Thermal: We could only do 4 stations because of only 4 DMM. Very hard to have enough boiling water and measure equal quantities for all stations so that the data can be collected at the same time. Have students plot their results since each student cannot work at every station. (#07)

15. Mechanical: Strobes back ordered and never arrived. Replaced lab with demo using one available strobe. Appeared to be excellent lab with proper equipment.

Fluid: Took 4 hours to set up. Students had to learn how manometer works, learn how air tank worked, develop a feel for very touchy gas regulator, decipher a poorly labelled table, make three runs, each lasting 10-12 minutes, complete a very complicated write up. Recommend replacing this one.

Electrical: Good introduction in use of oscilloscope. Fast and easy to set up and take down. Kids enjoyed using equipment.

Thermal: Time pressure prevented completion. In order to complete testing of Unit 3 before Christmas vacation, one class period had to be sacrificed for Evaluation. Appeared to be a significant setup time, so this one was it. (#30)

16. Flud: Vague instructions. Time consuming. Inaccurate results. Equipment difficulties. Fragile U-tubes. No vacuum pumps. Did as demo.

Electrical: Our function generators from S-W only produce square and sine wave forms. (#42)

17. Thermal: Substitution - lab on "Heat of Fusion of Ice." (#05)

COMMENTS FOR SUMMARY CLASS

1. Seemed to be well received. Comments on this unit were extremely variable, ranging from this unit really sucked to it was real interesting. The T-shirts arrived and were presentd in class today. Most kids put them on immediately and wore them all day long. (#30)

2. A field trip during the study of RATE was the highlight of this unit. We visited a plastics plant which incorporates all 4 systems. The students observed how industry can, and does, employ these systems they have been studying. From a teacher's viewpoint, the Electrical and Thermal system subunits were the most successful. I think the students would agree that they got more out of these two also. On the whole, the RATE unit was more successful than the previous units on FORCE and WORK. (#36)

3. One of the most useful videos yet. (#60)

4. Summary was very good. (#13)

5. Overall, good unit. I enjoyed teaching this one. (#32)

6. The most enjoyable unit of the three presented. (#40)

7. Why can't units come quicker so we can obtain lab equipment? (#62)

8. A very good prep for the posttest. (#63)

TEXT COMMENTS FROM TEACHER #12

PAGE NUMBER	CONCERN
3	Why resist the use of J/sec along with Btu/hr and cal/sec? Joules work in nicely with N m in WORK and N m/sec in RATE and make for easy conversions in ENERGY also. Then Watts make sense and heat mechanical work, light, etc., all seem interconvertible.
T7b	I never read these pages. They're so vague that I sometimes think you use the same page for every unit. Either leave them out or make the information more specific.
7	I gave each student a colored 5x7 index card on which to write all the formulas for this unit. Then they're handy and easy to look up. Punch hole(s) to keep it in the binder.
7	Hand out a copy of the upper and lower case Greeek letters from a physics text or the <u>Handbook of Chemistry and Physics.</u> Mine is from the Houghton Mifflin physics text for high school.
10	Table 3-1 conversion factors should go on a separate usable conversion factor sheet.
22	Our students have taken Algebra I, so use of exponential notation was easy for them. This can be very tough to teach to general math students.
35	The strobes we ordered from S-W have no flashes/sec setting. They are very hard to read accurately when you have to turn the knob back and forth to "stop" the motion. Don't recommend S.77545. S.77545-21 is easier to use and cheaper to use, too.
36	We went to our IA shop and measured various rotating wheels and disks which are part of the machinery there. And one of our kids pulled his car in the garage door and showed us his timing light.
A-4	Demo on angular rate seems identical to the lab.
54	Why is the answer to ACTIVITYZ not given in proper scientific notation?
T-56	Our trough wasn't shaped like the one shown. I couldn't figure our At = (0.596 in^2) + (3.625)y + (4.821)y. We used our own method to compute the area.
60	Step 3, our results were way off-frustrating for a

$76.00 piece of apparatus.

65 We haven't tried this lab again since you sent an equipment note. We had problems.

66 Step 4. The whole tube isn't $\pm$ 19" long! This seems an incredibly complex lab and its point is lost in the hose clamps conversion tables and data sheets. What is the point? When is an outfit like this used in technology? Our results were very poor, too.

76 Wiring in voltmeters and ammeters should have been learned in an earlier lab with solenoids, but as I remember, it wasn't clearly presented there.

78-79 This section calls for a little sub-lesson on waves in general and their properties of frequency, amplitude, wavelength, and period.

80 Mention universal relation between frequency and period. Might even mention the reciprocal key on many calculators. Given T punch 1/x to get f.

85A Demo the oscilloscope before doing the math lab.

86 This was a very difficult section for many students, so we did the math lab and several worksheets and some individual time with a scope.

101 Our oscilloscope didn't look much like the one on page 101, so I photocopied a page from the manual and gave each student a copy large enough to write notes on.

104 I don't like fractions written as volts/div x div. It's easier to see where the units go when you show it $\frac{\text{volts}}{\text{div}}$ x div.

Those slahses are hard to see sometimes. They just don't convey the idea of divison.

Demo A-15, you have lab jacks for this?

111 Example 3-K is a poor first example. The first sample problems should solve for Qh. You also should say at the start that "5000 Btu" means 5000Btu/hr. It's explained under "solution" which we don't look at right away. We try to work out the problem first, then we read "solution."

Table 3-2; 1 Btu = 1055 J

113 This table will be useful in the RESISTANCE unit (thermal) but it isn't reproduced here. What is given is not as useful.

114 I find these tough to teach, especially in as short a time as is given. The ideas seem to require some labs with calorimeters in order for them to sink in.

122 We did metric conversions much earlier. Isn't this a little late to learn to convert meters to centimeters and so on?

133 Is a DeWar really necessary? Wouldn't it work okay with an aluminum foil lined styrofoam picnic cooler? The DeWars are around $400.00 each. It seems like a pretty dinky lab for the money.

135 We used 24V AC and it took hours to heat up. With 10V 1DC the time threatened to become infinite.

136 Use of cylinder to describe the Al plug was confusing to students. They thought the DeWar was the cylinder.

Data Table "Heat Flow Rate Out Through Aluminum Cylinder."

140 Lab - Add "Go to #8 and predict results." Then later compare your written predictions with actual results.

143 No help (or useful questions) given in interpreting the temperature changes at the bottom of the page.

Practical applications?

PRINCIPLES OF TECHNOLOGY

Unit 4: RESISTANCE

Pilot Test Findings

Agency for Instructional Technology
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Bloomington, Indiana 47402

Center for Occupational Research and Development
601 C Lake Air Drive
Waco, Texas 76710

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 and related print 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 sponosred 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.

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INTRODUCTION

Principles of Techno .gy 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 35 state and provincial education agencies (see Appendix A for a list of participating agencies). The course consists of 14 units, each focusing on a principle that underlies today's technology. 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 members of a special review team (see Appendix B), from consortium representatives, and from teachers and students at classroom pilot test sites. The review team reviews preliminary drafts of the instructional materials before they are sent to consortium representatives and pilot test sites. Consortium representatives review the materials concurrently with the classroom pilot testing. The data from all sources -- review team, consortium representatives, and pilot sites -- are analyzed and reported to the developers, who use these findings to revise the materials.

Thus, an important part of the overall formative evaluation is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working, and 2) to identify specific problems with the materials. All pilot test teachers were oriented to the *Principles of Technology* course and to the pilot test procedures at one of two meetings held in Dallas during the summer of 1984.

This report details the findings of the pilot test of Unit 4: RESISTANCE. The report makes some comparisons of these findings with those for Units 1, 2, and 3, which are contained in separate reports (see "Unit 1: FORCE-Pilot Test Findings," December 18, 1984; "Unit 2: WORK-Pilot Test Findings," March 1, 1985; and "Unit 3: RATE-Pilot Test Findings," April 6, 1985). Finally, when reading this report it's important to remember that the data are formative data and that the developers are using them, along with the reactions of review team and consortium representatives, as a basis for revising the materials.

PILOT TEST PROCEDURES

Unit 4 pilot test materials were mailed to the teachers in mid-November 1984. These materials consisted of:

1) Pretest/posttests (see Appendix C).
2) Computerized scoring sheets for the pre/posttests.
3) Student attitude questionnaires (see Appendix E).
4) Teacher questionnaires (see Appendix F).

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the same test as a posttest and the student attitude questionnaires. All Unit 4 evaluation materials were then mailed back to AIT. Data contained in this report include all material received by April 1985.

LIMITATIONS OF THE METHODOLOGY

Two major limiting factors must be considered when the findings are interpreted: research design and external variables beyond the project's control.

RESEARCH DESIGN CONSTRAINTS

Several factors in the research design must be considered, including:

* Lack of matched control groups.

  The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in terms of time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to matc' *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

* The pretest/posttest format.

  The same test was used for both the pretest and the posttest. The effect that memory of the pretest might have on posttest performance was another concern. The research design addressed this concern in three ways:

  1) Students were not given the correct answers to the pretest. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

  2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

  3) A correlated t-test was used to analyze the pretest/posttest data. This technique helps to partial out any variance that might result from an intruding correlation -- in this case, memory.

* The pretest/posttest as an instrument (See section on development of the instrument, page 7).

  The test cannot measure all objectives. Therefore objectives had to

be sampled. Also, the items do not always directly match the intended objectives. The test was a cognitive test. Many of the objectives (particularly the lab objectives) are psychomotor objectives. One must consider each of these factors when assessing the validity of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

EXTERNAL CONSTRAINTS

Some factors beyond the project's control probably affected the results. Among these factors are:

* Equipment problems.

  As with the previous units, several teachers reported problems in securing necessary lab equipment.

* Student characteristics.

  Teachers and students have reported what appears to be considerable variability in the kinds of students in the course. This variability encompasses students' academic backgrounds, ability levels, and socioeconomic levels. The project has made no attempt to control these variables.

* Teaching pattern.

  Teachers report considerable variability in the length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess their impact on the instructional outcomes.

So, both research design and external constraint must be considered when the results are interpreted. It's important to remember that the pilot test was designed as a part of the overall formative evaluation, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

SAMPLE

The sample included 405 students in 22 sites. Student characteristics included:

* Grade†

  10 = 11%   11 = 66%   12 = 23%

* Sex

  Male = 85%   Female = 15%

Teacher characteristics included:

* Physics background.

  As with the previous units, there was a wide range in the teachers' physics background; 13% reported no college physics courses; 17% reported 1 college physics course; 39% reported 2-4 college physics courses; 9% reported 5-7 college physics courses; and 22% reported 8 or more college physics courses.

* Mathematics background.

  Almost all teachers (95%) have had 2 or more college mathematics courses; several (50%) have had 5 or more college mathematics courses.

* Teaching pattern.

  Over half (64%) taught *Principles of Technology* on consecutive days. Most (72%) taught sessions that were 60 minutes or shorter. Over half (52%) indicated that they had combined several classes into one session.

* Preparation time.

  Over half (56%) indicated they spent 60 minutes or less preparing to teach each subunit on RESISTANCE.

To ensure timely reporting of the results to the developers, arbitrary cut-off dates had to be established for processing and analyzing the data. Because several sites, for a variety of reasons (discussed in detail in the report for Unit 2), were taking longer than originally anticipated to complete the units, the sample dwindled to about 22 sites. Overall, the student and teacher demographics were similar to those reported for Units 2 and 3.

† Due to missing data, the pre/posttest student demographics don't match the student attitude demographics.

PRETEST/POSTTEST AS AN INSTRUMENT

To understand the results, one must first understand the characteristics of the test as a measurement instrument, including the process by which the test was developed and what statistical analysis reveal about the reliability and validity of the instrument.

Over 60 test questions were initiated at CORD by the content specialists. In a collaborative process between evaluators and content specialists these questions were pruned and revised to the eventual 36 questions. Each item is tied as directly as possible to a specific objective from Unit 4. However, it's impossible to match items exactly to some objectives because of the way those objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and the approximations of objectives are often the best that cognitive test developers can do. With only 36 items, not all objectives could be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were determined based on the relative importance of the concepts. (Appendix C lists the objective each item is intended to address above the item.)

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?). The reliability (Spearman-Brown test of internal consistency) of this instrument is .87, which is acceptable by most standards. Validity is a bit more complicated to judge. A factor analysis of the instrument indicated that almost all items were related to discrete factors. This is expected, because most items are tied to separate objectives. Readers are

encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?

2) Is a sufficient range of objectives addressed?

3) Overall, is the instrument a fair measure of Unit 4 instruction?

It should be pointed out that, in examining the pretest/posttest results for each of the first three units, the developers and evaluators encountered a few items in each unit (no more than 3 per unit) that they considered, for various reasons, to be poor items. Of course there is always wisdom in hindsight. Ideally, each of these instruments would itself be pilot tested. However, the project's schedule precludes the luxury of pilot testing the instrumentation. Therefore, even with careful planning, it's probably inevitable that a few poor items will be included in each test.

PRETEST/POSTTEST RESULTS

Several different analyses of the pretest/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 36 items.

MEAN DIFFERENCES

The overall pretest mean was 16.41. The overall posttest mean was 24.42. This increase was statistically significant (correlated t-test) at the .01 level.

The level of statistically significant learning gain (.01) is consistent with the gains shown for Units 1-3. Table 1 compares the pretest/posttest scores for Units 1-4.

Table 1

Unit	Number of Items	Pretest Mean (% correct)	Posttest Mean (% correct)
1	30	12.5 (41%)	20.1 (67%)
2	33	13.6 (41%)	17.6 (53%)
3	30	14.9 (49%)	19.4 (65%)
4	36	16.4 (46%)	24.4 (68%)

Thus, Units 1, 3, and 4 had fairly consistent pretest and posttest scores in terms of percentage correct; Unit 2 was somewhat lower.

INDIVIDUAL ITEMS

For each unit the project team has established criteria for acceptable performance on each test item. These criteria included either:

1) 70%+ correct on an item or

2) doubling of pretest score on the posttest.

In examining the Unit 4 items against these criteria, the results are:

70%+ or doubling of percentage correct - 1, 2, 4, 5, 6, 7, 10, 11, 12, 13, 16, 17, 19, 20, 21, 23, 24, 26, 27, 28, 30, 32, 34, 35, 36

Less than 70% and no doubling of percentage correct - 3, 8, 9, 14, 15, 18, 22, 25, 29, 31, 33

In this formative evaluation effort designed to improve the materials,

it has proved particularly useful to examine the content of the items on which students performed poorly. First, let's examine the items according to subunits.

Mechanical -- Three of six items did not meet criteria.
Fluid -- Two of seven items did not meet criteria.
Electrical -- Two of eight items did not meet criteria.
Thermal -- Two of six items did not meet criteria.
Overview -- Three of nine items did not meet criteria.

Thus, students performed least well on the mechanical and thermal subunits.

In the kinds of items on which students performed poorly, there continues to be consistency from the first three units. These items included:

1) Selected terms. Both mechanical and thermal subunits had some terms that seemed to cause students trouble.

2) SI/English units. These have been troublesome items for students on each of the first four units.

3) Mathematics items. Again, through the first four units, students have exhibited ongoing problems with items that require manipulation of formulas.

Students performed satisfactorily on items related to the unit's broad concepts. However, the detailed terms, units, and mathematical computations caused students the most problems.

PRETEST/POSTTEST BY SELECTED VARIABLES

The impact of several variables on students' test performance was examined, including:

1) Student characteristics.
   a) sex
   b) grade

2) Teaching pattern.
   a) consecutive days
   b) length of class periods
   c) combined activities

3) Teacher background.
   a) physics background
   b) mathematics background

These variables were analyzed with an analysis of covariance, which controlled for pretest scores. Table 2 examines the results of this analysis; all means reported in Table 2 are for the posttest.

Table 2

Main Effect	Level of Significance	Subset	Mean Score
Sex	.02	Boys (325)	24.37
		Girls (49)	25.37
Grade	.25	10th (39)	23.54
		11th (243)	24.67
		12th (89)	24.39
Teaching on consecutive days	.04	yes (284)	24.80
		no (121)	23.66
Minutes per class	.08	LT50 (243)	24.22
		50-60 (55)	26.53
		60-90 (26)	24.54
		90+ (81)	23.74
Combining sessions	.01	yes (96)	27.53
		no (309)	23.50
Teacher's physics background	.04	No classes (72)	23.71
		1 class (71)	25.45
		2-4 classes (177)	23.42
		5-7 classes (22)	25.86
		7+ classes (63)	26.62
Teacher's mathematics background	.01	No classes (--)	-----
		1 class (16)	11.31
		2-4 classes (253)	24.90
		5-7 classes (66)	23.68
		7+ classes (70)	26.61

PRETEST/POSTTEST RESULTS BY SITE

The attached graph (Appendix D) indicates the pretest/posttest results by site. All twenty-two sites showed statistically significant (.01 level) increases. Table 3 examines the number of sites showing no statistically significant gains for each of the first four units.

Table 3

Unit	Sites Showing No Significant Gains
1	1
2	4
3	4
4	0

These findings are very interesting. At this time there appear to be several plausible explanations for the steady increase in sites showing no significant learning gains until Unit 4, at which point there is a dramatic drop in the sites showing no significant gains. Possible explanations include:

- -- Variance may be caused by the tests. Some may be more difficult than others.
- -- Random variance.
- -- Teachers may be becoming more comfortable and adept at teaching the material.
- -- There may be transfer of learning across the first four units.
- -- The school schedule. It seems likely that Units 2 and 3 had longer intervals from pretest to posttest because of holidays.
- -- A combination of the above factors.

The first four units make up less than a third of the two-year course; it will be interesting to see the results, by site, for subsequent units.

STUDENT ATTITUDE FINDINGS

The student attitude findings (Appendix E) indicated:

-- The majority of students (68%) liked the RESISTANCE unit either a lot (15%) or a little (53%). When compared to the first three units, Unit 4 ranks third in terms of student appeal (80% indicated they liked Unit 1; 76% indicated they liked Unit 2; 62% indicated they liked Unit 3). It seems reasonable to expect that, as the novelty of the course wears off, the student appeal ratings will decrease before stabilizing, which seems to have happened through the first four units.

-- The most appealing components were the hands-on labs (33%) and the video programs (29%). These were also the most appealing components for the first three units.

-- The least appealing components were the math labs (28%) and the written materials (24%). Again, these were also the least appealing components for the first three units.

-- Over half said some (49%) or most (11%) of the material was difficult for them to understand. The percentage of students who indicated that most of the material was difficult for them to understand (11%) was lower than for Unit 3 (18%) and only slightly higher than for the first two units (8% for each).

-- As they did with Unit 3, students indicated that the most difficult components for them to understand were the written material (30%) and the math labs (27%). They indicated that the least difficult components for them to understand were the video programs. (Note: Items addressing the perceived difficulty of the components were not included for Units 1 and 2.)

-- Most students (80%) indicated they thought the material in the RESISTANCE unit was important for them to understand; this was about the same percentage as for Unit 3 (77%) but lower than for Units 1 (88%) and 2 (87%).

Thus, the attitude findings for Units 3 and 4 have stabilized at a somewhat lower level than they were for Units 1 and 2. It's likely that the extremely positive attitude findings for the firs two units reflected the novelty of the coruse. Nonetheless, the overall attitude results for Unit 4 could certainly still be classified as positive.

TEACHER RESULTS

Questionnaires were received from 26 teachers (due to team teaching, the number of sites and the number of teachers are not equal). Appendix F, which lists the detailed teacher comments, should be examined carefully, because the wealth of data contained in these comments is difficult to encapsulate. Overall, the teacher findings included:

* Teacher comfort.

  Almost all teachers (92%) indicated that they felt comfortable teaching the material in the RESISTANCE unit.

* Time

  Most (84%) indicated that the 6-day plan of 50-minute class sessions per subunit is a realistic time allotment. Some of the teachers indicated that some of the hands-on labs required more than 50 minutes to set up, conduct, and discuss. This is consistent with the findings for the first three units.

* Student reading.

  Many (72%) indicated that their students may not be doing the assigned readings at home. This is a disturbing finding and is consistent with what teachers (67%) reported for Unit 3.

* Unit 4 compared to Units 1-3.

  Most teachers (74%) indicated that Unit 4 was about the same as Units 1-3. The rest of the teachers were evenly divided; 13% indicated that Unit 4 was better than Units 1-3 and 13% indicated that Unit 4 was worse than the first three.

* Teacher's guide.

  Although most teachers (74%) thought the teacher's guide provided them with enough information to implement the unit successfully, several (28%) said the guide probably did not contain enough information. Generally, those teachers commented that the guide should contain more details on problems presented in the text and on "how to set up the labs."

* Appropriateness for students.

  Generally, teachers tended to indicate that each day of instruction was appropriate for their students. For the videos and C1/C2 days of instruction they were often unanimous in their responses. The majority indicated that the math labs and hands-on labs were

appropriate for their students, but some (10-15%) indicated that they were not. Two exceptions to this finding were the two electrical hands-on labs; teachers were unanimous in considering these labs appropriate for their students.

* Problems.

To the question, "What, if anything, caused you the most problems in teaching the unit on RESISTANCE?" twenty-one teachers responded. The problems reported included:

-- Hands-on labs, lack of equipment, etc. (10 teachers)
-- Need for more detail in the teacher's guide (2 teachers)
-- Students' "unwillingness to do any preparation" (2 teachers)
-- Trying to "get students to relate subject from text" (1 teacher)
-- "Variables used for different forces are different than those in most physics texts" (1 teacher)

Overall, these findings are consistent with the findings for Units 1-3. The hands-on labs continue to cause teachers the most problems. However, teachers continue to affirm the appropriateness of most of the material for their students. Finally, many specific recommendations for changes are contained in the teacher's comments; these are carefully examined by the developers.

CONCLUSIONS

Again, it is important to remember that the entire pilot test is part of the overall formative evaluation process. Data are being collected from the consortium review team, consortium representatives, and from teachers and students at the pilot test sites. These data are then used as a basis for revising the materials. Certainly this report contains much useful information. Some of the key findings include:

1) Overall, a statistically significant (.01 level) learning gain took place. This learning gain was independent of students' grade.

2) Students performed most poorly on test items dealing with mathematics and SI/English units. These types of items have also proved troublesome to students on the first three units.

3) Student attitudes were generally positive. The attitude findings for Units 3 and 4 were very comparable, neither being as high as the attitude findings for Units 1 and 2.

4) Teachers affirmed the appropriateness of most of the material for their students. Again, this is consistent with the findings for the first three units.

5) Teachers' comments indicated that the most problems were encountered with the hands-on labs. Again this is consistent with the findings for the first three units.

6) Teachers recommended many specific changes.

With this much information to report, it is difficult to arrive at a "bottom line." Certainly, much in this report suggests the need to revise the Unit 4 material. However, when taken in sum, the data suggest that the revision should probably be in the spirit of a "tune-up" rather than a major overhaul.

Appendix A

Participating Agencies

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

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

Nebraska Department of Education
Division of Vocational Education

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

TVOntario

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

Utah State Office of Education

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

Virginia Department of Education
Vocational and Adult 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

Review Team

Jon E. Buschko, Technical Instructor
Intel Corporation

Mr. Dick Cassel
Pennsylvania Department of Education

Dr. Joe Exline, Associate Director, Science Services
Virginia Department of Education

Dr. Darrel Parks, Executive Director, Vocational and Career Education
Ohio Department of Education

Mr. Robert Patton, Department of Vocational Education
Oklahoma Department of Education

Dr. Philip Rollain, Consultant, Department of Vocational Education
North Carolina State Department of Public Instruction

Ms. Margaret Sentif, Hinds Junior College, Rankin Center
Pearl, Mississippi

Mr. Don Torney
TVOntario

Mr. Jim Wilson, Assistant Superintendent, Coordinator of High-Tech Center
The Francis Tuttle Vo-Tech Center, Oklahoma

- All numbers in %
- Number above item is objective item is designed to address
- N=405

Appendix C

PRINCIPLES OF TECHNOLOGY
Unit IV: Resistance
Student Test

Pre	Post	Item
		O-2
		1. In each of the 4 energy systems, resistance involves:
13	4	a. a decrease in heat energy
44	83	* b. a force or force-like quantity divided by a rate
19	7	c. a force or force-like quantity multiplied by a rate
23	7	d. a displacement or displacement-like quantity divided by time

O-1
In the left column are descriptions that may or may not involve one of the types of resistance listed in the right column. On your answer sheet, fill in the letter of the type of resistance that corresponds to the numbered description.

Pre	Post	Description		Type of resistance
79	91	D2. Ceramic tile on the space shuttle	A.	Mechanical system resistance
30	58	B3. Turbulence in an air conditioning duct	B.	Fluid system resistance
79	94	A4. Friction in a bearing	C.	Electrical system resistance
87	93	B5. Pipeline pressure differences	D.	Thermal system resistance
68	87	C6. Carbon resistor element		
17	36	A7. Solid object moving through fluid		

Pre	Post	Item
		O-1
		8. In electrical energy systems, the force-like quantity that moves charge to overcome resistance is:
20	6	a. electrical conductivity
38	62	* b. voltage difference
35	30	c. current
8	3	d. a semi-conductor
		O-3
		9. Which of the units below <u>is not</u> a unit of resistance?
13	10	a. $\frac{\text{lb/in}^2}{\text{gal/min}}$
15	26	* b. $\frac{\text{kg/m}}{\text{liter}\cdot\text{sec}}$
29	15	c. $\frac{\text{C}^\circ}{\text{kcal/hr}}$
43	50	d. $\frac{\text{ohm}\cdot\text{cm}\cdot\text{cm}}{\text{cm}^2}$
		M-1
		10. The two types of resistance in mechanical energy systems are:
17	9	a. normal force and coefficient of friction
13	4	b. static friction and insulation
58	82	*c. drag and friction
13	6	d. surface area and surface roughness

(See back of page for questions 11-17)

M-6

11. Drag force on solid objects moving through fluids

Pre	Post		
12	10	a.	increases with increase of the object's speed
13	3	b.	is higher in liquids than in gases
22	13	c.	usually decreases with streamlining of the object
53	74	*d.	all of the above

M-1

12. Dry friction depends on the force that presses two surfaces together and on

Pre	Post		
17	8	a.	the area of the two materials in contact with each other
18	5	b.	the speed at which the two surfaces move past each other
16	40	*c.	the type of material of which the two surfaces are made
49	48	d.	all of the above

M-3

13. Kinetic friction is always _______ static friction.

Pre	Post		
25	59	*a.	less than
42	35	b.	greater than
15	3	c.	equal to
17	4	d.	sometimes greater than, sometimes less than

M-5

14. A plastic box weighing 100 lbs will initially start to slide on a metal truck bed when a push of 50 lb is applied. What is the coefficient of static friction for plastic on metal? (Remember $f = \mu N$)

Pre	Post		
9	3	a.	0.80
47	56	*b.	0.50
3[illegible]	36	c.	2.0
10	5	d.	1.5

M-5

15. A large crate weighs 300 newtons. The coefficient of kinetic friction for this crate moving on a wood surface is 0.5. The force needed to initially <u>start</u> the plate moving on the wood surface is: (Remember $f = \mu N$)

Pre	Post		
41	36	a.	150 N
27	49	*b.	a little greater than 150 N
16	7	c.	a little less than 150 N
16	9	d.	not enough information given to determine

F-2

16. When fluid layers swirl and mix among themselves while flowing in a pipe, the flow is

Pre	Post		
9	2	a.	streamlined
12	7	b.	laminar
60	86	*c.	turbulent
19	5	d.	both a and b

F-8

17. Which of the following factors contribute to fluid resistance in a pipe?

Pre	Post		
10	3	a.	cross-sectional area of the pipe
12	6	b.	length of the pipe
12	3	c.	type of fluid moving through the pipe
66	88	*d.	all of the above

Pre Post

F-4

18. A 25-ft long water hose has a flow rate of 4 gal/min with a pressure drop of 10 lb/in^2. If another identical hose is connected to the first hose, and the total pressure drop across the combined 50 ft length remains the same, the flow rate

33 24 a. will be the same
41 62 *b. will decrease
23 12 c. will increase
(1)

F-9

19. Resistance in a pipe may be decreased and flow rate increased by

22 12 a. avoiding sharp bends and choosing valves and fittings carefully
15 3 b. avoiding scale deposit through treatment or material selection
12 4 c. heating viscous liquids to aid in flow
51 81 *d. all of the above

F-6

20. What is the fluid resistance in a pipe when the flow rate is 36 gal/min and the pressure difference across the pipe length is 4 lb/in^2? ($R_F = \Delta P/Q_V$)

19 43 *a. 0.11 $\frac{lb/in^2}{gal/min}$

30 17 b. 9 $\frac{lb/in^2}{gal/min}$

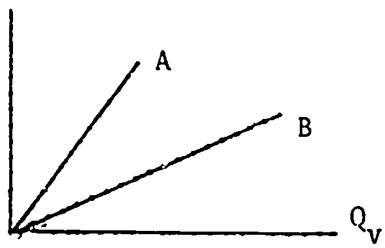
24 16 c. 0.11 $\frac{gal/min}{lb/in^2}$

27 24 d. 9 $\frac{gal/min}{lb/in^2}$

4F1-3 (lab)

21. The graph below shows the pressure drop versus the volume flow rate for pipes A and B. On your answer sheet indicate which pipe has the higher fluid resistance.

43 69 *a. pipe A
56 29 b. pipe B



F-8

22. Fluid resistance in a pipe

21 13 a. decreases as the pipe's length increases
41 68 *b. increases as the pipe's cross-section gets smaller
28 14 c. decreases as the fluid's viscosity increases
10 5 d. does not depend on the nature of the pipe's inner surface

E-1

23. Electrical resistance opposes _______ in electrical systems.

20 11 a. heat energy
17 8 b. insulation
58 80 * c. charge flow
5 2 d. fluid flow

260

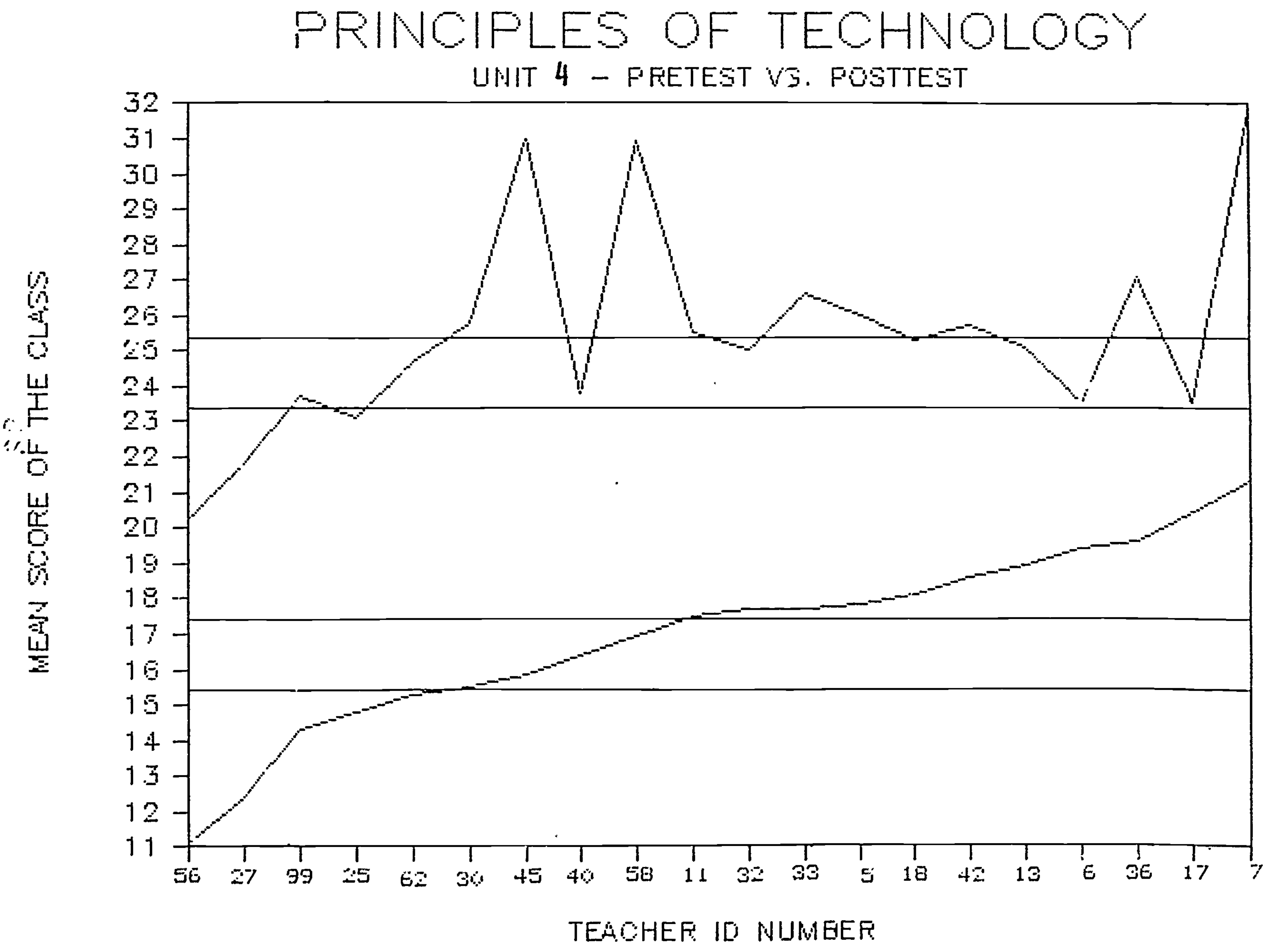
(1) ~% marked d, which was not an option

(See back of page for questions 24-30)

Pre	Post	
		E-3
		24. A correct statement of Ohm's Law in equation form is
21	10	a. $\Delta V = R/I$
20	8	b. $R = (\Delta V) \times I$
41	76	*c. $R = (\Delta V)/I$
18	6	d. $I = (\Delta V) \times R$
		E-5
		25. The resistance of a piece of wire <u>does not</u> depend on
12	5	a. wire material
35	64	*b. wire mass
26	13	c. wire length
26	18	d. wire cross-sectional area
		E-6
		26. The resistivity of a piece of wire depends on
48	71	*a. wire material
18	12	b. wire mass
21	9	c. wire length
17	9	d. wire cross-sectional area
		E-4
		27. The resistance in a circuit is 20 ohms. The voltage difference across the resistance is 100 volts. What is the <u>current</u> through the resistance? (Remember $R = \Delta V/I$)
19	12	a. 2000 amps
15	4	b. 120 amps
16	5	c. 80 amps
49	80	* d. 5 amps
		E-2
		28. In an electrical system, voltage difference is
14	4	a. a true force
55	77	* b. a force-like quantity
17	11	c. a rate
13	8	d. an ohm
		E-4; 4E2-1 (lab)
		29. A 12-volt source is placed across two resistors in parallel. If the resistors have values of 4 ohms and 8 ohms, the total current in the circuit is
27	33	a. 1 amp
19	9	b. 1.5 amps
31	20	c. 3 amps
23	38	* d. 4.5 amps
		E-9
		30. Copper wire and solder are each classified as
67	86	*a. conductors
10	4	b. insulators
11	4	c. resistors
12	7	d. semiconductors

Pre	Post	
		T-1, 6
		31. A defining equation for thermal resistance is
17	10	a. $R_T = \Delta P/Q_V$
23	9	b. $R_T = \Delta V/I$
41	68	* c. $R_T = \Delta T/Q_H$
17	14	d. $R_T = kA\Delta T/\ell$
		T-1
		32. Thermal resistance is the opposition to flow of ________
19	44	*a. thermal energy
24	10	b. molecules
16	11	c. temperature
40	35	d. all of the above
		T-3
		33. The thermal conductivity for a given material is a constant value. It depends on
21	19	a. thickness of material
43	66	* b. type of material
27	11	c. temperature difference across the material
9	4	d. surface area of the material
		T-10
		34. In the equation for heat flow, $Q_H = kA\Delta T/\ell$, ______ thermal conductivity, area or temperature will increase the heat flow rate.
2 53	73	*a. increasing
34	25	b. decreasing
		T-10
		35. In the equation for heat flow, $Q_H = kA\Delta T/\ell$, increasing thickness will ________ heat flow rate.
3 26	16	a. increase
62	81	*b. decrease
		T-8
		36. The higher the R-value rating for a thermal material, the ________ is it's insulating effect.
4 66	87	*a. greater
26	12	b. less

2 -- 13% marked C or D, which were not options
3 -- 13% marked C or D, which were not options
4 -- 8% marked C or D, which were not options


PRINCIPLES OF TECHNOLOGY
UNIT 4 - PRETEST VS. POSTTEST
MEAN SCORE OF THE CLASS
32
31
30
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19
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17
16
15
14
13
12
11
56 27 99 25 62 30 45 40 58 11 32 33 5 18 42 13 6 36 17 7
TEACHER ID NUMBER

Appendix D

n=424

All numbers in percent

Appendix E

PRINCIPLES OF TECHNOLOGY
UNIT 4: RESISTANCE
STUDENT ATTITUDE QUESTIONNAIRE

Sex: 15 Female 85 Male

Grade: ___ 9 11 10 66 11 23 12

1. Overall, did you like the unit on RESISTANCE?

15 yes, a lot
53 yes, a little
21 no, not very much
11 no, not at all

2. What component did you like most in the RESISTANCE unit?

3 the written material
29 the video programs
6 the math labs
33 the hands on labs
23 no preference
6 = more than 1

3. What component did you like least in the RESISTANCE unit?

24 the written material
5 the video programs
28 the math labs
7 the hands on labs
27 no preference
8 = more than 1

4. Overall, was the material that was covered in the RESISTANCE unit difficult for you to understand?

11 yes, most of the material was difficult for me to understand
49 yes, some of the material was difficult for me to understand
40 no, most of the material was not difficult for me to understand

5. Which component of the RESISTANCE unit was the most difficult for you to understand?

30 the written material
9 the video programs
27 the math labs
3 the hands on labs
23 no component was particularly difficult
8 = more than 1

6. Which component of the RESISTANCE unit was the least difficult for you to understand?

5 the written material
44 the video programs
14 the math labs
18 the hands on labs
14 all components were equally difficult
5 = more than 1

7. Do you think the material in the RESISTANCE unit is important for you to understand?

33 yes, very important
47 yes, sort of important
11 no, not very important
9 no, not at all important

8. Do you have any comments about the RESISTANCE unit?

THANK YOU!

n=26

all #s in %

Appendix F

PRINCIPLES OF TECHNOLOGY
UNIT IV: RESISTANCE
TEACHER QUESTIONNAIRE

1. What did you like most about the RESISTANCE unit?

See attached comments

2. What did you like least about the RESISTANCE unit?

See attached comments

3. Overall, how would you compare the RESISTANCE unit to units 1, 2, and 3?

13 better 74 about the same 13 worse

if worse, why?

See attached comments

4. In terms of their overall impact (instructional effectiveness, student interest, manageability) rank each of the components of the RESISTANCE unit using the following scale:

A = Excellent
B = Good
C = So-so
D = Poor
E = Terrible

Place the letter, corresponding to your ranking, next to each component.

A=24;B=68;C= 8 student handbook
A=40;B=44;C=12;D= 4 videos
A= 4;B=39;C=44;D= 4 math labs
E=9

A=12;B=46;C=17
D=17;E= 8 hands on labs
A=20;B=16;C=16 teacher's guide

Please explain any C, D, or E rankings and/or list any other comments you have about the components:

See attached comments

5. Which of your students seem to be the most successful with the Unit IV material?

72 above average 28 average ___ below average

Comments:

See attached comments

6. Based on your experiences, do you think the 6-day plan, per sub-unit, of 50-minute class sessions is realistic for the RESISTANCE sub-units?

 46 yes, definitely   8 no, probably not

 38 yes, probably   8 no, definitely not

If no, please explain:

See attached comments

7. On average, how much time did you spend preparing to teach each class in the unit on RESISTANCE?

 24 0-30 minutes   ___ 91-120 minutes
 32 31-60 minutes   4 121-180 minutes
 36 61-90 minutes   4 131 or more minutes

Comments:

See attached comments

8. Overall, did you feel comfortable teaching the materials in the unit on RESISTANCE?

 60 yes, very comfortable   8 no, not very comfortable

 32 yes, sort of comfortable   ___ no, not at all comfortable

If no, please specify:

See attached comments

9. Do you think most of your students did the assigned readings at home?

 4 definitely 24 probably 60 probably not 12 definitely not

Comments:

See attached comments

10. What, if anything, caused you the most problems in teaching the unit on RESISTANCE?

See attached comments

OVER

11. Do you feel the Teacher's Guide material provided you with enough information to help you successfully implement the unit?

 30 definitely 44 probably 24 probably not 4 definitely not

If no, what should be added to the guide to make it more useful?

See attached comments

12. Did you teach Unit IV: RESISTANCE on consecutive days for 26 days?

 64 yes 36 no

If no, what pattern did you use (for example, 3 days a week)?

See attached comments

13. How much time per session did you teach?

 48 50 minutes or less
 24 51-60 minutes
 12 61-90 minutes
 16 91+ minutes

14. Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

 52 yes 48 no

If yes, which classes did you combine?

See attached comments

15. How many physics courses did you take in college (undergraduate and graduate)?

 13 none
 17 1
 39 2-4
 9 5-7
 22 8 or more

16. How many math courses did you take in college (undergraduate and graduate)?

 ___ none
 5 1
 45 2-4
 27 5-7
 23 8 or more

17. Do you have any other comments, concerns, or suggestions for the unit on RESISTANCE?

See attached comments

The following chart lists each activity for the unit on RESISTANCE down the left column. Since there are no materials specifically for the sub-unit review classes, these classes have not been listed in the chart. For each activity, you should respond to the following questions by circling "yes" or "no":

1) Was the material (readings, labs, or videos) appropriate for your students? Was the material at the right grade level? Was the amount of material appropriate for your students? For any no responses, please use the attached pages to describe your concerns.

2) Were you able to cover the material to your satisfaction in the 50-minute time period? (Since this question doesn't apply to the video, no response options have been provided for the column. Please do respond, however, to the other questions about the video.) For any no responses, please use the attached pages to describe why you could not complete the material and/or what you chose to delete.

3) Were there any errors or inaccuracies in the material? For any yes responses, use the attached pages to specify the errors and recommended corrections.

4) Were there any problems managing the activity? For the labs, were all your students able to rotate through the labs? Did you experience any problems coordinating the labs? Did you experience any problems setting up or tearing down the labs? Did you experience any problems coordinating the activity? For any yes responses, use the attached pages to specify the problems you had and, if possible, suggest changes you feel would enable you to more easily manage the material.

5) Do you have any suggested modifications for the material? For any yes responses, use the additional pages to specify your suggestions. Include in this section any "teaching tips" - special procedures you used or means you discovered to more easily convey the information to students. Include in this section any comments you may have for the Teacher's Guide.

We recommend that you take a few minutes each day to complete the chart and, most importantly, to write down your comments. If you need more space for comments, use the back of the comments pages and/or attach additional sheets.

UNIT IV: RESISTANCE	Appropriate for students?		Completed in 50 minutes?		Any errors or inaccuracies?		Any management problems?		Any suggested modifications?	
Overview										
Video	100 yes	no	--------		yes	100 no	yes	100 no	5 yes	95 no
CO	100 yes	no	95 yes	5 no	yes	100 no	yes	100 no	6 yes	94 no
Mechanical Systems										
Video	96 yes	4 no	--------		yes	100 no	yes	100 no	20 yes	80 no
C1	92 yes	8 no	85 yes	15 no	5 yes	95 no	yes	100 no	15 yes	85 no
C2	100 yes	no	84 yes	16 no	yes	100 no	yes	100 no	yes	100 no
Math Lab	86 yes	14 no	84 yes	16 no	5 yes	95 no	18 yes	82 no	39 yes	61 no
4M1	91 yes	9 no	90 yes	10 no	10 yes	90 no	42 yes	58 no	40 yes	60 no
4M2	86 yes	14 no	79 yes	21 no	16 yes	84 no	44 yes	56 no	36 yes	64 no
Fluid Systems										
Video	95 yes	5 no	-------		yes	100 no	yes	100 no	15 yes	85 no
C1	100 yes	no	90 yes	10 no	yes	100 no	yes	100 no	5 yes	95 no
C2	100 yes	no	89 yes	11 no	yes	100 no	5 yes	95 no	5 yes	95 no
Math Lab	85 yes	15 no	89 yes	11 no	yes	100 no	16 yes	84 no	35 yes	65 no
4F1	85 yes	15 no	77 yes	23 no	5 yes	95 no	42 yes	58 no	20 yes	80 no
4F2	89 yes	11 no	77 yes	23 no	yes	100 no	47 yes	53 no	28 yes	72 no
Electrical Systems										
Video	95 yes	5 no	-------		14 yes	86 no	yes	100 no	20 yes	80 no
C1	100 yes	no	86 yes	14 no	5 yes	95 no	yes	100 no	5 yes	95 no
C2	100 yes	no	81 yes	19 no	33 yes	67 no	5 yes	95 no	10 yes	90 no
Math Lab	95 yes	5 no	86 yes	14 no	yes	100 no	15 yes	85 no	24 yes	76 no
4E1	100 yes	no	85 yes	15 no	5 yes	95 no	10 yes	90 no	5 yes	95 no
4E2	100 yes	no	79 yes	21 no	5 yes	95 no	11 yes	89 no	5 yes	95 no

	Appropriate for students?		Completed in 50 minutes?		Any errors or inaccuracies?		Any management problems?		Any suggested modifications?	
Thermal Systems Video	90 yes	10 no	--------		yes	100 no	yes	100 no	21 yes	79 no
C1	100 yes	no	89 yes	11 no	5 yes	95 no	yes	100 no	5 yes	95 no
C2	100 yes	no	90 yes	10 no	15 yes	85 no	10 yes	90 no	15 yes	85 no
Math Lab	89 yes	11 no	84 yes	16 no	32 yes	68 no	yes	100 no	33 yes	67 no
4T1	89 yes	11 no	77 yes	23 no	17 yes	83 no	21 yes	79 no	28 yes	72 no
4T2	94 yes	6 no	67 yes	33 no	12 yes	88 no	12 yes	88 no	6 yes	94 no
Summary Video	100 yes	no	--------		yes	100 no	yes	100 no	yes	100 no

Comments for Overview Class

See attached comments

Comments for Videos

Overview Video: See attached comments

Mechanical Systems Video: See attached comments

Fluid Systems Video: See attached comments

Electrical Systems Video: See attached comments

Thermal Systems Video: See attached comments

Summary Video:

Comments for C1 Classes

Mechanical Systems C1: See attached comments

Fluid Systems C1: See attached comments

Electrical Systems C1: See attached comments

Thermal Systems C1: See attached comments

Comments for C2 Classes

Mechanical Systems C2: See attached comments

Fluid Systems C2: See attached comments

Electrical Systems C2: See attached comments

Thermal Systems C2: See attached comments

Comments for Math Lab Classes

Mechanical Systems Math Lab: See attached comments

Fluid Systems Math Lab: See attached comments

Electrical Systems Math Lab: See attached comments

Thermal Systems Math Lab: See attached comments

Comments for Lab 1 Classes

Mechanical Systems Lab 1: See attached comments

Fluid Systems Lab 1: See attached comments

Electrical Systems Lab 1: See attached comments

Thermal Systems Lab 1: See attached comments

Comments for Lab 2 Classes

Mechanical Systems Lab 2: See attached comments

Fluid Systems Lab 2: See attached comments

Electrical Systems Lab 2: See attached comments

Thermal Systems Lab 2: See attached comments

Comments for Summary Class

See attached comments

PRINCIPLES OF TECHNOLOGY
UNIT IV: RESISTANCE
TEACHER QUESTIONNAIRE

Question 1 Comments

What did you like most about the RESISTANCE unit?

1. Some explanations were acceptable. (#13)

2. Electrical was good. (#62)

3. I like the way all the factors were tied together. The unifying of equations seems to help students understand the concepts better. (#25)

4. Videos. Written material was well organized but we are seeing more errors. (#33)

5. Video. (#23)

6. It's a subject that I remember most from my physics classes. It seems to be coming together for me now. (#11)

7. The Thermal subunit. (#37)

8. The Electrical subunit. (#36)

9. Finally getting to Electrical RESISTANCE and friction makes me more comfortable that some major high school physics concepts can now begin to fit together. (#30)

10. All okay. (#12)

11. It was all together a valuable unit. I like the Electrical subunit the best because of its practical uses. (#45)

12. The hands-on labs. (#58)

13. The overall material as presented. (#07)

14. Electrical subunit and labs. (#56)

15. Electrical math. (#17)

16. Printed material was easy to understand--good explanations. (#05)

17. This has been one of the better units so far. (#18)

18. Working with electrical resistors. (#08)

19. Subunit on electricity. (#27)

20. The labs 4M2 and 4F2. Also videos. The general review at the end was

helpful, and would be good at the end of each unit. #32)

21. The math aspect had a lot of real application and value. (#40)

Question 2 Comments

What did you like least about the RESISTANCE unit?

1. Math labs and laboratory work. (#13)

2. The labs on fluid pressure do not work well. For one thing it does not emphasize fluid difference which is emphasized in the text. (#25)

3. Problems encountered in getting all lab and demo equipment. (#33)

4. Math form. (#23)

5. We were unable to make effective use of the labs because of late shipments of materials. (#11)

6. The labs need fine tuning and we still have not been receiving our equipment from S-W on time. (#37)

7. The Fluid subunit labs. (#36)

8. When you use "drag" as a mechanical resistance concept, your fluid resistance subunit is seriously compromised. (#30)

9. Thermal labs were tough. Much work, much calculating, no obvious results. (#12)

10. The math labs seemed the hardest to get across to students. (#58)

11. Videos seemed weaker, especially thermal, good show but not much theory. (#56)

12. 4T1 Thermal lab. (#17)

13. Labs were difficult to implement. (#05)

14. Teacher guide not as good as first 3 units. (#27)

15. Demonstrations were virtually useless in this unit. (#08)

16. Some of the labs I had to skip because of equipment being unavailable. (#40)

Question 3 Comments

Overall, how would you compare the RESISTANCE unit to units 1, 2, and 3?

1. Worse, because of the errors in the math. (#63)

2. Maybe a little bit harder to manage due to our problems with equipment. (#37)

3. The fluid subunit labs were worse because we didn't have the proper hoses. (#36)

4. Some errors beginning to appear. Lab equipment has never arrived from supplier, meaning less precise testing of applications lab component. (#30)

5. It was better than Unit 2, the same as Unit 3 from standpoint of importance. (#45)

6. Harder for students to understand. (#05)

7. More mistakes. (#08)

Question 4 Comments

- In terms of their overall impact 'instructional effectiveness, student interest, manageability) rank each component of the RESISTANCE unit.

1. Videos are more motivational than educational. Math labs could have more problems as well as a better variety. (#25)

2. Student handbook does not explain well enough item being studied. Goes right to physics lab. Math labs do not coincide with item being studied. Hands on labs are right out of a physics lab, not applied. (#13)

3. Sometimes it seems that we don't emphasize the application enough. (#11)

4. Math labs contained errors, the equipment used is strictly physics lab type equipment, should we not use equipment that is used in industry that employs the principles being studied? Teacher's guide has math errors. (#63)

5. Math labs are too short. Teacher's guide not very inclusive. (#37)

6. Math labs were too short, equipment didn't arrive or was inadequate for some of the labs. (#36)

7. One math lab activity should really include a problem sheet on predicting resistances in circuit diagram. I want more than one un-dramatic demo per subunit. (#30)

8. Math labs were not appropriate to our math level. (#12)

9. Well the math labs could have been more involved in geometry and trig, for the students with more background in math. So as optional case we had some use for it. (#45)

10. The symbols seem the hardest to get the student to understand. (#58)

11. Math labs too wordy, not enough for students to do. Hands-on labs continue to be ridiculous! Choose materials we are likely to have in state. (#06)

12. Some students are becoming overwhelmed with formulas. I think more examples and practice problems are in order. (#56)

13. Labs do not work well. Math should become progressively more difficult. (#17)

14. Videos sometimes corny. (#55)

15. Videos are corny and kids think they are too simplistic. Math labs were inappropriate, more relevance to printed matter formulas. Labs were hard to implement. (#05)

16. Student handbook is over many students' heads. Math labs are way over students' heads. (#08)

17. Very little teacher information given, Re: labs. (#27)

18. Equipment problems and time. (#40)

Question 5 Comments

Which of your students seem to be the most successful with the Unit IV material?

1. Above average are always successful, average seemed to handle material okay. (#33)

2. However, this does not mean that average and below students do not fare well. The units are successful with the students. (#25)

3. The majority of my class is average or above average. (#63)

4. The "average" student seems to achieve more effectively than in a standard program. The "above average" are going to achieve well anyway. (#30)

5. Algebra skills essential. Also, the above-average student usually is one who is used to paying attention to details. (#12)

6. Obviously students above average felt more successful. (#45)

7. The above average had the least trouble with complete package, average had a little more trouble with math. (#58)

8. Hard for the average student to understand. (#C5)

9. Good math background students enjoy the challenge. (#40)

Question 6 Comments

Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for the RESISTANCE subunits?

1. The sequence keeps everything flowing at a fast pace, which is good in that something new is introduced each day. (#33)
2. Longer period needed for labs. (#62)
3. We teach under a 95 minute every other day schedule. (#11)
4. The labs require time to perform and it is difficult to set-up and clean up in 50 minutes. I feel the labs must be lengthened in time. (#63)
5. Once the kids are in the proper 26-day rhythm, it becomes difficult to slow them down. (#30)
6. I do not teach on this plan (#58)
7. But I sometimes had to extend teaching time on some principles, like drag. (#05)
8. Some of the labs require more than one period for prep, lab work, and discussion of results. (#27)

Question 7 Comments

- On average, how much time did you spend preparing to teach each class in the unit on RESISTANCE?

1. Each unit took me approximately 10 minutes to read. Since the material is presented in a straightforward manner planning was greatly simplified. (#25)

2. When we are doing labs I find it may require more than 3 hours for prep and follow up. (#63)

3. Preparation for lab classes measures into weeks while cooperative shops go into production on some of the equipment. Lecture class prep time is average for new course. (#30)

4. Shop students made the lab 2 apparatus. Lab dry run takes time, but only for first year of the course. (#12)

5. Lots of time spent building apparatus. (#32)

6. Read the lesson twice, check for errors and application. (#40)

Question 8 Comments

Overall, did you feel comfortable teaching the materials in the unit on RESISTANCE?

1. No. Example: Question 9 of test ($ohm \cdot cm \cdot cm/cm^3$)? (#62)

2. We have experienced major difficulties in acquiring lab equipment. I am not at all comfortable about that phase of my work. (#30)

3. I'm not a physics major. (#08)

4. No problems. (#40)

Question 9 Comments

Do you think most of your students did the assigned readings at home?

1. 50%. (#33)

2. One problem is that the units are in large 3 ring binders that are clumsy for them to carry. Therefore it would be advisable for them to be in smaller binders. (#25)

3. I've had to go to quizzes to get students to do the reading. (#11)

4. We have physically lost two students to extended illnesses and I believe that two more may be succumbing to school adjustment problems. (#30)

5. They don't perceive this as a class for which they have to read. (#12)

6. Almost 80% did I think. (#45)

7. We did all the reading in class. (#58)

8. My students read in class because I have 3 hours a day. (#17)

9. Students tended to be lazy. (#05)

10. They're reading more now that they realize they have to. (#42)

11. They do not do homework. (#08)

12. Reading continues to be the #1 problem I'm having. (#32)

13. Had to spend an extra day in review of math formulas. (#40)

Question 10 Comments

What, if anything, caused you the most problems in teaching the unit on RESISTANCE?

1. The labs not doing what we expected. Example: Dewar flask, heating element doesn't generate enough heat to give us a good variance. (#33)

2. The labs. (#25)

3. The labs. (#62)

4. Trying to get students to relate subject from text. Had to use more appropriate experiences. (#13)

5. Math. (#23)

6. Here again the most trouble I had in teaching RESISTANCE was in preparing mye lf so that I was comfortable with the subject. (#11)

7. Not enough ι acher guidance in teacher's guide. Tell us what the experimental results should be, what are realistic answers, for example. (#37)

8. Teacher guide could be a l.ttle more detailed. Teachers are not "all-knowing" in all areas. (#36)

9. Since your equipment list for Units 4-7 arrived so close to the scheduled teaching time for Unit 4, we are unequipped to carry on labs for demos. (#30)

10. Units, Btu, calories, joules, inconsistent or at least hard to compare. (#12)

11. Not enough extra materials and examples for more interested students. But overall I was very comfortable teaching the unit. (#45)

12. All lab materials take time to assemble. We have used very few of your ideas for labs, it's a real pain to face twice a week. (#06)

13. The variables used for different forces are different than those in most physics texts. (#07)

14. My major problem as always is the students' unwillingness to do any preparation at home. (#56)

15. 4T1. (#17)

16. Type of students taking course. They don't study, never have, don't know how, don't understand enough to ask questions. (#55)

17. Labs. (#05)

18. Lack of equipment. (#42)

19. Unfamiliarity with information contained in unit and had probems with the

demonstrations. (#08)

20. Securing or producing special materials or equipment for labs. (#27)

21. Labs. (#40)

Question 11 Comments

Do you feel the Teacher's Guide material provided you with enough information to help you successfully implement the unit? If no, what should be added to the guide to make it more useful?

1. Sometimes more detail could have been provided. (#11)

2. When formulas are used and a problem is demonstrated the teacher's guide should contain complete and correct explanations of problems. (#63)

3. More detail on how to set-up the labs. (#37)

4. Some of the labs take a good deal of thought and study to set-up. Request more detail on instructions. (#36)

5. The lecture classes are beginning to require more from the teacher to hold interest on the part of the students. Recommend more demos, and more interesting ones, be included. (#30)

6. Make clearer Btu/min, J/sec, cal/sec relations and print all data on k, Rt, etc. with all three units. (#12)

7. They were enough but not for above average students, they needed more problems and math examples. (#45)

8. Some teachers might require more information if they do not have a science background. (#07)

9. Put more answers in that are correct. (#42)

10. Should have more background material. (#08)

11. Teacher's guide should indicate a sample of expected results for labs. (#27)

Question 12 Comments

- Did you teach Unit IV: RESISTANCE on consecutive days for 26 days?

1. At least 3 days a week. (#25)

2. Two days a week, 2 hours a day. (#13)

3. 95 minutes every other day. (#11)

4. Four days a week. (#63)

5. Double periods, alternate weeks. Attempted to "stall" awaiting equipment deliveries, which never materialized. (#30)

6. Teach and demo, teach and math worksheet, math lab, lab, lab, wrap-up. (#12)

7. We are set up on 180 minute classes per day. (#58)

8. Normally we would have taught 26 days consecutively. Between 5 snow days and 4 flood days however, this was impossible. (#17)

9. For the most part, but it was difficult due to my illness. (#05)

10. Interrupted by snow but still taught consecutively when in school. (#42)

11. Did not teach math labs. (#08)

12. Required some double days for several lessons. (#27)

13. Took 29 days. (#32)

14. Used two hour blocks and tried to teach twice a week when time would permit. (#40)

Question 14 Comments

Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

1. C2 and math. (#25)
2. C1-C2, math and labs. (#13)
3. Most all. (#23)
4. C1-C2, math and L1, L2 and review. (#11)
5. When we had equipment for the labs we combined them or modified it. (#63)
6. CO-C1-C2, M1-M2, L2-Cs. (#30)
7. Math lab and C1, video with C1 and C2 (at the beginning and at the end). (#45)
8. I taught as much as time would allow. (#58)
9. I did change order i.e., C1, L1, M1, C2, L2, R. Gives me time to review lab work with class. (#06)
10. C1 and C2 classes were combined to allow for abilities of students and to provide more time for enrichment. Math labs were assigned for homework. (#07)
11. C1 and C2 are divided up over 3 40-minute periods. (#56)
12. 4E1 and 4E2. (#08)
13. The two hour block systems allow me to block units together. C1 and C2, labs and math are held in one block. (#40)

Question 17 Comments

- Do you have any other comments, concerns, or suggestions for the unit on RESISTANCE?

1. Increase the number of problems so that a teacher will have a greater choice in problem types. Also, this would keep fast learners from getting bored. (#25)

2. This unit needs improvement. Try to get out of the physics lab and into the real world. (#13)

3. Had to include several standard physics labs to replace those for which equipment was unavailable. Regretfully had to skip several labs for which no successful replacements could be found. (#30)

4. Suggest a mini-lab on finding mu and use of equation. Use blocks of wood plus cloth, pieces of inner tube, metal foil, or shoe soles on floor, carpet, lab table tops, sheet of glass, etc. This is to get an idea where mu values in the table come from. The demo is the lab, I skipped it. Do lab #1 at page 16, then teach and do lab #2. Math Lab page 60, we use the factor label method throughout (and have since the very first unit) so we already knew how to do these. Demo--R of fluids seemed to be the same as the lab so we didn't do it. There should have been no numbers on the bottom of the graph on page 73 to let the students write own scale. Page 78 doesn't allow (data table) for measurements in cm to match force in Newtons. Delta P in inches or cm. Restrictor plate 20% (page 78) sucked the water out of our manometers, so we put all the 20% plates away. Graph on page 79 is set for inches, our manometers were metric; leave the scale on y axis open for students to write in. Demo Electrical R, I didn't do steps 11 and 12. Prefer to teach Ohm's Law first. The demo was to introduce the idea that R increases with length, decreases with diameter. The idea of volts and amps comes later. Page 84, why persist in teaching that electricity is the flow of electrons down the wire? It isn't any harder to teach that it's the flow of charge, and leave the electrons pretty much in place. Page 86, I handed out a copy of the Greek alphabet (from the Houghton-Mifflin Physics text) to help students with omega, rho;, theta, etc. Page 92, equation for R total in parallel circuits is usually given as 1/Rt = 1/R1 + 1/R2 + 1/R3....Why is it given in another form on page 92? How about a universal, all-purpose, all-unit sheet of conversion factors - printed on heavy paper and laminated? It's hard to find the individual conversion factor when they're sprinkled throughout the text. Page 129-130, add a few words on conduction, convection, radiation, and explain how a DeWar prevents them all. Explain a bit why we're going back to heat flow rate on page 130. Just a few words about Resistance = F/Race would do it. Equaton 3 on page 131 can also be read as Rt=1/k, Rt=l, Rt=1/A, then R=1/conduct and C=1/R are easier to teach. Btu·in/hr·ft^2·°F may be used in construction but your lab gives results in cal cm/sec cm C, and the two can't (easily) be compared. Very useful review of fractions and labels before the lab. Page T-151, you can't use the set-up sketched because the wing nuts prevent the insulation and top aluminum plate from resting uniformly on the bottom plate. Add a screwdriver to equipment list to fasten to DP-DT switch. Aren't Tc-A, Tc-B, Tc-B labels mixed up on the DeWar/DP-DT sketch? Wrap up #1 on page 154. Can't compare (readily) since table of given values is in Btu, and lab results

are in calories. Page 157, specific heat worked out okay, even though students barely know what it was. (#12)

5. As far as the units are concerned, I must say, it couldn't be presented better. The unifying concepts and understanding the units were presented excellently. (#45)

6. I liked the relationship of RESISTANCE with the 3 previous units, i.e., how it fit into "unifying principle." (#05)

7. Be more accurate. Get your equipment drawings to the suppliers FASTER. We'd like to be able to use the equipment called for. (#42)

8. Question #15 on test should either say crate or plate, not both. Question #34 should insert word "difference" after temperature. (#08)

9. Labs 4M2 and 4T1 were not done because of lack of proper materials. (#27)

10. Good unit. (#40)

Comments for Overview Class

1. It is a wise idea in terms both of technology and physics to continue to unify the concepts. Technologically, to make memorization easier and scientifically to demonstrate the interrelaion of physical principles. (#30)

2. Helps the students a lot, about what they were going to study, and makes them feel comfortable at the start. (#45)

3. Okay. (#17)

4. Fine-okay. (#05)

5. Ceramic bundle - how can technician handle it if it is at the temperature she says? (#27)

6. Good unit. Some lab problems. (#40)

Comments for Videos

1. Thermal: Why not use infra-red picture of house in winter - something students could relate to. (#62)

2. Overview: Should solve equations instead of just giving them, i.e., Resistance = Force/Rate? Solve this rather than just run over it.

   Mechanical: Explain how drag and friction are figured out. Don't just run it through - solve a problem rather than talk about it. Further explanation of picture on turbulence. Answer questions about friction at end of video. (#13)

3. The videos in this unit were good. I didn't have a complaint with any of them. (#36)

4. Overall I find the videos to be very well done and useful in explaining concepts. (#63)

5. Overview: Real eye catching opening. Cute ending. Not the most interesting or informative middle of the series. (#30)

   Mechanical: Very clever situation employing resistance at opening. Much better interest level than in Overview video. While the live interview is important, it does allow interest to ebb over any length of time.

   Fluid: Music quite effectively used. Interview effective, but could be more so with the youngest looking technician in the place.

   Electrical: Adorable opening. Very interesting, until we get to the very knowledgeable technician, who talks about the film-transfer machine. My kids do not understand aspect ratio. His portion ran several seconds too long. Good ending pedagogically with the 50,000 ohm sign.

   Thermal: Interesting approach with dramatization. Was that really Larry going into the water? Very effective points made during the video because you used dramatically interesting settings and no talking heads; the doctor's presentation.

   Summary: Good review. Very amusing ending. Congratulations on avoiding the understandable impulse of having the actor say "I'm going to scram." (#30)

6. In general I was showing the tape two and sometimes three times during each subunit. I understand that students will benefit more as we go on the book a few days before they look at it, so I would do it frequently.

   Electrical: It was very good, but I felt that we could have used more practical examples, mostly trouble shooting. (#45)

   ll videos were excellent. We viewed all videos at one time at end of eaching plan, and I think it helped the student relate to subject. (#58)

8. Thermal: Reasonably well done. Dramatization of host scene a little too corny. Otherwise okay. (#06)

9. Mechanical: On the part where the man is sanding wood the arrow shown is confusing. Does it indicate the normal force? If so it is in error.

   Electrical: Safety error, connection could cause an explosion if done incorrectly. Ground to the frame of the car. Overall very good.

   Thermal: Language, although real, could cause some problems. (#07)

10. Fluid: I feel the technicians comment on how charge is carried on a wire is misleading. (#56)

11. Okay. We need humor, and keep the personal interviews coming. I particularly like solar panels as a subtle push for solar energy use. (#17)

12. Eliminate corny, kids today are used to a more sophisticated comedy. (#55)

13. Thermal: Parts seemed elementary (too corny). (#05)

14. Battery jump shown is dangerous, could blow up battery. Put pos. cables on first, either batter. Put neg. cable on good battery. Put neg. cable at least 18" away from bad battery on good ground. Remove in exact reverse. (#18)

15. Mechanical: Explain that extra 3000 lbs of fuel is for full range flight.

    Fluid: What is the significance of the hand in the pipe at the end of the tape? Why a wrench?

    Electrical: Electrons likened to a gas? Is this realistic? Bad procedure to connect clamps to battery. Don't attach both to battery, don't connect the terminal covered with corrosion.

    Thermal: Excellent video.

    Summary: Error, tape doesn't move for stated reason, it is pull of the take-up reel. Resistance of one hand on another (applause) is this a good example? (#27)

16. Fluid: Qv should still be flow rate instead of changing to quantity volume. Should not change from one to the other, should be consistent.

    Electrical: Safety violations: welder should wear gloves when welding. In properly hooked up jumper cables should not be hooked up to both terminals of the battery. Follow talking about film transfer machine was totally confusing to teacher and students.

    Thermal: No need for profanity. (#08)

17. All were good. (#40)

Comments for Ci Classes

1. Electrical: Every electrical course book uses E instead of DV. Later transistor courses use DV, but by then students are ready for it. (#62)

2. Mechanical: When using dry friction make a comparison to a lubricant. Students could not see comparisons of a box (dry) and piston (lubricant). Should be consistent.

   Fluid: Not enough info on closed systems. All about pipes carrying fluids to open ends.

   Electrical: In student exercises no graph for question #7, no voltage for question #12.

   Thermal: Fair on heat. (#13)

3. Mechanical: We could use more discussion on drag.

   Electrical: A couple of errors in the student exercises. Item #12 we could not calculate because of inefficient known values. Item #7, there is no diagram.

   Thermal' Calculations were a little difficult here. More instructions would h ~~ been helpful. (#36)

4. Mechanical: As alternative demo relating lubricant and friction: incline one long metallic surface. Increase the incline just until a second metallic object placed on it begins to slide. Measure the height of the incline at which static friction was overcome. Repeat the demo with the surfaces lubricated. Alternate method, try several different lubricants.

   Fluid: Since drag was discussed as a mechanical system, fluid resistance is left weak.

   Electrical: Material appropriate for all students except those from electrical wiring and electronics shops. Some extra material should be provided for them.

   Thermal: Presentation good, material good. (#30)

5. Mechanical: The subunit was excellent, students got more interested in this section than they (showed) did in Fluid and Thermal. I think that was because of feeling of the everyday examples of it.

   Fluid: I think it was enough material, and good.

   Electrical: This section was the most interesting part of the unit for the students. The materials were excellent and easy enough to understand. Students liked it very much.

   Thermal: It was good. (#45)

6. Thermal: It was good. I like the layout of goals and objectives. (#06)

7. Mechanical: I would prefer to use the symobl "F" for force and use subscripts to denote the kind of force, i.e., Ff-friction, Fw-weight, Fn-normal, etc. This would be more consistent with oter physics texts and it would be easier for students to understand. There are many types of forces and when we use a seperate letter without some unifying symbol such as "F" to show forces students have trouble relating concepts. Your explanation of normal force is not clear. The normal force is the force that holds the two surfaces together. Your diagrams indicate that the normal forces as an upward force in reaction (equilibriant) to the downward force of weight (Fw). Normal force and weight force are equal only if the applied force (Fa) is at right angles to these forces (Fig. 1). If the applied force (force producing motion) is at an angle other than 90, the above statement is no longer true. The normal force is equal to the weight minus the vertical component. The same thought holds true for inclined planes. The normal force should be shown as a vector drawn in the same direction as the weight vect so that its value can be shown as the vector sum of the forces that contribute to it, not as an equilibriant force to the weight.

   Electrical: Should introduce rho on page 87, where resulting is introduced. Page 88, equation, note that A is a cross-sectional area. (#07)

8. Mechanical: It is confusing to the kids to define the normal force as the reacton force to the weight and also say it is the force holding the surfaces together. I think it would be clearer if we just said that weight and normal are the same when horizontal and worry about components later. I'd like more workplace applications (this is a general comment for all units).

   Thermal: Kids really blown away with all the formulas and problems here. I don't know what to suggest. (#56)

9. Electrical: Okay, but took more than 2 days. (#05)

10. Electrical: Page 87, resistivity is expressed as rho, but is not explained like pi, mu and ohms are. Why not state Ohm's Law like it was stated by Ohm? (#08)

11. All were good. (#40)

Comments for C2 Classes

1. Thermal: Problem 10, wrong answer in teacher's copy. (#13)

2. Thermal: Student exercise #7, no graph is shown. #12, the voltage source is not clearly shown. (#11)

3. Mechanical: Not enough discussion on drag. No sample problems to do on drag. Kids could have used practice with this. Should go into more detail on drag, turbulence and aerodynamics.

   Electrical: Student exercise #12, you do not give the ΔV. On one of the questions, #7, you don't show a diagram.

   Thermal: Student exercise question #10, you are one exponent off in the answer, answer should be 4.5×10^{-5}. Also, we need to show how to go from ΔT in Celsius to ΔT in Farenheit. (#37)

4. Mechanical: #1 in student exercises as well as friction and drag, show about kinetic and static as alternate choice?

   Fluid: More could have been said about viscosity of fluids. Tech kids should know more about that than just an "oil number."

   Electrical: Page 95, #7 doesn't show graph. Please correct or clarify.

   Thermal: Class demo almost invisible from any distance away. Since temp sensing dots are one-time only, it is difficult or impossible to repeat for those who miss it. Something else, perhaps. (#30)

5. Electrical: It was excellent. There were some errors I found: question #6 on page 95 of student exercises was not clear; question #7 on same page, the graph was not on the page; question #12 on page 96 of the student exercises, should have had ΔV in its given values. (#45)

6. Thermal: But I would prefer to leave some of the lab discussions and material relating to new formulas put in C2 instead of lab. (#06)

7. Electrical: Page 95 student activities, problem #7 refers to a graph that is not found. (#07)

8. Thermal: Student exercises #10-12 contain math errors. (#55)

9. Thermal: Errors on page T-139 problem 10, should be 4.5×10^{-5} and problem 12 should be $40\ C = 40°C \times 1.8°F/1°C = 72°F+32 = 104°F$, thus making the final answer 2,316,288 Btu/hr. (#42)

10. Thermal: In the student exercise #10 and #12, you need to add 32 when converting °C to °F. (#60)

11. Fluid: Demo did not work as it was supposed to. Confetti went to dead air pockets in corners of appartus. Apparatus should be round instead of square. I took a piece of paper towel and wrapped it around the filter to simulate the same thing.

    Electrical: Errors on student exercises: #6, two "b" answers, no "c"

answers. #7, no graph. #11 and #12, voltage should be shown in the circuit rather than given in teacher's manual.

Thermal: Had problems with demo. Demo should be changed somehow. (#08)

12. Electrical: One single strand of wire from lamp cord wire works well for 40 wire.

Thermal: Not done, thermal indicators not available. (#27)

13. Electrical: Question #12, unsolvable. Question #7 incomplete.

Thermal: Question #10, error in answer. (#32)

14. All were good. (#40)

Comments for Math Labs

1. Thermal: Problem 2: 16/3 ÷ 3/16 = 16/3 × 16/3 = 256/9. (#33)

2. I have only one comment for the math labs. Increase the number and scope of the math problems. This way the teacher could select the problems to match the student. For example, a slow student could get more easy problems while a fast student would get less easy problems and do more difficult ones. (#25)

3. Not in the least bit "in tune" with what's being taught. If they can't add and subtract fractions, someone else has screwed up early in education. It would be easier to teach sex ed in this course. (#62)

4. Mechanical: What do speed, velocity and acceleration problems have to do with Resistance? No friction or drag mentioned in any problem.

   Fluid: Is all conversion from one form to another? Nothing about Resistance in fluid system. Very inappropriate math lab.

   Electrical: Okay.

   Thermal: All fractions, no mention of heat transfer. (#13)

5. Mechanical: Okay, but how come it only deals with rate problems? It was too short, however, I liked this math lab the best. Just a little bit more would be better.

   Thermal: Too easy, not long enough. T-146 has a mistake in the 3rd problem, and T-1‹3, last problem, answer should be Kg/sec^{2}m. (#37)

6. Electrical: Could be longer, requires too much supplemental work. (#36)

7. Thermal: Problem #10 should be 5568. Problem #12 converting from °C to °F, you failed to add 32°F. Problem 2, page 146: 16/3 ÷ 3/16 = 16/3 x3/16, 28.9. (#63)

8. Mechanical: The thing I like best about this course (or at least that I like a lot) is the relentless review. Even if the students do not quite get familiar with rate problems during the rate unit, they see them again in an upcoming math lab.

   Fluid: Good practice, no problem. Some kids enjoy the math labs more than any other part of the course.

   Electrical: Recommend adding activity to determine theoretical resistance in various circuit diagrams in parallel and resistance circuits. The activity supplied was very good, however. (#30)

9. Electrical: It was excellent, materials were so important and easy for most of the students to understand. Practical point of view of this section, I think was the basic reason for the students liking it so much. (#45)

10. Mechanical: Use of rate equation now seems out of place.

    Thermal: A little too simplistic. Need more on activity #2. (#06)

11. Mechanical: Use of the term cancel on page 23, divide would be mathematically correct. Cancel would leave nothing, rather than 1 as needed in the operation. Example C page 24, unit conversion should be shown (factor label method). The factor label method is easier for students to understand. Unit conversions and calculation using formulas can be shown by this method. (#07)

12. Mehcanical: Math lab was inappropriate for unit on RESISTANCE (give this in RATE unit).

    Electrical: Okay, but this lab should not have had to deal with multimeters, save it for lab.

    Thermal: Okay, but students felt it was too simple and redundant. (#05)

13. Mechanical: This lab seems more appropriate for the math lab in mechanical RATE.

    Electrical: Question #7 on page 95 has no graph. Cannot be worked unless 6 volts is put on the power supply in question 11.

    Thermal: page 146, 28 4/9. Page 148, kg/sec^{2}m. (#18)

14. Thermal: Error on page T-146, 3rd line from top should be 16/3÷3/16 = 16/3x3/16. Page T-148 should read Kg/sec^{2}m. (#42)

15. Fluid: Proved difficult for some students.

    Thermal: This should be in electrical subunit. (#27)

16. Electrical: Good. It was better to have a math lab that related to the concepts of the section. (#60)

17. Thermal: Problem #2, 3rd answer wrong. (#32)

18. Mechanical: No problem for the better math students.

    Fluid: Problems with pressure difference and formulas.

    Electrical: Formula problems.

    Thermal: Lecture on F° to C° and back. (#40)

Comments for Lab I Classes

1. Thermal: The voltage (15V) didn't seem to generate the heat we needed. (#33)

2. Fluid: Did not use, cannot trust students with water in classroom, made up experiments using air.

   Thermal: Too much like a physics lab, not real world. (#13)

3. We were unable to run the labs as written due to our equipment not being used. However, we did try to improvise on our own to show the principles.

   Fluid: Most of the labs in this unit were not used. This was mainly due to shipment of materials not being complete.

   Electrical: We were able to take resistance reading of several resistors using the VOM DMM and comparing them to the color coding. (#11)

4. Mechanical: The small aluminum plat had burrs on the bottom so that when you pulled the plate it would drag and therefore the spring balance reading was messed up. Also the holes on the plate shouldn't be there because the cord or string in the hole prevented the small plate from lying flat on the large plate.

   Fluid: Our equipment did not arrive. We had to improvise but it worked poorly. We tried to do it as a demo. Not so great. Very frustrating.

   Thermal: Good, except the heater is 120V and by using 15V on the power supply it takes too long for the kids to get a stable reading. Need to increase the voltage. (#37)

5. Mechanical: Good concept but didn't work as well because of the roughness of the plate. Equipment supplier could have done a better job in workmanship.

   Fluid: Another fluid lab disaster, proper equipment didn't arrive.

   Electrical: Electrical labs have been the best so far.

   Thermal: A good lab but the heater takes too long to heat up. Students spend too much time waiting for something to happen. (#36)

6. Mechanical: Since S-W equipment did not arrive, we homemade the slides. We will need to do some surface work on them before next year. Without specifying the quantity of oil to use in the lab directions, our electronics experts miscalculated and innundated us. Just Kuwait until I do this one again.

   Fluid: 3/8" diameter garden hose not available (special order only for $1 a foot). They also do not stock 25' lengths of any garden hoses in this vicinity. Pressure gauges never arrived from S-W. Obviously we did not complete this lab.

Electrical: Did our best on this one without breadboards. Replaced the write-up sheet and attempted to compromise. Results were not discouraging.

Thermal: 1/4" aluminum plate costs $100. Ten minutes doesn't do it. This lab takes about 45 minutes to set up, another 45 minutes to run before any results show. The kids are bored silly, just as they were the last time these "ovens" were out. The idea is good, but the execution needs work. (#30)

7. Mechanical: Include use of slant board and calculate mu from time and theta.

   Fluid: Difficult to see apparent charge in flow.

   Electrical: Standard, why do other three units? Have to have labs so exotic! We have lots of physics equipment to use or adapt.

   Thermal: Lab is too exotic. Could and did use more common lab equipment. (#06)

8. Electrical: Breadboards from S-W are a joke. (#07)

9. Mechanical: Didn't care for this one. Results were very inconsistent and not very conclusive. Also very messy.

   Fluid: Fairly effective lab except for some reason the 50' length always had less resistance according to the graph.

   Thermal: Got a reasonable answer, but could find no value of R to compare it to. (#56)

10. Thermal: Could not get to work. (#17)

11. Need too much preparation time. We are not given that much time. (#55)

12. Mechanical: Okay, I had to readjust the lab to fit the equipment we had available.

    Fluid: We worked the lab without doing it (lack of equipment).

    Thermal: Okay. Used equipment available and adjusted the lab accordingly. (#05)

13. Mechanical: This was not a very good lab. The aluminum plate on the aluminum plate gave varying results and inaccurate of what was to be discussed. The experiment could be better conducted on a cement floor with the plate and weights. (#18)

14. Electrical: S-W solderless breadboard consisted of a piece of white pine plus 12 spring clips pounded into pre-drilled holes. Total rip-off, don't buy!!

    Thermal: Error on page 152, figure 2, lab set up, 2nd drawing of De-War has mislabeled TC-B and TC-A. Page 154 wrap up, there are no K values given in the text for styrofoam insulation. Also, no answers

given for wrap up questions. (#42)

15. Please put more detail on how labs should be set-up. It's hard to tell exactly where some parts are placed.

    Thermal: #1 too long to get warmed up so the student could read a voltage. (#60)

16. Thermal: Not done, no DeWar flask available. (#27)

17. Mechaical: It was extremely difficult to get a reading in the short time it took to pull the plate from one end to the other. Base plate should be much longer and should maybe have a lip on it to keep oil on plate.

    Fluid: I changed the lab and used water pressure of city water. Put a pressure guage on both ends of the hoses and looked at difference in large hose vs. small hose and short hose vs. long hose. A lot simpler.

    Electrical: These two labs could be combined.

    Thermal: Page 153 DT should + C° not °C. The whole lab combines the use of English and SI units so you cannot compare the answers you get with anything in the text. ℓ represents the length of insulation in measurements and thickness in equation, should not represent both. (#08)

18. Lack of equipment. (#40)

Comments for Lab 2 Classes

1. Mechanical: Either a smaller tube or larger objects - we used a substantial wet and dry vac - but the reading we received wasn't noticeable. (#33)

2. Fluid: Did not have equipment for lab. Used my pneumatic robot arm with controlled air flow. (#13)

3. Mechanical: We were unable to run this lab, no equipment again. I was unable to prepare something else. So we discussed what was happening and the purpose of the lab. (#11)

4. Mechanical: Well, same old story, S-W didn't ship the vacuums to us. We borrowed one vacuum and did as demo. Big problem with keeping air out of the bottom of the tube. The vacuum fit in the bottom of the tube, but the vacuum didn't fit flushly and a lot of air was there to prevent the experiment from working.

   Fluid: We did not receive all equipment on time, could not do the lab. (#37)

5. Mechanical: Equipment supplied did not work. We had to modify the experiment and use a vacuum brought from home. Shop vacuums ordered from S-W didn't arrive.

   Fluid: Another failure, no equipment.

   Electrical: Pretty good lab.

   Thermal: Ran out of time. (#36)

6. Mechanical: Without equipment this lab was deleted. We will attempt to test again at a later, convenient date.

   Fluid: Equipment did not arrive, we were unable to Mickey Mouse sufficiently to make an attempt.

   Electrical: Again, no equipment. Did our best to adapt. Worked fairly well, with promise of better luck next time.

   Thermal: Good lab. Time is close enough to 50-minutes to call it clear. Good results, good concept. (#30)

7. Electrical: It was excellent. There was an error on page 121, step 17b. Equation 4 should be written 1/Rt=1/R1+1/R2+1/R3. (#45)

8. Mechanical: This fits better with fluid. We did not do, sub the slant board.

   Thermal: Why pipe? Calorimeter is better suited. (#06)

9. Mechanical: Lab went smoothly. Is there any way to show the air flow over the object, like in a wind tunnel?

   Electrical: Good lab. (#56)

10. Mechanical: Good. Somewhat critical to set up and get to operate properly. (#17)

11. Mechanical: The shapes were too small for the size of the plastic air flow apparatus, so results were not even discernable. I made an airfow tube out of a smaller diameter electrical conduit that gave excellent test results.

    Electrical: Took a little longer than one 50-minute period, so we reviewed the principles as a group during the 2nd lab used on it. (#18)

12. Mechanical: No answers for questions in 4M2. No equipment so I did as a demo using "homemade" equipment.

    Thermal: No answers for wrap up or for student challenge. At least give ball park figures and save us a lot of calculations. (#42)

13. Mechanical: Lab did not work with spring scale suggested in lab. I modified lab using a rubber band and measured distance object moved, but it was still small movement. I was unable to take all readings required.

    Fluid: Readings you get off the scale of the graph given in the lab. Graph should be changed.

    Electrical: These two labs could be combined.

    Thermal: ΔT should = C° not °C on page 161. Water did not have sufficient time to boil and do experiment. (#08)

14. Mechanical: Not done, plastic tube not available. (#27)

15. Lack of equipment. (#40)

Comments for Summary Class

1. Summary class filled the time well reviewing what the unit was all about. (#13)

2. Flu season - lots of absences this time. (#62)

3. Use of the medial summary every few units is good both pedagogically and motivationally. It was well received, as was the entire unit in general. (#30)

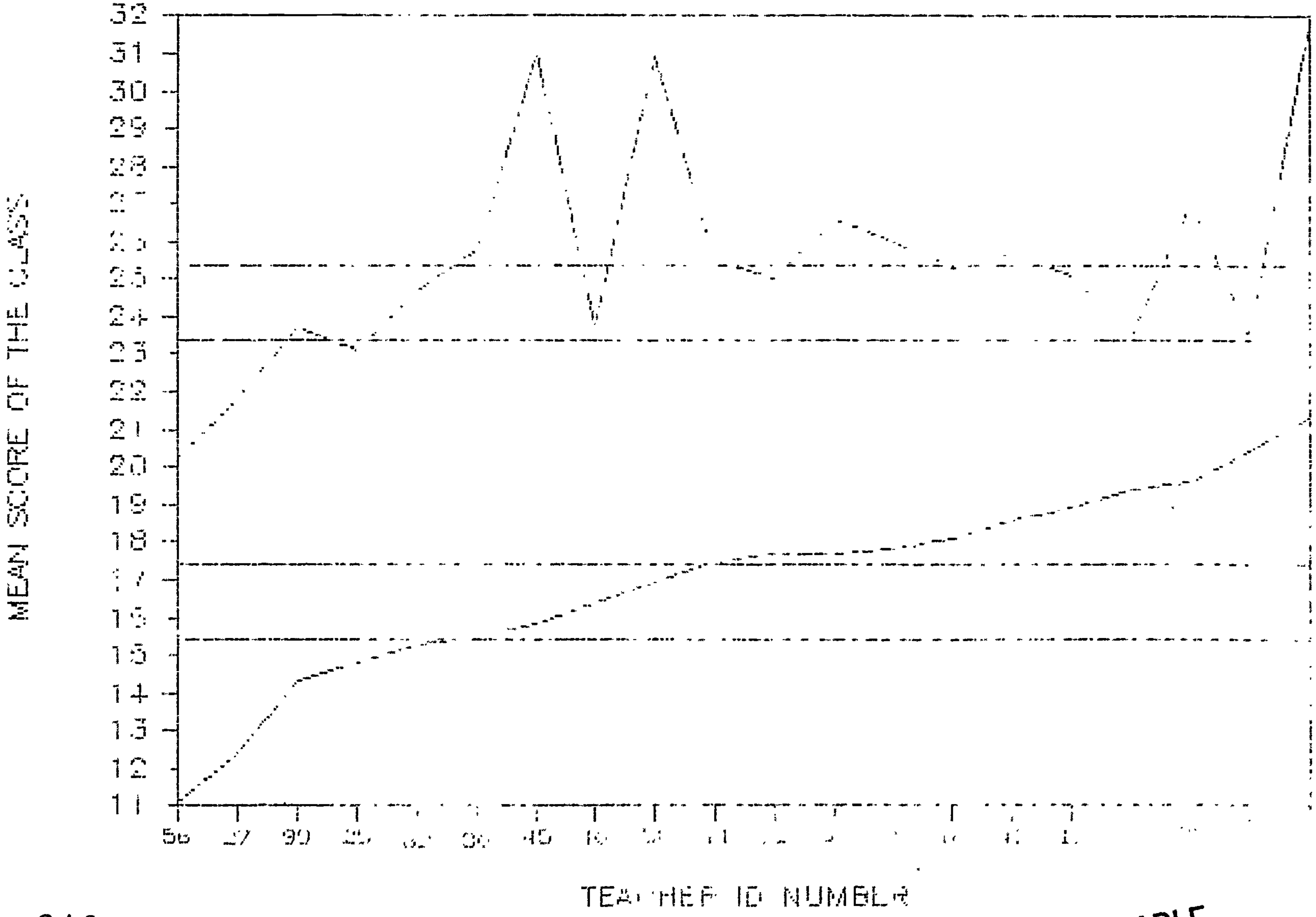
4. They were excellent. (#45)

5. Kind of repetitive. Future summary could include a machine or a device with a discussion and student challenge as ending. (#17)

6. Good. I personally enjoy the student exercises at the end of the presented material, glad to see you making them more challenging. (#05)

PRINCIPLES OF TECHNOLOGY

UNIT 4 - PRETEST VS. POSTTEST



Appendix D

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PRINCIPLES OF TECHNOLOGY

Unit 5: ENERGY

Pilot Test Findings

Agency for Instructional Technology
Box A
Bloomington, Indiana 47402

Center for Occupational Research and Development
601 C Lake Air Drive
Waco, Texas 76710

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 and related print 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 technicans 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.

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Introduction

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 35 state 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. 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 members of a special review team (see Appendix B), from consortium representatives, and from teachers and students at classroom pilot test sites. The review team reviews preliminary drafts of the instructional materials before they are sent to consortium representatives and pilot test sites. Consortium representatives review the materials concurrently with the classroom pilot testing. The data from all sources -- review team, consortium representatives, and pilot sites -- are analyzed and reported to the developers, who use these findings to revise the materials.

Thus, an important part of the overall formative evaluation is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working, and 2) to identify specific problems with the materials All pilot test teachers were oriented to the *Principles of Technology* course and to the pilot test procedures at one of two meetings held in Dallas the summer of 1984.

This report details the findings of the pilot test of Unit 5: ENERGY. The report makes some comparisons of these findings with those for Units 1, 2, 3, and 4, which are contained in separate reports (see "Unit 1: FORCE -- Pilot Test Findings," December 18, 1984; "Unit 2: WORK -- Pilot Test Findings," March 1, 1985; "Unit 3: RATE -- Pilot Test Findings," May 6, 1985; and "Unit 4: RESISTANCE -- Pilot Test Findings," May 29, 1985). Finally, it's important to remember that the data in this report are formative data. The developers are using the data, along with reactions of the review team and consortium representatives, as a basis for revising the materials.

Pilot Test Procedures

Unit 5: ENERGY pilot test materials were mailed to the teachers in mid-December 1984. These materials consisted of:

1) Pretest/Posttests (see Appendix C).
2) Computerized scoring sheets for the pretest/posttests.
3) Student attitude questionnaires (see Appendix E).
4) Teacher questionnaires (see Appendix F).

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the same test as a posttest along with the student attitude questionnaires. All Unit 5 evaluation materials were then mailed back to AIT. Data contained in this report include all materials received by June 1985.

Limitations of the Methodology

Two major limiting factors must be considered when the findings are interpreted: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered, including:

* Lack of matched control groups.

  The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in terms of time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

* The pretest/posttest format.

  The same test was used for both the pretest and the posttest. The effect that memory of the pretest might have on posttest performance was another concern. The research design addressed this concern in three ways:

  1) Students were not given the correct answers to the pretest. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

  2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

  3) A correlated t-test was used to analyze the pretest/posttest data. This technique helps to partial out any variance that might result from an intruding correlation -- in this case memory.

* The pretest/posttest as an instrument (see section on development of the instrument, page 6).

  The test cannot measure all objectives. Therefore, objectives had to be sampled. Also, the items do not always directly match the intended objectives. The test was a cognitive test. Many of the objectives (particularly the lab objectives) are psychomotor objectives. One must consider each of these factors when assessing the validity

of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results. Among these factors are:

* Equipment problems.

As with the previous units, several teachers reported problems in securing necessary lab equipment.

* Student characteristics.

Teachers and students have reported what appears to be considerable variability in the kinds of students in the course. This variability encompasses students' academic backgrounds, ability levels, and socio-economic levels. The project has made no attempt to control these variables.

* Teaching pattern.

Teachers report considerable variability in the length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess their impact on the instructional outcomes.

So, both research design and external constraints must be considered when the results are interpreted. It's important to remember that the pilot test was designed as a part of the overall formative evaluation, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

Sample

The sample included 388 students in 22 sites. Student characteristics included:

* Grade[†]

  10 = 13%   11 = 63%   12 = 24%

* Sex

  Male = 79%   Female = 21%

Teacher characteristics included:

* Physics background.

  As with previous units, there was a wide range in the teachers' physics background; 11% reported no college physics courses; 22% reported one college physics course; 28% reported 2-4 college physics courses; 11% reported 5-7 college physics courses; and 28% reported 8 or more college physics courses.

* Mathematics background.

  All teachers (100%) reported having had 2 or more college mathematics courses; several (50%) have had 5 or more college mathematics courses.

* Teaching pattern.

  About half (47%) taught *Principles of Technology* on consecutive days. Most (90%) taught sessions that were 60 minutes or shorter. Over half (71%) indicated that they had combined several classes into one session.

* Preparation time.

  The majority (79%) indicated they spent 60 minutes or less preparing to teach each subunit on ENERGY.

Since the sample seems to have stabilized at about 22 sites that are roughly on schedule, it's not surprising that the student and teacher demographics were similar to those for prior units.

† Due to missing data, the pretest/posttest student demographics don't match the student attitude demographics.

Pretest/Posttest as an Instrument

To understand the results, one must first understand the characteristics of the test as a measurement instrument, including the process by which the test was developed and what statistical analyses reveal about the reliability and validity of the instrument.

Over 60 test questions were initiated at CORD by the content specialists. In a collaborative process between evaluators and content specialists these questions were pruned and revised to the eventual 35 questions. Each item is tied as directly as possible to a specific objective from Unit 5. The item/objective match is not always exact. It's impossible to match items exactly to some objectives because of the way those objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and that approximations of objectives are often the best that cognitive test developers can do. With only 35 items, not all objectives could be tested. Therefore, objectives had to sampled. Generally, priorities for this sampling were based on the relative importance of the concepts. (Appendix C lists the objective each item is intended to address above the item.)

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?). The reliability (Spearman-Brown test of internal consistency) of this instrument is .89, which is acceptable by most standards. Validity is a bit more complicated to judge. Readers are encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?

2) Is a sufficient range of objectives addressed?

3) Overall, is the instrument a fair measure of Unit 5's instruction?

It should be pointed out that, in examining the pretest/posttest results for each of the first four units, the developers and evaluators encountered a few items in each unit (no more than three per unit) that they considered, for various reasons, to be poor items. Of course there is always wisdom in hindsight. Ideally, each of these instruments would itself be pilot tested. However, the project's schedule precludes the luxury of pilot testing the instrumentation. Therefore, even with careful planning, it's probably inevitable that a few poor items will be included in each test.

Pretest/Posttest Results

Several different analyses of the pretest/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 35 items.

Mean Differences

The overall pretest mean was 13.26. The overall posttest mean was 22.66. This increase was statistically significant (correlated t-test) at the .01 level.

The level of statistically significant learning gain (.01) is consistent with gains shown for Units 1-4. Table 1 compares the pretest/posttest scores for Units 1-5.

Table 1

Unit	Number of Items	Pretest Mean (% correct)	Posttest Mean (% correct)
1	30	12.5 (41%)	20.1 (67%)
2	33	13.6 (41%)	17.6 (53%)
3	30	14.9 (49%)	19.4 (65%)
4	36	16.4 (46%)	24.4 (68%)
5	35	13.2 (38%)	22.6 (65%)

Thus, Units 1, 4 and 5 had fairly consistent pretest-to-posttest learning gains in terms of percentage correct. Learning gain in Units 2 and 3, while somewhat lower, was still statistically significant indicating that a change in the students' knowledge level has occurred in each unit.

Individual Items

For each unit the project team has established criteria for acceptable performance on each test item. These criteria included either:

1) 70%+ correct on an item or

2) doubling of the pretest score on the posttest.

In examining the Unit 5 items against these criteria, the results are:

70%+ or doubling of percentage correct - 1, 2, 3, 4, 5, 7, 8, 9, 10,

11, 14, 15, 18, 19, 21, 26, 27, 28, 29, 32, 33, 34

Less than 70% and no doubling of percentage correct - 6, 12, 13, 16, 17, 20, 22, 23, 24, 25, 30, 31, 35

Because this is a formative evaluation effort designed to improve the materials, it has proved particularly useful to examine the content of the items on which students performed particularly poorly. First, let's examine the items according to subunits.

Mechanical/Fluid I -- Two of eight items did not meet criteria.
Mechanical/Fluid II -- Three of six items did not meet criteria.
Electrical -- Four of nine items did not meet criteria.
Thermal -- Three of six items did not meet criteria.
Overview -- One of six items did not meet criteria.

Thus, students performed least well on the Mechanical/Fluid II and Thermal subunits.

In the kinds of items on which students performed poorly, there continues to be consistency from the first three units. These items included:

1) Selected terms. Both the Electrical and Thermal subunits had some terms that seemed to cause students trouble.

2) SI/English units. These have been troublesome items for students on each of the first five units.

3) Mathematical items. Again, through the first five units, students have exhibited ongoing problems with items that require manipulation of formulas.

Students performed satisfactorily on items related to the unit's broad concepts. However, the detailed terms, units, and mathematical computations caused students the most problems. These findings are generally consistent with the findings for the first four units.

Pretest/Posttest by Selected Variables

The impact of several variables on students' test performance was examined including:

1) Student characteristics.
   a) sex
   b) grade

2) Teaching pattern.
   a) consecutive days
   b) length of class periods
   c) combined activities

3) Teacher background.
   a) physics background
   b) mathematics background

These variables were analyzed with an analysis of covariance, which controlled for pretest scores. Table 2 examines the results of this analysis; all means reported in Table 2 are for the posttest.

Table 2

Main Effect	Level of Significance	Subset	Mean Score
Sex	.02	Boys (282)	23.04
		Girls (76)	21.28
Grade	.02	10th (60)	20.17
		11th (223)	22.80
		12th (74)	24.26
Teaching on Consecutive Days	.22	Yes (287)	22.37
		No (94)	23.57
Minutes per Class	.01	LT50 (248)	21.47
		50-60 (49)	25.55
		60-90 (31)	22.42
		90+ (53)	25.47
Combining Sessions	.02	Yes (69)	25.61
		No (312)	22.02
Teacher's Physics Background	.01	No classes (69)	24.20
		1 class (54)	23.74
		2-4 classes (126)	22.48
		5-7 classes (66)	19.38
		8+ classes (66)	23.83
Teacher's Mathematics Background	.01	No classes (--)	-----
		1 class (--)	-----
		2-4 classes (281)	21.83
		5-7 classes (34)	27.29
		8+ classes (66)	23.83

Table 3 examines these variables for each of the first five units. As Table 3 indicates, student's sex and grade did not have a consistent impact on their test scores. The teaching pattern, including length of class period, teaching on consecutive days, and combining activities, has consistently had a significant impact on students' test scores. It appears from these findings that classes taught on consecutive days and for 50-60 minutes constitute the optimal teaching pattern.

The effects of the teachers' physics and mathematics backgrounds on students' scores have been more difficult to understand. As Table 3 indicates, the teachers' physics background has consistently been a significant

variable. However, the relationship has not been linear; as the teachers' physics background increased, there was not a corresponding increase in students' scores. Therefore, Table 3 labels the effects of the teachers' physics background as inconclusive. The teachers' mathematics background was significant for three units. Therefore, the impact of the teachers' mathematics background has also been labeled inconclusive.

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Table 3

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IMPACT OF SELECTED VARIABLES ON TEST PERFORMANCE

VARIABLE	UNIT/SIGNIFICANT 1	2	3	4	5	OVERALL
Sex	No	No	Yes	Yes	No	Negligible
Grade	No	No	Yes	No	No	Negligible
Consecutive days	Yes	Yes	Yes	Yes	No	Important
Minutes per class	Yes	Yes	Yes	No	Yes	Important
Combining sessions	Yes	Yes	Yes	Yes	No	Important
Physics background	Yes	Yes	Yes	Yes	Yes	Inconclusive
Math background	No	Yes	No	Yes	Yes	Inconclusive

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Pretest/Posttest Results by Site

The attached graph (Appendix D) indicates the pretest/posttest results by site. Twenty-one sites showed statistically significant (.01 level) increases; one site showed no statistically significant gain. Table 4 examines the number of sites showing no statistically significant gains for each of the first five units.

Table 4

Unit	Sites Showing No Significant Gains
1	1
2	4
3	4
4	0
5	1

These findings are very interesting. At this time there appear to be several plausible explanations for the inordinate number of sites showing statistically non-significant learning gains in Units 2 and 3, and the dramatic drop thereafter. Possible explanations include:

-- Variance may be caused by the tests. Some may be more difficult than others.

-- Random variance.

-- Teachers may be becoming more comfortable and adept at teaching the material.

-- There may be transfer of learning across the first five units.

-- The school schedule. It seems likely that Units 2 and 3 had longer intervals from pretest to posttest because of holidays.

-- A combination of the above factors.

Thus, with the exception of Units 2 and 3, the vast majority of sites have shown significant gains on each unit.

Student Attitude Findings

The student attitude findings (Appendix E) indicated:

The majority of students (63%) liked the ENERGY Unit either a lot (16%) or a little (47%).

The most appealing components were the video programs (32%) and the hands-on labs (25%). These were also the most appealing components for the first four units.

The least appealing components were the mathematics labs (34%) and the written material (24%). Again, these were also the least appealing components for the first three units.

More than half the students said some (52%) or most (16%) of the material was difficult for them to understand.

As they did with Units 3 and 4, some students indicated that the most difficult components for them to understand were the mathematics labs (38%) and the written material (21%). They indicated that the least difficult component for them to understand was the video programs (45%). (Note: Items addressing the perceived difficulty of the components were not included for Units 1 and 2.)

Most students (77%) indicated that they thought the material in the ENERGY unit was important for them to understand.

Table 5 examines the student attitude findings from the first five units on three important variables -- appeal, difficulty, and perceived importance. As Table 5 indicates, the attitude findings for Units 1 and 2 were somewhat more positive than for Units 3-5. However, the student attitude findings for all five units would still have to be characterized as fairly positive. Students found each of the units moderately appealing, few (16%) indicated that most of the material was difficult to understand, and, perhaps most important, most continue to affirm the importance of the material they are covering.

Table 5

PRINCIPLES OF TECHNOLOGY
STUDENT ATTITUDES
UNITS 1-5

	UNIT/FINDING				
CATEGORY	1	2	3	4	5
Liked (a lot or a little)	80%	76%	62%	68%	63%
Difficult (most)	8%	8%	18%	11%	16%
Important (very or sort of)	89%	87%	77%	80%	77%

Teacher Results

Questionnaires were received from 21 teachers (due to team teaching, the number of sites and the number of teachers are not equal). Appendix F, which lists the detailed teacher comments, should be examined carefully, because the wealth of data contained in these comments is difficult to encapsulate. Overall, the teacher findings included:

* Teacher comfort.

  Almost all teachers (88%) indicated that they felt comfortable teaching the material in the ENERGY unit.

* Time.

  Most (83%) indicated that the 6-day plan of 50-minute class sessions per subunit is a realistic time allotment. Two teachers indicated that some of the hands-on labs required more than 50 minutes to set up, conduct, and discuss. This is consistent with the findings for the first four units.

* Student reading.

  Many (77%) indicated that their students may not be doing the assigned readings at home. This disturbing finding, consistent with what 67% of the teachers reported for Unit 3 and what 72% reported for Unit 4, raises a question: Are students not doing the assigned readings at home because of an inherent weakness in the material or because of their own constraints (motivation, time, etc.)? Whatever the reasons, several teachers indicated that they allow students time in class to read the material.

* Unit 5 Compared to Units 1-4.

  The majority of teachers (59%) indicated that Unit 5 was about the same as Units 1-4. However, several teachers (35%) indicated they thought Unit 5 was worse than Units 1-4. A couple of those teachers indicated they thought there was too much mathematics in the unit and that it looked like "classic physics."

* Teacher's guide.

  Althought most teachers (76%) thought the teacher's guide provided them with enough information to implement the unit successfully, several (24%) said the guide probably did not contain enough information. Generally, those teachers commented that the guide should contain more details on problems presented in the text and on "how to set up the labs".

* Problems.

To the question, "What, if anything, caused you the most problems in teaching the unit on ENERGY?" seventeen teachers responded. The problems reported included:

- Hands-on labs, lack of equipment, etc. (12 teachers)
- Mathematics labs. Four teachers indicated that they were too difficult.

Overall, these findings are consistent with what teachers reported for Units 1-4. The hands-on labs continue to cause teachers the most problems. However, teachers continue to affirm the appropriateness of most of the material for their students. Finally, many specific recommendations for changes are contained in the teacher's comments; these are carefully examined by the developers.

Conclusions

Again, it is important to remember that the entire pilot test is part of the overall formative evaluation process. Data are being collected from the consortium review team, consortium representatives, and from teachers and students at the pilot test sites. These data are then used as a basis for revising the materials. Certainly, this report contains much useful information. Some of the key findings include:

1) Overall, a statistically significant (.01 level) learning gain took place. This learning gain was independent of students' grade and sex.

2) Students performed least well on test items dealing with mathematics and SI/English units. These types of items also proved troublesome to students on the first four units.

3) Student attitudes were generally positive. The attitude findings for Units 3-5 were similar. All were lower than those for Units 1 and 2.

4) Teachers affirmed the appropriateness of most of the material for their students. Again, this is consistent with the findings for the first four units.

5) Teachers' comments indicated that the most problems were encountered with the hands-on labs. Again, this is consistent with the findings for the first four units.

6) Teachers recommended many specific changes.

Overall, these data were very consistent with the data for Units 1-4. As a formative evaluation effort, this report gives many indications of necessary revisions. The revisions should probably focus on the same areas suggested for Units 1-4 -- the hands on labs and the mathematics labs.

Appendix A

Participating Agencies

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

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

Nebraska Department of Education
Division of Vocational Education

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

TVOntario

Oregon Department of Education
Division of Vocational Education

Pennsylvania Department of Education

Rhode Island State Department of Education
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
Vocational and Adult 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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PRINCIPLES OF TECHNOLOGY
Unit V: ENERGY
Student Test

Pre	Post	
		0-1
		1. When a mechanical, fluid, electrical or thermal system has energy,
14	7	a. the energy is always in the form of heat energy.
13	3	b. the energy is always converted to useful work with an efficiency of 100%.
63	81	* c. part of the energy can be used by the system to do work.
10	9	d. both a & b.
		0-2
		2. The potential energy of an object
21	9	a. increases when its speed increases.
25	6	b. often changes when its position or shape changes.
22	21	c. can be stored for use at a later time.
32	65	* d. both b & c.
		0-3
		3. The kinetic energy of an object
61	83	* a. is energy of motion.
12	4	b. cannot be used to do work on another object
14	5	c. is present in a stretched spring that is not moving.
14	8	d. is always equal to the potential energy of the object.
		0-4
		4. The law of conservation of energy implies that
23	13	a. potential and kinetic energy are always completely changed to useful work in an energy system.
44	69	* b. the total energy of a system remains constant, if all forms of energy are considered.
22	12	c. losses do not occur when energy changes from one form to another.
10	6	d. all heat energy is wasted.
		0-4
		5. Which of the following statements is false?
16	9	a. When work is done on a system, energy is given to the system.
18	8	b. When a system has energy, part of that energy can be used by the system to do useful work.
51	75	* c. When work is done on a system, only potential energy can be given to the system.
15	9	d. When we expend (use) energy to do work, the work we do may result in a different form of energy.
		0-5
		6. Which of the following units is <u>not</u> a unit of energy or work?
17	19	a. a British thermal unit (Btu)
30	13	b. a foot-pound (ft·lb)
28	47	* c. a joule per second (j/sec)
25	21	d. a calorie (cal)

MFI, 1 & 4
The following items in the left-hand column are related to the type of energy described in the right-hand column. On your answer sheet fill in the letter of the type of energy that corresponds to the numbered description in the left-hand column.

Pre	Post	Item
75	93	7. D___ a flywheel that is spinning
75	93	8. B___ a stretched, stationary auto brake-return spring
31	67	9. C___ a pendulum at the very bottom of its swing
39	74	10. A___ water stored behind a dam

a. gravitational potential energy
b. elastic potential energy
c. kinetic energy (translational)
d. kinetic energy (rotational)

MFI, 2
11. What is the gravitational potential energy stored in a 200-lb elevator counterweight hanging 60 ft above the basement in an elevator shaft? (Remember: $E_p = wh$)

Pre	Post	Choice
11	3	a. 60,000 ft.lb
21	5	b. 33.33 lb/ft
10	3	c. 16.66 lb/ft
58	89	* d. 120,000 ft·lb

MFI, 3
12. A spring is compressed 4 inches by a force of 10 lb. If the spring constant $k = F/d$, what is the amount of elastic potential energy that is stored in the spring when it is compressed 6 inches? (Remember: $E_p = 1/2kd^2$)

Pre	Post	Choice
16	10	a. 90 in·lb
42	63	* b. 45 in·lb
26	16	c. 7.2 in·lb
16	11	d. 2.4 in·lb

MFI, 5
13. A 1180-kg automobile strikes a barrier at a speed of 60 mph (26.8 m/sec). How much kinetic energy does the automobile possess? (Remember: $E_k = 1/2mv^2$)

Pre	Post	Choice
18	10	a. 115,813 N·m
26	16	b. 231,624 N·m
39	65	* c. 423,762 N·m
18	10	d. 848,231 N·m

MFI, 6
14. Potential energy of an object may be found by measuring

Pre	Post	Choice
23	7	a. the elastic constant k and the object's speed.
31	63	* b. the work done to raise the object some height above a reference level.
22	8	c. the distance the object moves in a given time.
23	22	d. the mass and speed of the object.

MFII, 1
15. The moment of inertia of a body describes how its ______ is distributed around a specified axis.

Pre	Post	Choice
34	72	* a. mass
18	8	b. kinetic energy
33	15	c. rotational speed
15	5	d. potential energy

Pre Post

MFII, 2

16. The moment of inertia for a solid-disk flywheel is calculated from the formula $I = 1/2\ mr^2$. What is the kinetic energy stored in a 100-kg flywheel of 0.4 radius that is rotating at 600 rpm (62.8 rad/sec)? (Remember: $E_k = 1/2 I\omega^2$)

27 47 *a. 15,775 N·m
30 21 b. 31,752 N·m
30 24 c. 46,628 N·m
14 9 d. 63,504 N·m

MFII, 3

17. In fluid systems, fluid mass is raised to increase potential energy or moved faster to increase kinetic energy. In the energy equations, $E_p = mgh$ and $E_k = 1/2mv^2$, the fluid in mass "m" can be determined if

22 20 a. the displacement and volume of the fluid are known.
30 19 b. the volume flow rate of the fluid is known.
37 53 *c. the density (ρ) and the volume (V) of the fluid are known.
12 8 d. the pressure of the fluid is known.

MFII, 4

18. Mechanical methods of doing work introduce energy into a mechanical system that may cause

14 2 a. potential energy to be stored.
21 11 b. energy to be changed from one form to another.
16 9 c. something to move.
49 78 *d. all of the above.

MFII, 5

19. An object has 2000 ft·lb of potential energy at a height 20 ft above the ground. By the conservation of energy law, this would mean the object possesses ______ as it falls past the 5-ft height above the ground.

18 12 a. A total energy equal to the kinetic energy.
31 15 b. A total energy equal to the potential energy.
31 21 c. 1500 ft·lb of potential energy and 500 ft·lb of kinetic energy.
21 53 *d. 1500 ft·lb of kinetic energy and 500 ft·lb of potential energy.

MFII, 6

20. A force pushes on an object, causing it to pick up speed as it moves along a horizontal surface. Assume that friction is very small. The kinetic energy of the object may be determined completely by measuring

33 56 *a. the work done by the force to move an object.
29 22 b. the speed of the object.
24 16 c. the moment of inertia of the object.
14 6 d. the density and volume of the object.

E1

21. Potential energy in electrical systems is stored

19 9 a. when charge flows through an electrical device.
24 11 b. when a voltage drop occurs across a resistor in a circuit.
43 76 *c. when positive and negative charges are separated from one another in a capacitor.
14 4 d. when a battery is discharged.

E2

22. Capacitors in an electrical circuit

344

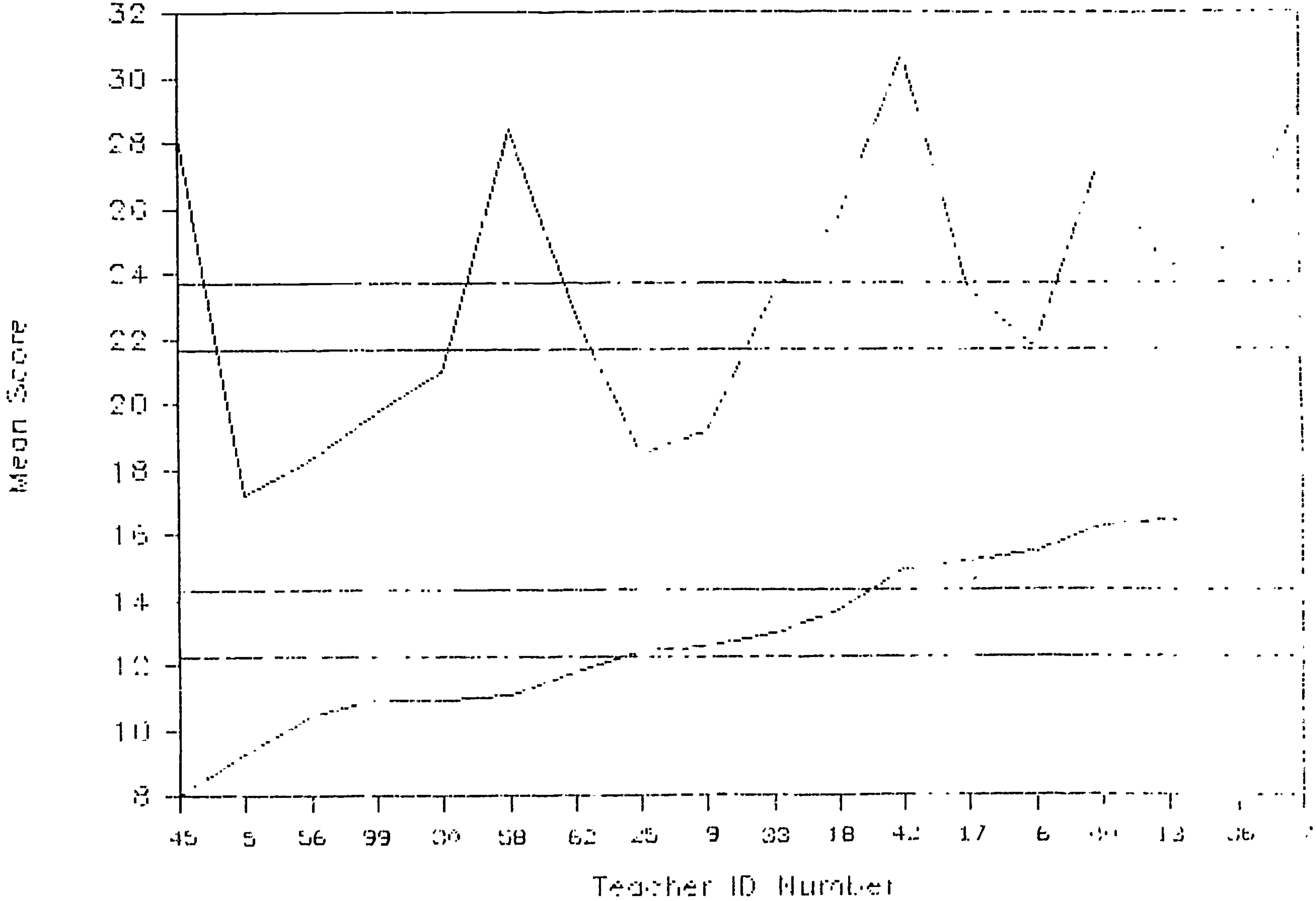
20 9 a. oppose current flow.
20 9 b. always allow AC current to flow freely.
41 67 *c. smooth out voltage changes and store electrical energy.
13 d. are made of coils of wire wrapped around an iron core.

Pre	Post	
		E3
		23. A unit of capacitance is defined as
22	43	a. one farad.
20	5	b. one coulomb divided by one volt.
22	7	c. a unit of charge divided by a unit of voltage.
15	29	*d. all of the above
21	15	e. a & b only.
		E4
		24. How much potential energy is stored in a capacitor rated at 20 μf (20×10^{-6}f) when the voltage difference is 100 volts? [Remember: $E_p = 1/2C(\Delta V)^2$]
22	47	a. 0.10 joules
28	23	*b. 10.0 joules
30	20	c. 100.0 coulomb·volts
20	10	d. 0.01 coulomb·volts
		E5
		25. Inductors in an electrical circuit
26	22	a. are made of parallel conducting plates separated by an insulator.
24	10	b. are used as single-pole, single-throw switches.
25	11	c. oppose resistance changes and store heat energy.
26	58	*d. oppose current changes and store electrical energy.
		E6
		26. Inductance is measured in units of
15	4	a. ohms
45	86	*b. henries
27	7	c. farads
13	4	d. watts
		E5
		27. Inductance for a given coil depends on
16	5	a. the core material.
24	7	b. number of loops in the wire coil.
16	5	c. length and cross-sectional area of the coil.
37	80	*d. all of the above.
6	3	e. none of the above.
		E7
		28. An inductor has an inductance of 8 henries and draws 15 amps of current. What amount of energy is stored by the inductor? (Remember: $E_p = 1/2LI^2$)
27	63	*a. 900 J
31	13	b. 1800 J
27	16	c. 600 J
15	7	d. 300 J
		E8
		29. In electrical systems, work is done to store energy by
19	18	a. moving charge from one plate to another in a capacitor.
20	9	b. pushing charge through an inductor.
19	7	c. charging an automobile battery.
25	50	*d. all of the above.
17	16	e. a & c only.
		T1
		30. When work is done, heat energy is often produced. This heat energy
15	7	a. may be totally wasted.
32	24	b. may be used in part to do work
[illegible]	2	c. is never of concern to a technician
[illegible]	65	*d. both a & b

Pre	Post	
		T2
		31. The mechanical equivalent of heat is
28	27	a. equal to the mechanical energy expended divided by the heat energy produced..
24	14	b. a direct conversion between mechanical energy and heat energy.
24	19	c. a conversion between ft·lb or joules of work to Btus or calories of heat.
22	40	*d. all of the above.
		T3
		32. If a steel ball of mass 2 kg loses 300C° of temperature when dropped in a water bath, how much heat is transferred to the water if the specific heat of steel is 0.11 kcal/(kg·C°)? (Remember: $H=mc\Delta T$)
18	4	a. 11 kcal
30	15	b. 33 kcal
40	76	*c. 66 kcal
12	5	d. 99 kcal
		T4
		33. Heat energy is not transferred by the process of
24	7	a. convection.
41	83	*b. insulation.
22	6	c. conduction.
13	5	d. radiation.
		T5
		34. When a change of state of a material--such as water to ice--takes place, the heat given up is known as
29	57	*a. latent heat of fusion.
23	10	b. sensible heat of vaporization.
33	22	c. latent heat of vaporization.
15	11	d. sensible heat of fusion.
		T6
		35. The total energy of a system
24	34	*a. always remains the same.
26	22	b. decreases with each conversion from one form of energy to another.
22	23	c. is always equal to the kinetic energy plus the potential energy.
27	21	d. depends on how much resistance is present in the system.

PRINCIPLES OF TECHNOLOGY

Unit Five--Pretest vs. Posttest



Appendix D

-29-

Appendix E

n=363

PRINCIPLES OF TECHNOLOGY
UNIT 5: ENERGY
STUDENT ATTITUDE QUESTIONNAIRE

Sex: 21 Female 79 Male

Grade: __ 9 13 10 63 11 24 12

1. Overall, did you like the unit on ENERGY?

   16 yes, a lot
   47 yes, a little
   24 no, not very much
   13 no, not at all

2. What component did you like most in the ENERGY unit?

   6 the written material
   32 the video programs
   6 the math labs
   25 the hands-on labs
   26 no preference
   3 = more than one component

3. What component did you like least in the ENERGY unit?

   24 the written material
   5 the video programs
   34 the math labs
   7 the hands-on labs
   26 no preference
   4 = more than one component

4. Overall, was the material that was covered in the ENERGY unit difficult for you to understand?

   16 yes, most of the material was difficult for me to understand
   52 yes, some of the material was difficult for me to understand
   32 no, most of the material was not difficult for me to understand

5. Which component of the ENERGY unit was the most difficult for you to understand?

   21 the written material
   2 the video programs
   38 the math labs
   6 the hands-on labs
   26 no component was particularly difficult
   7 = more than one component

6. Which component of the ENERGY unit was the least difficult for you to understand?

   11 the written material
   45 the video programs
   6 the math labs
   19 the hands-on labs
   15 all components were equally difficult
   4 = more than one component

7. Do you think the material in the ENERGY unit is important for you to understand?

   36 yes, very important
   41 yes, sort of important
   12 no, not very important
   11 no, not at all important

8. Do you have any comments about the ENERGY unit?

THANK YOU!

Appendix F

n=21

PRINCIPLES OF TECHNOLOGY
Unit V: ENERGY
Teacher Questionnaire

1. What did you like most about the ENERGY unit?

See attached comments

2. What did you like least about the ENERGY unit?

See attached comments

3. Overall, how would you compare the ENERGY unit to units 1, 2, 3 and 4?

6 better   59 about the same   35 worse

If worse, why?

See attached comments

4. In terms of their overall impact (instructional effectiveness, student interest, manageability) rank each of the components of the ENERGY unit using the following scale:

A = Excellent
B = Good
C = So-so
D = Poor
E = Terrible

Place the letter, corresponding to your ranking, next to each component.

A=5;B=79;C=16 student handbook
A=31;B=53;C=16 videos
A=21;B=53;C=11 math labs
D=5;E=10

A=7;B=27;C=33
D=20;E=13 hands on labs
A=6;B=61;C=22 teacher's guide
E=11

Please explain any C, D, or E rankings and/or list any other comments you have about the components:

See attached comments

5. Which of your students seem to be the most successful with the Unit V material?

81 above average   19 average   ___ below average

Comments:

See attached comments

6. Based on your experiences, do you think the 6-day plan, per sub-unit, of 50-minute class sessions is realistic for the ENERGY sub-units?

44 yes, definitely — 11 no, probably not

39 yes, probably — 6 no, definitely not

If no, please explain:

See attached comments

7. On average, how much time did you spend preparing to teach each class in the unit on ENERGY?

21 0-30 minutes
58 31-60 minutes
16 61-90 minutes
5 91-120 minutes
___ 121-180 minutes
___ 181 or more minutes

Comments:

See attached comments

8. Overall, did you feel comfortable teaching the materials in the unit on ENERGY?

44 yes, very comfortable — 11 no, not very comfortable

44 yes, sort of comfortable — ___ no, not at all comfortable

If no, please specify:

See attached comments

9. Do you think most of your students did the assigned readings at home?

6 definitely 17 probably 65 probably not 12 definitely not

Comments:

See attached comments

10. What, if anytning, caused you the most problems in teaching the unit on ENERGY?

See attached comments

OVER

11. Do you feel the Teacher's Guide material provided you with enough information to help you successfully implement the unit?

35 definitely 41 probably 18 probably not 6 definitely not

If no, what should be added to the guide to make it more useful?

See attached comments

12. Did you teach Unit V: ENERGY on consecutive days for 26 days?

47 yes 53 no

If no, what pattern did you use (for example, 3 days a week)?

See attached comments

13. How much time per session did you teach?

58 50 minutes or less
32 51-60 minutes
5 61-90 minutes
5 91+ minutes

14. Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

71 yes 29 no

If yes, which classes did you combine?

See attached comments

15. How many physics courses did you take in college (undergraduate and graduate)?

11 none
22 1
28 2-4
11 5-7
28 8 or more

16. How many math courses did you take in college (undergraduate and graduate)?

___ none
___ 1
50 2-4
17 5-7
33 8 or more

17. Do you have any other comments, concerns or suggestions for the unit on ENERGY?

See attached comments

The following chart lists each activity for the unit on ENERGY down the left column. Since there are no materials specifically for the sub-unit review classes, these classes have not been listed in the chart. For each activity, you should respond to the following questions by circling "yes" or "no":

1) Were the materials (readings, labs, or videos) appropriate for your students? Was the material at the right grade level? Was the amount of material appropriate for your students? For an no responses, please use the attached pages to describe your concerns.

2) Were you able to cover the material to your satisfaction in the 50-minute time period? (Since this question doesn't apply to the video, no response options have been provided for the column. Please do respond, however, to the other questions about the video.) For any no responses, please use the attached pages to describe why you could not complete the material and/or what you chose to delete.

3) Were there any errors or inaccuracies in the material? For any yes responses, use the attached pages to specify the errors and recommended corrections.

4) Were there any problems managing the activity? For the labs, were all your students able to rotate through the labs? Did you experience any problems coordinating the labs? Did you experience any problems setting up or tearing down the labs? Did you experience any problems coordinating the activity? For any yes responses, use the attached pages to specify the problems you had, and if possible, suggest changes you feel would enable you to more easily manage the material.

5) Do you have any suggested modifications for the material? For any yes responses, use the additional pages to specify your suggestions. Include in this section any "teaching tips" - special procedures you used or means you discovered to more easily convey the information to students. Inlcude in this section any comments you may have for the Teacher's Guide.

We recommend that you take a few minutes each day to complete the chart and, most importantly, to write down your comments. If you need more space for comments, use the back of the comments pages and/or attach additional sheets.

Unit V: ENERGY	Appropriate for students?		Completed in 50 minutes?		Any errors or inaccuracies?		Any management problems?		Any suggested modifications?	
	yes	no	yes	no	yes	no	yes	no	yes	no
Overview										
Video	100		---------			100		100		100
CO	100		100			100		100		100
Mechanical Systems										
Video	100		---------		7	93		100	13	87
C1	100		86	14	23	77	23	77	39	61
C2	100		79	21	14	86	27	73	29	71
Math Lab	93	7	79	21	29	71		100	21	79
5MF1	91	9	80	20		100	55	45	37	63
5MF2	90	10	100			100	54	45	30	70
Fluid Systems										
Video	100		---------			100		100		100
C1	100		86	14	7	93		100	8	92
C2	93	7	86	14	7	93		100	8	92
Math Lab	93	7	100		21	79		100	8	92
5MF3	100		86	14		100	55	45	29	71
5MF4	100		88	12		100	50	50	25	75
Electrical Systems										
Video	100		---------			100		100		100
C1	100		100		7	93		100		100
C2	100		100		[illegible]	100		100		100
Math Lab	100		93	7	[illegible]	93		100	8	92
5E1	77	23	79	21	[illegible]	83	38	62	50	50
5E2	100		100			100	40	60	22	78

	Appropriate for students?		Completed in 50 minutes?		Any errors or inaccuracies?		Any management problems?		Any suggested modifications?	
Thermal Systems										
Video	93 yes	7 no	--------		yes	100 no	yes	100 no	yes	100 no
C1	100 yes	no	100 yes	no	7 yes	93 no	yes	100 no	yes	100 no
C2	100 yes	no	100 yes	no	yes	100 no	yes	100 no	yes	100 no
Math Lab	100 yes	no	85 yes	15 no	46 yes	54 no	yes	100 no	17 yes	83 no
5T1	100 yes	no	100 yes	no	23 yes	77 no	21 yes	79 no	15 yes	85 no
5T2	100 yes	no	92 yes	8 no	10 yes	90 no	25 yes	75 no	8 yes	92 no
Summary										
Video	100 yes	no	--------		yes	100 no	yes	100 no	yes	100 no

Comments for Overview Class

See attached comments

Comments for Videos

Overview Video: See attached comments

Mechanical & Fluid Systems I: See attached comments

Mechanical & Fluid Systems II: See attached comments

Electrical Systems: See attached comments

Thermal Systems: See attached comments

Summary Video: See attached comments

Comments for Cl Classes

Mechanical & Fluid Systems I Cl: See attached comments

Mechanical & Fluid Systems II Cl: See attached comments

Electrical Systems Cl: See attached comments

Thermal Systems Cl: See attached comments

Comments for C2 Classes

Mechanical & Fluid Systems I C2: See attached comments

Mechanical & Fluid Systems II C2: See attached comments

Electrical Systems C2: See attached comments

Thermal Systems C2: See attached comments

Comments for Math Lab Classes

Mechanical & Fluid Systems I Math Lab: See attached comments

Mechanical & Fluid Systems II Math Lab: See attached comments

Electrical Systems Math Lab: See attached comments

Thermal Systems Math Lab: See attached comments

Comments for Lab 1 Classes

Mechanical & Fluid Systems I Lab 1: See attached comments

Mechanical & Fluid Systems II Lab 1: See attached comments

Electrical Systems Lab 1: See attached comments

Thermal Systems Lab 1: See attached comments

Comments for Lab 2 Classes

Mechanical & Fluid Systems I Lab 2: See attached comments

Mechanical & Fluid Systems II Lab 2: See attached comments

Electrical Systems Lab 2: See attached comments

Thermal Systems Lab 2: See attached comments

Comments for Summary Class

See attached comments

PRINCIPLES OF TECHNOLOGY
UNIT V: ENERGY
TEACHER QUESTIONNAIRE

Question 1 Comments

What did you like most about the ENERGY unit?

1. Diagrams illustrating the various types of energy in the different systems. (#09)
2. Videos, written materials were good. (#33)
3. Reading material simply written. (#13)
4. All of it, especially Mechanical and Electrical subunits. (#45)
5. Nice sequence fit, seems to get difficult in math lab. (#06)
6. Good handling on Mechanical and Fluids. (#17)
7. Content. (#07)
8. The math had a relative relationship to something students understand. (#40)
9. The labs in the thermal unit. (#08)
10. The math. (#18)
11. It seems to tie things together very well. You can see understanding in the students. (#38)
12. The information was easy for the students to understand and easy to explain. (#05)
13. The Electrical subunit even though the lab seemed to be difficult for the students. (#36)

Question 2 Comments

What did you like least about the ENERGY unit?

1. The fact that lab equipment wasn't available on time, in fact, we still don't have it. (#33)

2. The subunit of moment of inertia needs further explanation. (#09)

3. Math labs. (#13)

4. Not having advanced problems for the prepared students. (#45)

5. Exam, read comments for summary. (#62)

6. Having no equipment because the design plans were late getting to the suppliers. (#42)

7. We lacked "stuff" for Electrical unit labs. Math labs too tough, gradiate them easy to hard. (#06)

8. Electrical section for the most part is too general. (#17)

9. Too much math and too many example problems, at least for the level kids I have in class. They enjoy most of the theory and applicaton but get frustrated with the formulas and math. (#56)

10. Demonstrations could be more dramatic. There are particularly effective demos for moment of intertia. (#30)

11. Electrical subunit. (#17)

12. The lack of equipment to do the experiments. (#08)

13. Problem with equipment supply. (#13)

14. The fact that we didn't have the equipment to complete some of the labs. (#36)

Question 3 Comments

Overall, how would you compare the ENERGY unit to units 1, 2, 3 and 4? If worse, why?

1. Reading material and labs did not coincide. (#13)

2. We are experiencing burnout, our spring break fell in middle of unit. We are so far behind. You need to schedule time for tests. (#06)

3. More mistakes and omissions.

4. Too general and lacks application in real world. (#40)

5. This unit was the most difficult for me. There was too much math and physics with unit 6 application. This was mostly due to the fact that we didn't have the equipment. (#36)

6. It was presented like "classic physics" and we lost some kids in this unit. As an example, look at page 21, it looks very threatening. (#37)

7. It seemed too long. (#05)

Question 4 Comments

In terms of their overall impact (instructional effectiveness, student interest, manageability) rank each of the components of the ENERGY unit. Please explain any C, D, or E rankings.

1. Videos did not always seem to cover enough (for exmaple the video on thermal). Labs are too complex for most of the students (at least some are) e.g., hydraulic accumulator, flywheel generator. (#25)

2. The hands-on labs would be better if we could do everything. (#33)

3. Labs did not coincide with reading material. Teacher's guide was sketchy in a lot of areas. (#13)

4. How many schools allow use of calculators for math labs and exams? Who furnishes the calculator? (#62)

5. Math lab could have had more advanced problems for the interested students. Teacher's guide could have had more theoretical and practical examples. (#45)

6. Math labs are just tough problems, no remedial or progressive skills attend to. Labs continue to need exotic set ups -- get practical. (#06)

7. Videos are getting too redundant in electrical. (#17)

8. The flywheel lab was excellent but the others need work. The fluid labs were a pain in the neck and just didn't work well. (#56)

9. Demonstrations could use improvement. (#30)

10. Students and teacher are getting extremely tired of PT. (#08)

11. Could use a little more explanation in some areas of teacher's guide. (#18)

12. Videos were okay, but seemed long and drawn out. Equipment is still a problem. (#05)

13. Equipment not here, we couldn't do many of the labs. Some labs still have kinks in them. Teacher's guide, not nearly enough guidance. (#37)

14. Instructions to the teacher and students were not detailed enough. The teacher's guide assumed that he/she knew everything. (#36)

Question 5 Comments

Which of your students seem e most successful with the Unit 5 material?

1. While the above av rage student did best, motivation was the most important part. Those below average students who were motivated to do the work fared much better than the avverage student who lacked motivation. (#25)

2. Third trimester, several more students dropped because of scheduling and ________ . (#33)

3. The unit was basically adequate for the average students, but the above average naturally were more successful, just because of their effort and spending more time studying it. (#45)

4. We are really losing the below average student. (#18)

Question 6 Comments

Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for the ENERGY subunits?

1. When and if I ever get lab material, not enough time for labs. (#62)

2. Pretest, posttest both need scheduled time. (#06)

3. Some of the labs needed more time than just 1-60 minute period. (#05)

Question 7 Comments

On average, how much time did you spend preparing to teach each class in the unit on ENERGY?

1. This is difficult to say since some require more thought than others. (#[illegible])

2. As prepared as I was the problems in the math labs would take 3 days. (#06)

3. Strong math background. (#40)

Question 8 Comments

Overall, did you feel comfortable teaching the materials in the unit on ENERGY?

1. Continued to work very hard, but feel comfortable as we go through each unit. (#33)

2. No way to build your experiment. Took voc-ed teacher 3 weeks to assemble accumulator. (#06)

3. I had difficulty in following the content. Even though I average about an hour preparing some lessons took longer due to a lack of understanding. (#36)

Question 9 Comments

Do you think most of your students did the assigned readings at home?

1. Mostly they were done in class. (#09)

2. About 80% of my students, I think did the assigned readings, and of course they were more successful. (#45)

3. ~~They are bogged~~ down following example probl s. Can you consider programming some of the problems? (#06)

4. We read in class. (#17)

5. At this point, reading to them is not necessary. (#05)

Question 10 Comments

What, if anything, caused you the most problems in teaching the unit on ENERGY?

1. Lack of equipment. (#09)

2. The math. Students who couldn't do simple algebra or fractions have a lot of difficulty doing the problems, which frustrates them. My own opinion is that either more emphasis be placed on bringing these students to a competent level of math ability for the material covered or that the mathematics be somehow made to be less involved. I would like to see problems on three separate scales from easy to moderate to difficult and so labeled. That way a student could progress from the easy to the difficult at his or her own pace. This would also help with motiviaion because the slow learner, who could do the easy problems, would probably be more likely to try the moderate problems and so on, just as the average student after doing all the moderate problems, would probably be inclined to try the more difficult problems. (#25)

3. Understanding some of the formulas and the lack of lab equipment. (#33)

4. Labs, math and experiments. (#13)

5. Basically nothing. But if there were more problems, especially in sub-units 1 and 2, it would have been easier. (#45)

6. Interactions in examples, blanks with answers on next page. (#06)

7. Nothing in particular. (#17)

8. Lab set up and student responses to the problems. (#56)

9. We didn't have the equipment for the labs. (#07)

10. The lack of specialized lab equipment led to skipping over lab experiences in the text. Without a lab component, the course does not teach well. Word for the future: Do not adopt P/T unless you are willing to pay for the needed equipment. (#30)

11. Some of the math equations. (#40)

12. The lack of equipment to do the experiments. (#08)

13. The lab experiments, hold up because of equipment; that is why we are so far behind. (#18)

14. Not having equipment. (#39)

15. The lab equipment. (#05)

16. Labs. (#37)

17. Lack of equipment for demonstrations and labs. There was not enough time to adapt new things. (#36)

Question 11 Comments

Do you feel that the Teacher's Guide material provided you with enough information to help you successfully implement the unit?

1. Definitely to finish the unit, but as I said before, a little more theoretical problems would have helped me more with the above average students. (#45)

2. Get rid of the mistakes. Add some approximate values for labs. (#42)

3. Lab info needs to be more specific. We're building most of the labs and it would be helpful to have more details, i.e., discussions, ranges, anticipated error, etc. (#56)

4. More, and more, dramatic demonstrations. (#30)

5. Why were inductors introduced and then nothing done with them? (#18)

6. More guidance in labs. (#37)

7. You need more explanation on how to set up the lab and possible substitute labs. (#05)

8. More detail in the instruction. (#36)

Question 12 Comments

Did you teach Unit V: ENERGY on consecutive days for 26 days? If no, what pattern did you use?

1. It had to be varied to fit into the shops' curriculum but was included at least 3 days per week, though on average probably 4 days a week. (#25)
2. Longer time period, periods cancelled. (#62)
3. Also had spring break, state mandate tests. (#06)
4. Yes, consecutively but it took more like 34-35 days. (#56)
5. We did not take the full 26 days for the unit because we had to omit some of the labs due to lack of equipment. (#07)
6. Double periods, alternate weeks. (#30)
7. 2 hours per day, 2 days per week. (#40)
8. We skipped the math labs and labs we did not have equipment for. (#08)
9. It took more than 26 days because of experiments. Filled in with research work in technology, wind tunnel tested model cars; flow tested in a stream; designed and implemented a test for car valve springs. (#18)
10. No lab equipment shortened unit. (#38)
11. Normally yes, but some intervening because of school testing, etc. (#05)

Question 14 Comments

Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)? If yes, which classes did you combine?

1. C1 and C2 in most units. (#13)
2. Mostly C1 and C2, also showing the videos at least twice during each subunit. (#45)
3. C1, C2, lab and prep over a 3 day period. (#56)
4. CO, C1, C2; M1 and L1; L2 and R. (#30)
5. Lecture units and lab units. (#40)
6. SMF1 and SMF2. (#08)
7. C1 and C2. (#38)
8. SMF3 and SMF4, SE1 and SE2. (#05)
9. C1 and C2. Sometimes the overview was combined with C1. (#36)

Question 17 Comments

Do you have any other comments, concerns or suggestions for the unit on ENERGY?

1. Page 17, no justification for $Ep=1/2kd^2$. A lot of students wanted to know why. Page 21, problem 10, a good problem for advanced students, but a stumper for average an below. This proved to be a waste of their time. Again, if problems were ranked then students could choose the ones they could do themselves first and feel positive about something. Test problem 11 is wrong. Ep=wh=12,000, not 120,000. This was pointed out by some of the better students. Page 57, look at the formulas for I. The book uses 1 for I, evidently a typo. Page 30 DP should be DV. (#25)

2. I would not dump these problems on a well prepared physics class. When the math labs were remedial they were better accepted. (#06)

3. No, basically an excellent unit overall. (#17)

4. Give me more concrete examples and everyday applications and less problems. (#56)

5. About halfway through Unit 5 the Unit 5 materials list arrived. By the time we were 3/4 through Unit 5 the Unit 4 equipment was delivered. Can I have a new schedule? (#30)

6. Good unit. (#40)

7. Problem #11 on the test has no correct answer. D should be 12,000 ft lb. (#08)

8. Do something with inductance. (#18)

Comments for Overview Class

1. I think it was excellent. Maybe it could have been a little longer and had more examples. (#45)

2. Good. (#17)

3. No problems. (#30)

4. Good unit. Energy and insulation had meaning to students in North Dakota. (#40)

5. It was okay. (#18)

6. Put page T-9 into the student text before p. 13 and again on page 13. (#37)

Comments for Videos

1. In general if the videos are shown at least twice during C1 and C2 classes it would have more use for the students. Probably once before the start and once after the lecture, when students become more familiar with the concepts. Generally they were good, and we could have used more examples. (#45)

2. All well done, informative and thought provoking. (#06)

3. All were okay, summary video was excellent. (#56)

4. All were okay.

   Electrical: Need more electricity applications we haven't seen before.

   Summary: Too redundant. (#17)

5. All were very good. (#07)

6. Overview: As a group, the overviews tend to be less interesting than the subunit videos.

   Mechanical & Fluid I: Very good.

   Mechanical & Fluid II: Kicker was too much. Kids reacted negatively to that part of the video.

   Electrical: Nice illustration of capacitor. Kids reacted positively to the light moments. Nicely done.

   Thermal: Positive student reaction.

   Summary: Good review for just before the test. Cute ending. (#30)

7. Electrical and Thermal: Hard for slower students to understand. (#40)

8. Mechanical & Fluid I: Screwdriver falling off the building would not land point down.

   Thermal: Could do without showing a person smoking a cigarette. (#06)

9. All were okay. (#18)

10. All the videos were pretty good. (#36)

Comments for C1 Classes

1. Mechanical & Fluid I: Page 13, block middle of page uses small m for both mass and meters (confused students).

   Mechanical & Fluid II: Same complaint as in C1, page 60. (#13)

2. Mechanical: 9 lines from bottom (gravity due to apple's weight), should be mass. (#45)

3. Electrical: Error on page 99, example 5-O, part b, final Ep = 1.224 joules, not 1.44.

   Thermal: Error on page 133, end of step 1, Ek should be 10,355.8 not 10,350. (#42)

4. All were excellent. (#17)

5. I'm not sure about the combining of mechanical and fluid. I would have had time to do rotational before the labs in Mechanical and I think the Fluid could have been beefed up to fill 2 class periods. (#56)

6. Mechanical & Fluid I: Exammple 5-B on pages 14-15: you do not make it specific that "2000 kg" of water is to be considered mass rather than weight. This means that the students have difficulty understanding why you use w/g k instead of m h.

   Mechanical & Fluid I: Well done. No apparent problems.

   Electrical: Students in electronics shops already know far more about what capacitors do than given in text. One might cite reference material so that we can answer the question "Why do we have to read it if we already know it?" while still teaching the basics to our machinists and mechanics.

   Thermal: Where you mention "bimetallic strips" show one. List it as a demo. (#30)

7. All were good.

   Electrical and Thermal: Hard. (#40)

8. Mechanical & Fluid I: In order to cover objective 3 reading should go to page 20. Errata sheet shows a correction on page 15 that should be on page 16.

   Mechanical & Fluid II: Page 57 Figure 5-13, "1" should be an "I," not a one in the equations. (#03)

9. All were okay.

   Mechanical & Fluid II: Page 57, formula are using 1 instead of I for inertia. (#18)

10. No real problems with any of these. (#36)

11. Mechanical & Fluid I: We've got to try to camoflauge the math a bit more. (#37)

12. Mechanical & Fluid II: The formula for moment of inertia was unrealistic for students to memorize in short amount of time (page 57). (#05)

Comments for C2 Classes

1. All were excellent. (#45)

2. Mechanical & Fluid I: Error page T-25, answer 11a is wrong, and answer 12 should be 50 ft lb. (#42)

3. All were excellent. (#17)

4. All were good.

   Electrical and Thermal: Hard units. (#40)

5. Mechanical & Fluid II: No apparent problems.

   Electrical: Demo suggested for this subunit is weak. Class attention wanders when the entire point of a demo is to watch the needle of a strip chart recorder drift for 10 minutes. (#30)

6. Mechanical & Fluid I: Should start reading on page 20. It is unnecessary for the demo to be as complicated as it is written. It could have been written on less than one page (i.e., nails don't have to be a certain distance apart!).

   Mechanical & Fluid II: Too much math. (#08)

7. All were okay.

   Mechanical & Fluid II: Fluid Potential Energy, block top of page. SI formula: h = height water is lifted in m not feet. (#18)

8. I needed more than 1 period to explain this info. (#05)

9. No real problems here on any of these. (#36)

Comments for Math Lab Classes

1. Mechanical & Fluid II: Error on problem 2a, answer should be 1680 instead of 1580. (#33)

2. Mechanical & Fluid I: Math should pertain to unit material. Nothing about Mechanical energy in any of the problems or examples.

   Electrical: Problems should deal with electricity, not springs.

   Thermal: Problems should deal with energy in heat, not moment of inertia. (#13)

3. Mechanical & Fluid I: In example 2, ΔP = area x length of cylinder, it should be ΔV = area x length of cylinder.

   Mechanical & Fluid II: Probably we need more complicated problems for interested students. (#45)

4. Mechanical & Fluid I: Poor judgment. I'd like you to try this section in one period of any level student. Required too much research to find formulas, ended with a so-what effect.

   Mechanical & Fluid II: In most cases the math labs have 6-8 pages of reading (30 min.), 2-4 examples to study (15 min.), theories to discuss (10 min.), 5-6 problems (60 min) = 2 hours. More time is needed if you want all students to understand.

   Thermal: Problems were too complex. (#06)

5. Mechanical & Fluid I: Errors on page 30, under solution ΔP = area x length of cylinder should be ΔV. Under conclusion, we're not asked to determine if the work produced was sufficient to close the gate.

   Mechanical & Fluid II: Error page T-74, problem 2, f = 1680 lb not 1580. T-76, a of problem 6, second line, Qh = 305 should be Qh =350. Page T-76, b of problem 6 Qh = 1224.6 BTU/hr. Page T-76 c of problem 6, no answer given.

   Electrical: Page 109, problem 2, Final E_k = 19,198.2 ft lb, not 19,200. Error page T-111, problem 4a, Ep=300 ft lbs not 3600 ft lbs.

   Thermal: Page T-147 problem 3, Ek is 47.33 J and not 5725.6. W is 41.87 rad/sec and not 460.5. Page T-148 problem 3, part a, w^2 = 253,120 not 253,130. (#42)

6. All were okay. (#56)

7. Mechanical & Fluid I: First part of 5M1 had excellent examples. Absolutely the best. We need more like these.

   Electrical: Okay, but what does it have to do with electricity? (#17)

8. Thermal: Problem #3 has an error, w = 41.89 rad/sec. (#07)

9. All were okay.

Electrical and Thermal: Hard for slower students. (#40)

10. Mechanical & Fluid I: Page 30, line 15 should read ΔV = area x length. Very good math lab, since many have difficulty with word problems. This difficulty, however, tends to use more time than planned for in the math lab.

Mechanical & Fluid II: For the first time, assigned as a homework assignment over shop week, when there are no academic classes. Nobody did it. Problem 2, teacher's guide, Page T-74, answer should be 1630.

Electrical: No problem. Short for 42 minutes.

Thermal: Good review. Best feature of the course is its constant reinforcement provided by the math labs. (#30)

11. Mechanical & Fluid II: Too complicated. (#08)

12. Mechanical & Fluid I: Took two periods (tougher than usual for students)

Mechanical & Fluid II: Page T-74, problem #2, answer (a) = 1680 lb, not 1580 lb.

Electrical: Okay.

Thermal: Page T-147, problem #3: solution w = 41.87 rad/sec
w^2 = 1752.8 rad2/sec2; Ep = 47.33 n m or J. (#18)

13. Thermal: Error in math lab problem #3 computation of rad/sec. (#38)

14. Took longer than 1 period. (#05)

15. Thermal: Some errors noted in teacher guide, page 147, problems 2 and 3. (#36)

16. Thermal: Page T-147 Problem 2: I = (2/5)(8 kg)(.0169 m^2)
Problem 3: Ek instead of Ep. Ek = 47.333, w=41.87 rad/sec, using w = 41.87. (#37)

Comments for Lab 1 Classes

1. Thermal: Some of the written material was wrong. They tell you to fill a 600 ml beaker half full, when it should only be 1/4 full. (#33)

2. Mechanical and Fluid I: Could not get students to measure energy as compressing a spring and trying to estimate energy.

   Mechanical & Fluid II: Should deal with subject.

   Electrical: Should deal more with electrical properties. These were better than most. (#13)

3. Mechanical & Fluid I: This experiment was good, but another form of setting the lab up could be considered (simpler form needed).

   Mechanical & Fluid II: Good.

   Electrical: This part was excellent and the students got to know how to read and interpret the graph of capacitor discharge. We could have had an experiment using the component (capacitor) or showing the capacitor discharge, like a camera's flash. (#45)

4. Mechanical & Fluid I: No equipment.

   Mechanical & Fluid II: No equipment.

   Thermal: Errors on page 155, main ideas. "Measured in calories per gram per C^o." "Measured in Btus per lb per F^o." Should be cal/gm C^o and Btus/lb F^o. (#42)

5. Mechanical & Fluid I: We used smaller spring in graduate graphs were great.

   Mechanical & Fluid II: Hydraulic accumulator was built to specifications but did not demonstrate the desired results. We had it hooked to city water supply, will retry when we have a pump. It did show funciton of check value.

   Electrical: Really, $900 strip recorder' 'ou guys live in the world of funding that does not resemble educational funds.

   Thermal: Specific heat lab, 300 g of water is too large a mass for use with most specific heat sample sets. (#06)

6. All were good. (#17)

7. Mechanical & Fluid II: Works pretty well even though there's not much in the way of quantitative results. Air tank is a problem. It just won't run enough to do a good job or let the students use the strobe.

   Electrical: Lab seems reasonably pointless, besides did you ever try to buy a strip chart recorder on a budget like mine, or try to find somebody to donate it? Good luck.

   Thermal: Simple but effective. (#56)

8. Sargent-Welch did not provide the equipment list in time to order materials for the ENERGY labs.

   Mechanical & Fluid I: We used the spring holder jig (item #9) instead of the equipment listed. This would save about $30/station.

   Mechanical & Fluid II: No equipment.

   Electrical: The chart was very hard to read. (#07)

9. Mechanical & Fluid I: Equipment not available. Will return when (and if) it becomes so.

   Mechanical & Fluid II: Equipment not available.

   Electrical: Page 117, last sentence should be 2a. Do you really think it is cost efficient to use a strip-chart recorder to demonstrate how a recording is made, and then invest 40 minutes into interpreting a chart? If the r corder is to be used again several times, I agree.

   Thermal: orked well, except that we were forced to sub 2 beakers (with insulating materials between them) for styrofoam cups which were not available in this area. (#30)

10. Electrical and Thermal: Short of equipment. (#40)

11. Mechanical & Fluid I: Because of lack of equipment we did a demo with a spring off of a boat trailer and demonstrated the same principle.

    Electrical: Much too complicated.

    Thermal: Why can't all labs be this uncomplicated? (#08)

12. Mechanical & Fluid I: Okay.

    Mechanical & Fluid II: Did not do because of lack of equipment, probably could have done if I had time to prepare the equipment using an air drill.

    Electrical: Okay.

    Thermal: Okay. (#18)

13. Equipment was not available for the labs. I shall try to get some lab work done the last week of school. (#38)

14. Mechanical & Fluid I: We just couldn't perform some of the labs because of the lack of equipment.

    Electrical: This lab was more difficult for the student to understand than I had anticipated. I think another approach is in order. It was more difficult to fathom and understand. It had to be read 3 or 4 times understanding what must be done. Also references 2A and 2B are incorrect.

    Thermal: This lab went pretty well except for the poly cups. We dis-

covered, too late, that they were smaller than text called for so we had to modify the lab. (#36)

15. Mechanical & Fluid I: Had a hard time finding the appropriate equipment. Modified it.

Mechanical & Fluid II: Combined classes because of lack of equipment. Also, the equipment used in Lab SMF4 did not work well for us.

Electrical: This lab was hard for them to follow. (#05)

16. Mechanical & Fluid I: Couldn't do lab, didn't receive spring test apparatus from S-W and we ordered it. I wrote up my own lab:

Purpose: To determine the Ep of a given spring. The students are allowed to use any of the following equipment: ring stand, clamp, spring, meter stick, pencil, graph paper, set of weights. The students are told to determine the Ep of the spring but they are not told how; when they are done each pair of students "shows and tells" their method and data and Ep to the class. A) many kids find the spring constant by graphing F vs D and calculating slope. B) many students graph F vs D and determine the area of the graph using the area of a triangle and determine the potential energy. This was the best method and got good results.

Mechanical & Fluid II: Couldn't do, equipment not received.

Electrical: This lab was really "too" difficult for the students. We really had to make it less confusing. We used a different graph (same curve) so that the kids could easily determine the ΔV grid and Δt grid. Page 117 has some error. Step 2A is referred to and it should be step 2B and vice versa. The ΔV and ΔT explanation of volt/line and sec/line had to be totally reworked so the kids could follow.

Thermal: Why do we use such a large volume of water? Styrofoam cups S-W sent us would hold only approx 150 ml. The results turn out even better if you double the styrofoam cups for added insulation. (#37)

Comments for Lab 2 Classes

1. All were excellent. (#45)

2. Because of lack of equipment, we had to substitute.

   Electrical: Instead of strip recorder, why not just a table, then make a graph. (#62)

3. Didn't do any of them, no equipment. ((#42)

4. Mechanical & Fluid I: Did not do. Used flywheel idea before as generator.

   Mechanical & Fluid II: No air motor.

   Thermal: Did not do, seemed similar to last unit. (#06)

5. Electrical: Good but should be used in Year 2 as part of Energy Convertors.

   Thermal: Good but hard to control. (#17)

6. Mechanical & Fluid I: Great lab, I really liked it except you have to teach half of the next unit before you can do the lab.

   Mechanical & Fluid II: I tried to build this one but the prototype just didn't do much. What size pipe, what range guages, what flow rate, etc?

   Electrical: So, how big is the accumulator assembly (Vol = ?). What does it matter? What should be capacity of air motor? What flow rates should we expect for the flowmeter? These are some problems. Lab looked good but our flowmeter didn't have a range sufficient to measure flow from motor, so we were stymied again. (#56)

7. No equipment. (#07)

8. Electrical: Short of equipment. Time a problem.

   Thermal: Short of equipment. (#40)

9. Mechanical & Fluid I: Equipment not available. Will try again later.

   Mechanical & Fluid II: Equipment not available.

   Electrical: Equipment not available.

   Thermal: Found styrofoam cups. S-W sspecific heat sets include an aluminum sample which is too large for use. This is not a significant problem since your directions do not specify which 3 of the 5 to use. (#30)

10. Mechanical & Fluid I: Because of lack of equipment we set up a demo, but were unable to take any data because the flywheel did not spin long enough.

Thermal: Had problem with my metal samples, did not change the temp of the water significantly. (#08)

11. Mechanical & Fluid I: Okay.

Mechanical & Fluid II: No need for the stopwatch listed in equipment list.

Electrical: Page 125, 4th line from bottom and 3rd line from bottom, mistake in number of Joules/ft·lb. (#18)

12. Equipment was not available for the labs at this time. I shall try to get some labs done the last week of school. (#38)

13. Mechanial & Fluid I: Difficult for kids to follow.

Mechanical & Fluid II: Equipment not received in time, couldn't do it. Also, all of our flow control valves leak, we used them in the last unit.

Electrical: Could not do because we didn't receive the equipment from S-W even though we ordered it.

Thermal: Did not receive all the equipment again like the specific heat sample set. (#37)

14. Mechanical & Fluid I: Modified lab to suit equipment.

Electrical: Combined with SE1. (#05)

15. There was little we could do with the labs on this page due to lack of equipment. Very discouraging. (#36)

Comments for Summary Class

1. We reviewed each lab and worked through a few, but students could not complete all of them because of lack of equipment. (#33)

2. I detest, hate, tests with questions that have answers such as (all of the above) (a and b or a and c) or not any of the following, or select the wrong answer (which statement is false). I honestly believe the poorest part of this course so far have been the tests. (#62)

3. They were good. The answer to question #24 in the answer key is wrong, it's marked B and should be A. The answer to question 11 on the test is 12000, so d is the answer, not 120,000. (#45)

4. I really don't appreciate spending time trying to make sense out of your mistakes. Don't use length and width with graphs, vertical and horizontal. (#42)

5. No major difficulty. (#30)

6. Error in test key. Lab equipment short. Math a problem for slower students. Time a problem to finish 7 units. (#40)

7. Okay. (#18)

8. This is to summarize the Energy unit in general. It has been the most difficult unit to date. The primary factor affecting the successful presentation of this unit is the lack of equipment. We had ordered it well in advance of the anticipated date of use. However, when the day came to present the lab, the equipment had not arived. This is supposed to be an applied class but very little application was done during this unit. Students got discouraged, as did the teachers. (#36)

PRINCIPLES OF TECHNOLOGY

Unit 6: POWER

Pilot Test Findings

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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 and related print 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.

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INTRODUCTION

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 35 state and provincial education agencies (see Appendix A for a list of cooperating agencies). The course consists of fourteen units, each focusing on a principle that underlies today's technology. 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), from consortium representatives, and from teachers and students at classroom pilot test sites. The review team reviews preliminary drafts of the instructional materials before they are sent to consortium representatives and pilot test sites. Consortium representatives review the material concurrently with the classroom pilot testing. The data from all sources -- review team, consortium representatives, and pilot sites -- are analyzed and reported to the developers, who use these findings to revise the materials.

Thus, an important part of the overall formative evaluation is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working and 2) to identify specific problems with the materials. All pilot test teachers were oriented to the *Principles of Technology* course and to the pilot test procedures at one of two meetings held in Dallas the summer of 1984.

This report details the findings of the pilot test of Unit 6: POWER. The report makes some comparisons of these findings with those for Units 1, 2, 3, 4 and 5, which are contained in separate reports (see "Unit 1: FORCE -- Pilot Test Findings," December 18, 1984; "Unit 2: WORK -- Pilot Test Findings," March 1, 1985; "Unit 3: RATE -- Pilot Test Findings," May 6, 1985; "Unit 4: RESISTANCE -- Pilot Test Findings," May 29, 1985; and "Unit 5: ENERGY -- Pilot Test Findings," July 15, 1985). Since the majority of the pilot test teachers completed only six of the seven units planned for the first year of the pilot testing, this report will also serve as a summary of the first year findings. It's important to remember that all data are formative data;

the developers are using the data, along with the review team and consortium representatives' reactions, as a basis for revising the materials.

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PILOT TEST PROCEDURES

Unit 6: POWER pilot test materials were mailed to the teachers in mid-January 1984. These materials consisted of:

1) Pretest/posttest (see Appendix C).
2) Computerized scoring sheets for the pretest/postest.
3) Student attitude questionnaires (see Appendix E)
4) Teacher questionnaires (see Appendix F)

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the same test as a posttest along with the student attitude questionnaires. All Unit 6 data evaluation materials were then mailed back to AIT. Data contained in this report include all materials received by July 1985.

LIMITATIONS OF THE METHODOLOGY

Two major limiting factors must be considered when the findings are interpreted: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered, including:

• Lack of matched control groups.

The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in terms of time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

• The pretest/posttest format.

The same test was used for both the pretest and the posttest. The effect that memory of the pretest might have on posttest performance was another concern. The research design addressed this concern in three ways:

1 ıdents were not given the correct answers to the pretest. The effect of memory was limited, ımmediately, to the nature of the questions without accompanying knowledge of the correct answers.

2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

3) A correlated t-test was used to analyze the pretest/posttest data. This technique helps to partial out any variance that might result from an intruding correlation -- in this case memory.

• The pretest/posttest as an instrument (see section on development of the instrument, page 7).

The test cannot measure all objectives. Therefore objectives had to be sampled. Also, the items do not always directly match the intended objectives. The test was a cognitive test. Many of the objectives (particularly the lab objectives) are psychomotor objectives. One must consider each of these factors when assessing the validity of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results, including:

• Equipment prcblems.

As with ،he previous units, several teachers reported problems in securing necessary lab equipment.

• Student characteristics.

Based on reports from teachers and self-reports from students, there appears to be considerable variability in the kinds of students in the course. This variability encompasses students' academic backgrounds, ability levels, and socioeconomic levels. The project has made no attempt to control these variables.

• Teaching pattern.

Teachers report considerable variability in the length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess the impact of the various conditions on the outcomes.

So, both research design and external constraints must be considered when the results are interpreted. It's important to remember that the pilot test was designed as a part of the overall formative evaluation, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

SAMPLE

The sample included 349 students in 21 sites. Student characteristics included:

- Grade§

  10 = 18%   11 = 61%   12 = 21%

- Sex

  Male = 82%   Female = 18%

Teacher characteristics included:

- Physics background.

  As with previous units, there was a wide range in the teachers' physics backgrounds; 16% reported no college physics courses; 26% reported one college physics course; 32% reported 2-4 college physics courses; 5% reported 5-7 college physics courses; and 21% reported 8 or more college physics courses.

* Mathematics background.

  Almost all teachers (95%) reported having had 2 or more college mathematics courses; several (37%) have had 5 or more college mathematics courses.

* Teaching pattern.

  The majority (70%) taught Unit 6: POWER on consecutive days. Most (80%) taught sessions that were 60 minutes or shorter. About half (45%) indicated that they had combined several classes into one session.

* Preparation time.

  The majority (70%) indicated that they spent 60 minutes or less preparing to teach each subunit on POWER.

Since the sample seems to have stabilized at about 21 sites that are roughly on schedule, it's not surprising that the student and teacher demographics were similar to those for prior units.

§Due to missing data, the pretest/posttest student demographics don't match the student attitude demographics.

PRETEST/POSTTEST AS AN INSTRUMENT

To understand the results, one must first understand the characteristics of the test as a measurement instrument, including the process by which the test was developed and what statistical analyses reveai about the reliability and validity of the instrument.

Over 70 test questions were initiated at CORD by the content specialists. In a collaborative process between evaluators and content specialists these questions were pruned and revised to the eventual 31 questions. Each item is tied as directly as possible to a specific objective from Unit 6. The item/objective match is not always exact. It's impossible to match items to some objectives because of the way those objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and that approximations of objectives are often the best that cognitive test developers can do. With only 31 items, not all objectives could be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were determined based on the relative importance of the concepts. (Appendix C lists the objective each item is intended to address above the item.)

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, whether it's measuring what you think it's measuring). The reliability (Spearman-Brown test of intemal consistency) of this instrument is .86, which is acceptable by most standards. Validity is a bit more complicated to judge. Readers are encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?
2) Is a sufficient range of objectives addressed?
3) Overall, is the instrument a fair measure of Unit 6's instruction?

It should be pointed out that, in examining the pretest/posttest results for each of the first five units, the developers and evaluators encountered a few items in each unit (no more than three per unit) that they considered, for various reasons, to be poor items. For the Unit 6 test, item 30 was an incorrect item and was eliminated from the overall analysis. Therefore, the test became a 30-item instrument. Of course

there is always wisdom in hindsight. Ideally, each of these instruments would itself be pilot tested. However, the project's schedule precludes the luxury of pilot testing the instrumentation. Thus, even with careful planning, it's probably inevitable that a few poor items will be included in each test.

PRETEST/POSTTEST RESULTS

Several different analyses of the pretest/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, for which 30 items were analyzed. (Item 30 was eliminated from the analysis because it contained an error).

• Mean Differences

The overall pretest mean was 11.46. The overall posttest mean was 18.27. This increase was statistically significant (correlated t-test) at the .01 level.

The level of statistically significant learning gain (.01) is consistent with the gains shown for Units 1-5. Table 1 compares the pretest/posttest scores for Units 1-6.

Thus, Units 1, 4, 5, and 6 had fairly consistent pretest-posttest learning gains in terms of percentage correct. Learning gains for Units 2 and 3, while somewhat lower, were still statistically significant, indicating that a change in the students' knowledge level has occured for each unit.

Individual Items

For each unit the project team has established criteria for acceptable performance on each test item. These criteria included either:

1) 70%+ correct on an item or

2) doubling of pretest score on the posttest.

Against these criteria, the results for Unit 6 are:

70%+ or doubling of percentage correct - items 1, 4, 6, 7, 9, 10, 11, 12, 13, 15, 16, 17, 27, 28.

Less than 70% and no doubling of percentage correct - items 2, 3, 5, 8, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 29, 31.

Because this is a formative evaluation effort designed to improve the materials, it has proved particularly useful to examine the content of the items on which students performed especially poorly.

First, let's examine the items according to subunits.

Mechanical -- Three of eleven items did not meet criteria.
Fluid -- Six of six items did not meet criteria.
Electrical -- Five of eight items did not meet criteria.
Overview -- Three of five items did not meet criteria.

Thus, students performed particularly poorly on the items dealing with the Fluid and Electrical subunits and on the Overview.

In the kinds of items on which students performed poorly, there continues to be consistency from the first five units. These items include:

1) Selected terms. The Electrical subunit had some terms that seemed to cause students trouble. Students also performed poorly on the item that dealt with one of the unit's key concepts -- that thermal power and thermal rate are equal. Generally, however, there were fewer terms on the Unit 6 test than there were on previous tests. The items tended to be more analytical/computational.

2) SI/English units. These have been troublesome items for students on each of the first five units, and continued to be for Unit 6.

3) Mathematical items. Again, through the first five units, students have exhibited ongoing problems with items that require manipulation of formulas.

Thus, even though there was an overall statistically significant learning gain for this unit, in a formative sense the results certainly seem to indicate the need for a careful consideration of some of the unit's material. The findings of this test indicate that the Fluid and Electrical subunits deserve particular attention.

Table 1
Principles of Technology
Pretest and Posttest Scores, Units 1-6

Unit	Number of Items	Pretest Mean (% correct)	Posttest Mean (% correct)
1	30	12.5 (41%)	20.1 (67%)
2	33	13.6 (41%)	17.6 (53%)
3	30	14.9 (49%)	19.4 (65%)
4	36	16.4 (46%)	24.4 (68%)
5	35	13.2 (38%)	22.6 (65%)
6	30	11.5 (38%)	18.3 (61%)

PRETEST/POSTTEST BY SELECTED VARIABLES

The impact of several variables on students' test performance was examined, including:

1) Student characterisics.
   a) sex
   b) grade

2) Teaching pattern.
   a) consecutive days
   b) length of class periods
   c) combined activities

3) Teacher background.
   a) physics background
   b) mathematics background

These variables were analyzed with an analysis of covariance, which controlled for pretest scores.

Table 2 examines the results of this analysis; all means reported in Table 2 are for the posttest.

Table 2

Main Effect	Level of Significance	Subset	Mean Score
Sex	.48	Boys (257)	18.05
		Girls (54)	18.30
Grade	.87	Tenth (64)	17.11
		Eleventh (188)	17.98
		Twelfth (60)	18.87
Consecutive days	.19	Yes (228)	18.64
		No (12)	17.56
Minutes per class	.30	LT50 (199)	18.19
		50-60 (39)	20.56
		60-90 (27)	17.96
		90+ (83)	17.48
Combining sessions	.03	Yes (78)	20.85
		No (270)	17.52
Physics background	37	No classes (65)	17.71
		1 class (71)	18.23
		2-4 classes (89)	18.64
		5-7 classes (63)	16.63
		8+ classes (60)	20.08
Mathematics background	.01	1 Class (16)	7.56
		2-4 classes (241)	18.40
		5-7 classes (31)	19.26
		8+ classes (60)	20.08

Table 3 examines these variable for each of the first six units. As Table 3 indicates, students' sex and grade did not have a consistent impact on their test scores. The teaching pattern, including length of class period, teaching on consecutive days, and combining activities have had a fairly consistent impact on students' test scores, although the overall teaching pattern seems to have been less important for Units 5 and 6.

The effects of the teachers' physics and mathematics backgrounds on students' scores continue to be somewhat difficult to understand. As Table 3 indicates, Unit 6 is the first unit on which the teacher's physics background was not consistently correlated with students' scores. On the other hand, the teachers' mathematics background was consistently correlated with student test scores. Perhaps these findings reflect the more analytical/computational nature of the test, which is of course tied to the objectives for Unit 6.

Table 3
Principles of Technology
Impact of Selected Variables on Test Performance

	Unit/Significant						
Variable	1	2	3	4	5	6	Overall
Sex	No	No	Yes	Yes	No	No	Negligible
Grade	No	No	Yes	No	No	No	Negligible
Consecutive days	Yes	Yes	Yes	Yes	No	No	Important
Minutes per class	Yes	Yes	Yes	No	Yes	No	Important
Combining sessions	Yes	Yes	Yes	Yes	No	No	Important
Physics background	Yes	Yes	Yes	Yes	Yes	No	Inconclusive
Math background	No	Yes	No	Yes	Yes	Yes	Inconclusive

PRETEST/PC TTEST RESULTS B'' SITE

Appendix D indicates the pre st/posttest resu 's by site. Eighteen sites showed statistically significant (.01 level) increases; three sites showed no statistically significant gain. Table 4 shows the number of sites showing no statistically significant gains for each of the first six units.

Table 4

Unit	Sites showing no significant gains
1	1
2	4
3	4
4	0
5	1
6	3

Thus, Unit 6 had more sites showing no significant gains than Units 1, 4, and 5 but fewer than Units 2 and 3. There may be several expla nations for the variance, including:

-- Variance caused by the tests. Some may be more difficult than others.

-- Random variance.

-- The school schedule. It seems likely that Units 2 and 3 had longer intervals from pretest to posttest because of holidays. Unit 6 was covered at the end of the school year in most sites.

-- A combination of the above factors.

Although there may well be a variety of mitigating factors involved in the increased number of sites showing no significant gain for Unit 6, this finding may serve as additional evidence that some . the material in the unit may need to be reconsidered. This report has already indicated that the Fluid and Electrical subunits should be carefully examined.

STUDENT ATTITUDE FINDINGS

The student attitude findings (Appendix E) indicated:

The majority of students (69%) liked the POWER unit either a lot (16%) or a little (53%).

The most appealing components were the video programs (38%) and the hands-on labs (21%). These were also the most appealing components for the first five units.

The least appealing components were the mathematics labs (29%) and the written material (18%). Again, these were also the least appealing components for the first five units.

Over half said some (50%) or most (14%) of the material was difficult for them to understand.

As they did with Units 3, 4, and 5, students indicated that the most difficult components for them to understand were the mathematics labs (37%) and the written material (18%). They indicated that the least difficult component for them to understand were the video programs (46%). (Note: Items addressing the perceived difficulty of the components were not included for Units 1 and 2).

Most students (76%) indicated they thought the material in the POWER unit was important for them to understand.

Table 5 examines the student attitude findings from the first six units on three important variables -- appeal, difficulty, and perceived importance. As Table 5 indicates, the attitude findings for Units 1 and 2 were somewhat more positive than those for Units 3-6. However, the student attitude findings for all six units can be characterized as fairly positive. Students found each of the units moderately appealing, few indicated that most of the material was difficult to understand, and, perhaps most important, the majority of students continue to affirm the importance of the material they are covering.

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Table 5
Principles of Technology
Student Attitudes, Units 1-6

Category	Unit/Significant					
	1	2	3	4	5	6
Liked (a lot or a little)	80%	76%	62%	68%	63%	69%
Difficult (most)	8%	8%	18%	11%	16%	14%
Important (very or sort of)	89%	87%	77%	80%	77%	76%

TEACHER RESULTS

Questionnaires were received from 20 teachers (due to team teaching, the number of sites and the number of teachers are not equal). Appendix F lists the detailed teacher comments and should be examined carefully, because the wealth of data contained in the teachers' comments is difficult to encapsulate. Overall, the teacher findings included:

• Teacher comfort.

Almost all teachers (95%) indicated they felt comfortable teaching the material in the POWER unit.

• Time.

The majority (75%) indicated that the 6-day plan of 50-minute class sessions per subunit is a realistic time allotment for Unit 6. Two teachers indicated that some of the hands-on labs required more than 50 minutes to set up, conduct, and discuss. This is consistent with the findings for the first five units.

• Student reading.

Many (74%) indicated that their students may not be doing the assigned readings at home. This is a disturbing finding and is consistent with what teachers reported for Units 3 (67%), 4 (72%) and 5 (77%). This finding raises yet an additional question: Are students not doing the assigned readings at home because of an inherent weakness in the material or because of students' own constraints (motivation, time, etc.)? Whatever the reasons, several teachers indicated that they allow class time for students to read the material.

• Teacher's guide.

Although most teachers (85%) thought the teacher's guide provided them with enough information to implement the unit successfully, a few (15%) said the guide probably did not containenough information. Generally, those teachers commented that the guide should contain more details on problems presented in the text, but one suggested "more background material."

• Appropriateness for students.

Generally, teachers tended to indicate that each day of instruction was appropriate for their students. For the videos and C1/C2 days of instruction they were unanimous in their responses. For the first time in the project, almost all teachers (90%+) also rated both the hands-on labs and mathematics labs as appropriate for their students.

• Problems.

To the question, "What, if anything, caused you the most problems in teaching the unit on POWER?" nineteen teachers responded. The problems reported included:

- Hands-on labs, lack of equipment, etc. (12 teachers)
- Electrical subunit. (2 teachers, neither of whom elaborated on the problems)
- Student apathy. (2 teachers, one of whom commented, "Motivation always difficult in June.")
- Conversion of units. (1 teacher)
- Reading the kilowatt/hour meter. (1 teacher)
- Formulas. (1 teacher)

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These findings are consistent with what teachers reported for Units 1-5. Availability of equipment for the hands-on labs continues to cause teachers the most problems. On the other hand, teachers continue to affirm the appropriateness of most of the material for their students. Finally, many specific recommendations for changes, including the correction of errors in the text, are contained in the teacher's comments; these are carefully examined by the developers. Overall, the teachers tended to be fairly positive about Unit 6.

CONCLUSIONS

Again, it is important to remember that the entire pilot test is part of the overall formative evaluation process. Data are being collected from the consortium review team, from consortium representatives, and from teachers and students at the pilot test sites. These data are then used as a basis for revising the materials. Certainly, this report contains much useful information. Some of the key findings include:

1) Overall, a statistically significant (.01 level) learning gain took place. These learning gains were independent of students' grade and sex.

2) Students performed least well on test items dealing with mathematics and SI/English units. These types of items alsoproved troublesome to students on the first five units. Also, students performed particularly poorly on the items dealing with the Fluid and Electrical subunits.

3) Student attitudes were generally positive. The attitude findings for Units 3-6 were similar. All were lower than the attitude findings for Units 1 and 2.

4) Teachers affirmed the appropriateness of most of the material for their students. Again, this is consistent with the findings for the first five units.

5) Teachers' comments indicated that the most problems were encountered with the hands-on labs. Again, this is consistent with the findings for the first five units.

6) Although the teachers were generally quite positive about the unit, they did recommend several specific changes.

Thus, the data for Unit 6 were somewhat inconsistent. Student test scores indicated a statistically significant learning gain, and yet they also revealed that students had serious problems with the Fluid and Electrical subunits. The teacher data were generally positive, but two teachers also indicated that the Electrical subunit caused them particular problems. As has been the pattern for the first six units, several teachers also indicated that difficulties in acquiring lab equipment caused problems. Although the data for Unit 6 were generally consistent with data from Units1-5, in a formative evaluation sense they suggest that the material contained in the Unit 6 Fluid and Electrical subunits be carefully examined.

Appendix A

Participating Agencies

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

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

Nebraska Department of Education
Division of Vocational Education

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

TVOntario

Oregon Department of Education
Division of Vocational Education

Pennsylvania Department of Education

Rhode Island State Department of Education
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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The objective each item is intendëd to address is listed above each item

Appendix C

PRINCIPLES OF TECHNOLOGY
Unit 6: POWER
Student Test

Pre	Post	
		O-1
		1. Power is defined as ________.
22	5	a. work out divided by work in
16	7	b. force x distance
45	78	*c. work divided by time
17	10	d. work x time
		O-2
		2. Thermal power and thermal rate are ________.
19	16	a. both measures of temperature
40	50	*b. both equal to thermal energy divided by time
14	6	c. both independent of time
28	27	d. both measured in units of calories or Btu's
		O-4
		3. Two unifying equations for power in mechanical, fluid and electrical systems are P = W ÷ T and ________.
17	18	a. P = force x distance
23	6	b. P = work ÷ distance
20	12	c. P = work out ÷ work in
40	64	*d. P = force x rate
		O-3
		4. When one thousand newton-meters of work is done, the power used ________.
19	11	a. depends only on the force applied while the work is done
44	73	*b. depends on the time it takes to get the work done
20	7	c. is the same no matter how long it takes
16	9	d. is always less when more friction is present
		O-5
		5. Which of the following units <u>is not</u> a correct unit for power?
13	7	a. newton meter/sec $\left(\frac{N\cdot m}{sec}\right)$
20	13	b. foot pounds/sec $\left(\frac{ft\cdot lb}{sec}\right)$
40	60	*c. kilowatt hours (kwh)
27	20	d. joules/sec $\left(\frac{J}{sec}\right)$
		M6
		6. A machine that is doing work equal to 120×10^4 ft·lb will ________ if it does the work in a shorter period of time.
48	75	*a. use more power
25	13	b. use less power
24	11	c. use the same amount of power
		M5
		7. Power in mechanical systems can be described as measured in units of _____.
32	14	a. horsepower (hp)
10	4	b. foot pound/sec (ft·lb/sec)
[illegible]	1	c. newton meter/sec (N·m/sec)
	13	d. b and c only
	69	*e. a, b, and c

Pre	Post	
		M1, 2, 4
		8. Which of the following formulas <u>does not</u> describe power in a mechanical system?
16	6	a. $p = \frac{F \times D}{t}$
33	31	b. $p = F \times v$
19	14	c. $p = W/t$
32	50	*d. $p = T \times \theta$
		M8
		9. A crane lifts an 1800 pound beam upward at constant speed a distance of 10 feet. The work done is __________.
20	7	a. 180 ft·lb
53	76	*b. 18,000 ft·lb
11	5	c. 180 ft lb/sec
15	12	d. 18,000 ft·lb/sec
		M8
		10. The crane in problem 9 moves the 1800 pound beam a distance of 10 feet in 2 seconds. The power required is __________.
19	4	a. 360 ft·lb/sec
11	4	b. 18,000 ft·lbs
58	84	*c. 9,000 ft·lbs/sec
12	7	d. 18,000 ft·lbs/sec
		M8
		11. The crane in problem 9 moves the 1800 pound beam a distance of 10 feet in 1 second. The power required is __________.
52	83	*a. 18,000 ft·lbs/sec
20	4	b. 4,500 ft·lbs/sec
14	4	c. 9,000 ft·lbs/sec
15	9	d. 18,000 ft·lbs
		M7
		12. A force of 25 newtons is needed to keep a piston moving at a speed of 0.5 meters per second. The piston power is __________ (power = "force" x rate).
54	88	*a. 12.5 watts
15	4	b. 25.0 joules/sec
16	4	c. 50.0 horsepower
15	3	d. 25.0 newton meter/sec
		M9
		13. Efficiency of a machine can be defined as __________.
36	69	*a. output power divided by input power
31	14	b. input power divided by output power
14	6	c. input work times output work
19	11	d. input work divided by output work
		MLM3 (page 37)
		14. The efficiency of a block-and-tackle that raises a 100 kg mass a distance of 1 meter in 1 second while requiring 1000 watts of input power is __________.
49	59	a. 0.10 or 10%
17	11	b. 0.49 or 49%
26	25	*c. 0.98 or 98%
8	5	d. 1.02 or 102%

Power in a mechanical, fluid or electrical system can be calculated by using the unifying equation, power = "force" x rate. Match the "force x rate" equation given in column B with the appropriate energy system from column A where it applies.

Pre	Post	Column A	Column B
38	72	15. d (M2) linear mechanical system	A. $P = \Delta V \times I$
51	80	16. c (M4) linear rotational system	B. $P = \Delta p \times Qv$
53	83	17. a (E2) electrical system	C. $P = T \times \omega$
32	61	18. b (F1) fluid system	D. $P = F \times v$
			E. $P = \Delta p \times V$

F1
19. Fluid power used in a water pump to lift water can be calculated when we know the ________.

Pre	Post	
18	6	a. weight of water raised through a given distance
43	64	*b. weight of water raised through a given distance in a measured time interval
25	20	c. rate of water being moved (gal/min)
14	10	d. pump pressure and water density

F3
20. Which of the following <u>is not</u> a correct equation for calculating fluid power (P_f)?

Pre	Post	
20	9	a. $P_f = \frac{\Delta p \times V}{t}$
27	45	*b. $P_f = p \times \Delta v$
27	12	c. $P_f = \Delta p \times Qv$
27	34	d. $P_f = W/t$

F3
21. Fluid power can be measured correctly in units of

Pre	Post	
62	67	a. gal/min or lbs/sec
14	6	b. newton meters
17	24	*c. horsepower or foot·lbs/sec
7	4	d. kilowatts/sec

F4, 5
22. A gasoline pump refuels an automobile by raising 42 pounds of gasoline (about 7.5 gallons or 1 cubic foot) a distance of 10 feet each minute. The power used by the gasoline pump is ________ (P = W/T).

Pre	Post	
16	13	a. 420 ft lbs/sec
49	61	*b. 420 ft lbs/min
24	21	c. 75 gal/min
11	5	d. 10 cubic feet/sec

Pre Post

F4, 5

23. A gasoline pump refuels an aircraft by developing a pump pressure of 500 lbs per square foot while moving gasoline from the tanker to the plane at a rate of 30 gallons per minute (30 gallons = 4 cubic feet). The fluid power used by the pump is _________ $\left(P_f = \frac{\Delta P \times V}{T}\right)$.

36 38 a. 15,000 ft·lbs/min
21 7 b. 2,000 ft·lbs
38 47 *c. 2,000 ft·lbs/min
11 8 d. 15,000 ft·lbs

E1, 2

24. Which of the following is not a correct definition for electrical power?

27 25 a. The rate at which electrical work is done.
32 46 *b. Work done when a voltage moves or displaces electric charge.
33 27 c. Equal to voltage difference times current.

E3

25. Electrical power can be expressed in all of the following equations except _____.

17 4 a. $P = \Delta V \times I$
36 16 b. $P = I^2 \times R$
24 44 *c. $P = \Delta V/R$
23 37 d. $P = (\Delta V \cdot q)/T$

E4

26. The kilowatt hour (kwh) is a unit of

47 43 a. power
29 50 *b. energy
17 6 c. resistance

E4

27. Electrical power can be described or measured correctly in all of the following units except _________.

13 5 a. watts
32 25 b. volts x amps
39 24 c. joules/sec
16 46 *d. kilowatt hour

E5

28. An electrical toaster requires a voltage of 110 volts and a current of 9.09 amps. Its power usage is _________ (power = "force" x rate).

21 7 a. 99.9 watts
52 83 *b. 999.9 watts
14 5 c. 0.110 watts
12 5 d. 1.10 watts

E5

29. A 60 watt lamp bulb operating on 110 volts uses _________ (power = "force" x rate)

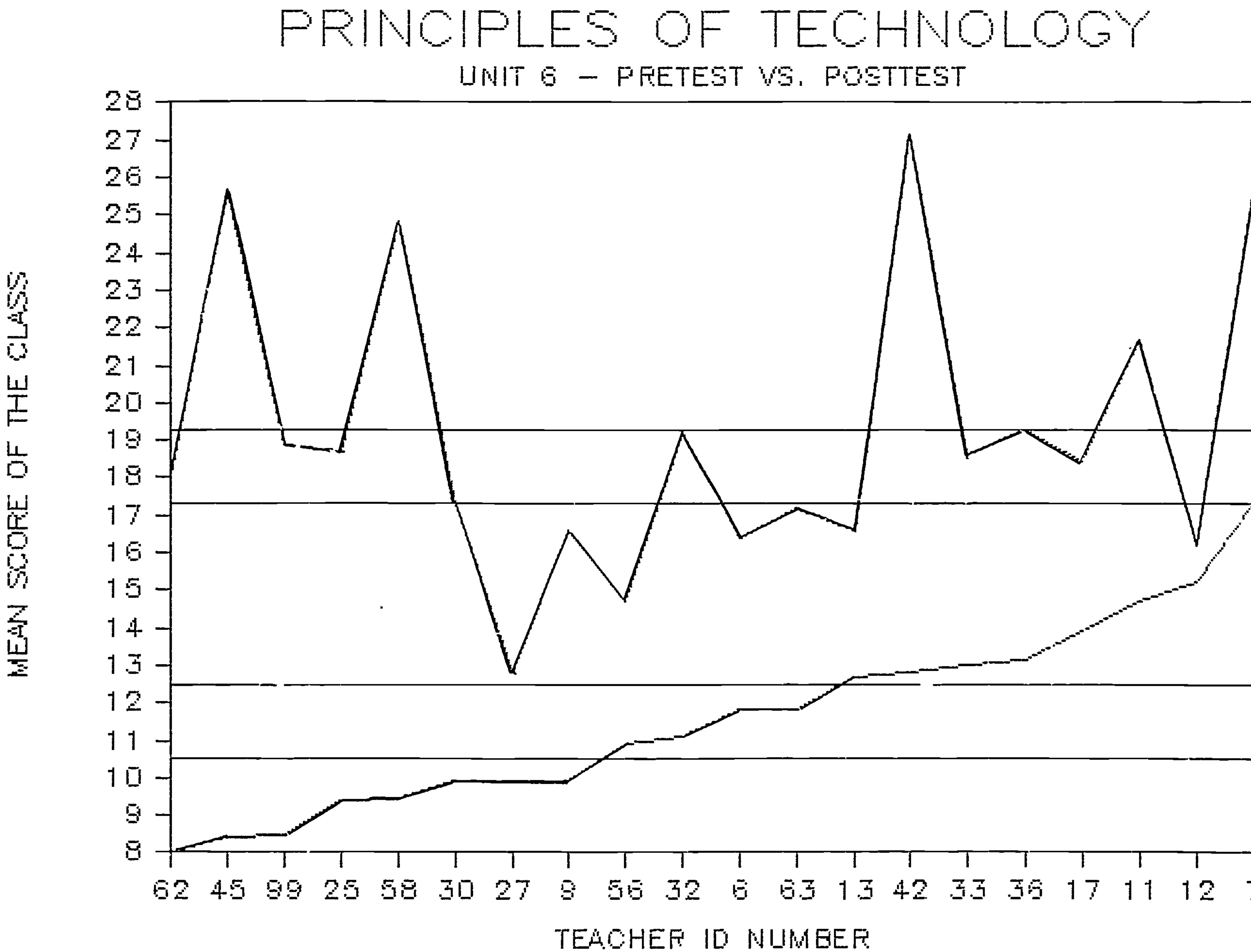
15 7 a. 5.45 amps of current
35 49 *b. 0. 545 amps of current
24 18 c. 6.6 amps of current
27 26 d. 66 amps of current

30. What's the maximum current that can flow through a resistor rated at 25 ohms and 10 watts ($P = \Delta V \times I$ and $\Delta V = I \times R$)?

*a. 2 amps
b. 4 amps
c. 1 amp
d. not enough information to solve the problem
E5

31. How much electrical energy is consumed if a 10 horsepower motor operates for 10 seconds (1 horsepower = 746 watts and 1 watt = 1 joule/sec)?

Pre	Post	
30	31	a. 7, 460 watts
20	9	b. 74,000 watts
28	25	c. 7,460 joules
22	34	*d. 74,600 joules



-29-

Appendix D

423

424

All numbers in percent
Due to rounding numbers
do not equal 100%
n=311

Appendix E

PRINCIPLES OF TECHNOLOGY
UNIT 6: POWER
STUDENT ATTITUDE QUESTIONNAIRE

Sex: 18 Female 82 Male

Grade: ___ 9 18 10 61 11 21 12

1. Overall, did you like the unit on POWER?

16 yes, a lot
53 yes, a little
20 no, not very much
11 no, not at all

2. What component did you like most in the POWER unit?

5 the written material
38 the video programs
8 the math labs
21 the hands on labs
31 no preference
more than one component = 7

3. What component did you like least in the POWER unit?

18 the written material
6 the video programs
29 the math labs
4 the hands on labs
34 no preference
more than one component = 9

4. Overall, was the material that was covered in the POWER unit difficult for you to understand?

14 yes, most of the material was difficult for me to understand
50 yes, some of the material was difficult for me to understand
35 no, most of the material was not difficult for me to understand

5. Which component of the POWER unit was the most difficult for you to understand?

18 the written material
2 the video programs
37 the math labs
6 the hands on labs
28 no component was particularly difficult
more than one component = 9

6. Which component of the POWER unit was least difficult for you to understand?

10 the written material
46 the video programs
6 the math labs
15 the hands on labs
18 all components were equally difficult
more than one component = 5

7. Do you think the material in the POWER unit is important for you to understand?

35 yes, very important
41 yes, sort of important
15 no, not very important
9 no, not at all important

8. Do you have any comments about the POWER unit?

All numbers if percent
Due to rounding numbers
do not equal 100%
n=20

Appendix F

PRINCIPLES OF TECHNOLOGY
UNIT VI: POWER
TEACHER QUESTIONNAIRE

1. What did you like most about the POWER unit?

   See attached comments

2. What did you like least about the POWER unit?

   See attached comments

3. In terms of their overall impact (instructional effectiveness, student interest, manageability) rank each of the components of the POWER unit using the following scale:

   A = Excell t
   B = Good
   C = So-so
   D = Poor
   E = Terrible

   Place the letter, corresponding to your ranking, next to each component.

A=25;B=50;C=5 student handbook B=74;C=13;C=13 hands on labs
A=45;B=50;C=5 videos A=5;B=75;C=15;D=5 teacher's guide
A=32;B=42;C=16 math labs
D=5;E=5

   Please explain any C, D, or E rankings and/or list any other comments you have about the components:

   See attached comments

4. Which of your students seem to be the most successful with the Unit VI material?

   50 above average   35 average

   ___ below average   15 ability level didn't seem to affect student performance

   Comments:

   See attached comments

5. Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for the POWER subunits?

30 yes, definitely

45 yes, probably

15 no, probably not

10 no, definitely not

Please comment:

See attached comments

6. On average, how much time did you spend preparing to teach each class in the unit on POWER?

25 0-30 minutes
45 31-60 minutes
20 61-90 minutes
5 91-120 minutes
5 121-180 minutes
___ 181 or more minutes

Comments:

See attached comments

7. Overall, did you feel comfortable teaching the materials in the unit on POWER?

55 yes, very comfortable

40 yes, sort of comfortable

5 no, not very comfortable

___ no, not at all comfortable

If no, please specify:

See attached comments

8. Do you think most of your students did the assigned readings at home?

10 definitely 16 probably 53 probably not 21 definitely not

Comments:

See attached comments

9. What, if anything, caused you the most problems in teaching the unit on POWER?

See attached comments

10. Do you feel the Teacher's Guide material provided you with enough information to help you successfully implement the unit?

45 definitely   40 probably   10 probably not   5 definitely not

If no, what should be added to the guide to make it more useful?

See attached comments

11. Did you teach Unit VI: POWER on consecutive days for 26 days?

70 yes   30 no

If no, what pattern did you use (for example, 3 days a week)?

See attached comments

12. How much time per session did you teach?

55 50 minutes or less
25 51-60 minutes
10 61-90 minutes
10 91+ minutes

13. Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

45 yes   55 no

If yes, which classes did you combine?

See attached comments

14. How many physics courses did you take in college (undergraduate and graduate)?

16 none
26 1
32 2-4
5 5-7
21 8 or more

15. How many math courses did you take in college (undergraduate and graduate)?

___ none
5 1
58 2-4
21 5-7
16 8 or more

16. Do you have any other comments, concerns, or suggestions for the unit on POWER?

See attached comments

The following chart lists each activity for the unit on POWER down the left column. Since there are no materials specifically for the subunit review classes, these classes have not been listed in the chart. For each activity, you should respond to the following questions by circling "yes" or "no":

1) Was the material (readings, labs, or videos) appropriate for your students? Was the material at the right grade level? Was the amount of material appropriate for your students? For <u>any no responses</u>, please use the attached pages to describe your concerns.

2) Were you able to cover the material to your satisfaction in the 50-minute time period? (Since this question doesn't apply to the video, no response options have been provided for the column. Please do respond, however, to the other questions about the video.) For <u>any no responses</u>, please use the attached pages to describe why you could not complete the material and/or what you chose to delete.

3) Were there any errors or inaccuracies in the material? For <u>any yes responses</u>, use the attached pages to specify the errors and recommended corrections.

4) Were there any problems managing the activity? For the labs, were all your students able to rotate through the labs? Did you experience any problems coordinating the labs? Did you experience any problems setting up or tearing down the labs? Did you experience any problems coordinating the activity? For <u>any yes responses</u>, use the attached pages to specify the problems you had and, if possible, suggest changes you feel would enable you to more easily manage the material.

5) Do you have any suggested modifications for the material? For <u>any yes responses</u>, use the additional pages to specify your suggestions. Include in this section any "teaching tips" - special procedures you used or means you discovered to more easily convey the information to students. Include in this section any comments you may have for the Teacher's Guide.

We recommend that you take a few minutes each day to complete the chart and, most importantly, to write down your comments. If you need more space for comments, use the back of the comments pages and/or attach additional sheets.

The number of responses is the middle number in each column.

Unit VI: POWER	Appropriate for students?	Completed in 50 minutes?	Any errors or inaccuracies?	Any management problems?	Any suggested modifications?
Overview					
Video	100 yes 17 no	---------	yes 16 no 100	yes 16 no 100	11 yes 18 no 89
CO	100 yes 17 no	85 yes 13 no 15	yes 15 no 100	yes 15 no 100	6 yes 16 no 94
Mechanical Systems					
Video	100 yes 17 no	---------	yes 15 no 100	yes 16 no 100	6 yes 17 no 94
C1	100 yes 17 no	87 yes 15 no 13	7 yes 15 no 93	yes 15 no 100	6 yes 16 no 94
C2	100 yes 17 no	86 yes 14 no 14	yes 14 no 100	yes 14 no 100	7 yes 15 no 93
Math Lab	93 yes 14 no 7	54 yes 13 no 46	43 yes 14 no 57	8 yes 13 no 92	21 yes 14 no 79
6M1	100 yes 13 no	67 yes 12 no 33	17 yes 12 no 83	17 yes 12 no 83	31 yes 13 no 69
6M2	100 yes 9 no	50 yes 8 no 50	yes 8 no 100	25 yes 8 no 75	33 yes 9 no 67
Fluid Systems					
Video	100 yes 16 no	---------	yes 14 no 100	yes 15 no 100	6 yes 16 no 94
C1	100 yes 15 no	85 yes 13 no 15	yes 13 no 100	yes 13 no 100	7 yes 14 no 93
C2	100 yes 15 no	85 yes 13 no 15	29 yes 14 no 71	yes 13 no 100	14 yes 14 no 86
Math Lab	93 yes 14 no 7	50 yes 12 no 50	8 yes 12 no 92	yes 12 no 100	25 yes 12 no 75
6F1	92 yes 12 no 8	73 yes 11 no 27	9 yes 11 no 91	27 yes 11 no 73	42 yes 12 no 58
6F2	100 yes 8 no	50 yes 6 no 50	yes 7 no 100	29 yes 7 no 71	43 yes 7 no 57
Electrical Systems					
Video	100 yes 17 no	---------	yes 15 no 100	yes 16 no 100	6 yes 17 no 94
C1	100 yes 16 no	86 yes 14 no 14	yes 14 no 100	yes 14 no 100	7 yes 15 no 93
C2	100 yes 16 no	86 yes 14 no 14	13 yes 15 no 87	yes 14 no 100	13 yes 15 no 87
Math Lab	93 yes 15 no 7	77 yes 13 no 23	7 yes 14 no 93	yes 13 no 100	14 yes 14 no 86
6E1	100 yes 12 no	70 yes 10 no 30	yes 10 no 100	27 yes 11 no 73	36 yes 11 no 64
6E2	100 yes 9 no	43 yes 7 no 57	yes 7 no 100	29 yes 7 no 71	50 yes 8 no 50

The number of responses is the middle number in each column.

	Appropriate for students?	Completed in 50 minutes?	Any errors or inaccuracies?	Any management problems?	Any suggested modifications?
Thermal Systems					
Video	100 yes 16 no	---------	yes 15 100 no	yes 14 100 no	7 yes 14 93 no
C1	94 yes 16 6 no	86 yes 14 14 no	yes 14 100 no	yes 14 100 no	14 yes 14 86 no
Summary					
Video	100 yes 16 no	---------	yes 14 100 no	yes 14 100 no	yes 14 100 no

Comments for Overview Class

See attached comments

Comments for Videos

Overview Video: See attached comments

Mechanical Systems Video: See attached comments

Fluid Systems Video: See attached comments

Electrical Systems Video: See attached comments

Thermal Systems Video: See attached comments

Summary Video: See attached comments

Comments for C1 Classes

Mechanical Systems C1: See attached comments

Fluid Systems C1: See attached comments

Electrical Systems C1: See attached comments

Thermal Systems C1: See attached comments

Comments for C2 Classes

Mechanical Systems C2: See attached comments

Fluid Systems C2: See attached comments

Electrical Systems C2: See attached comments

Comments for Math Lab Classes

Mechanical Systems Math Lab: See attached comments

Fluid Systems Math Lab: See attached comments

Electrical Systems Math Lab: See attached comments

Comments for Lab 1 Classes

Mechanical Systems Lab 1: See attached comments

Fluid Systems Lab 1: See attached comments

Electrical Systems Lab 1: See attached comments

Comments for Lab 2 Classes

Mechanical Systems Lab 2: See attached comments

Fluid Systems Lab 2: See attached comments

Electrical Systems Lab 2: See attached comments

Comments for Summary Class

See attached comments

PRINCIPLES OF TECHNOLOGY
UNIT VI: POWER
TEACHER QUESTIONNAIRE

QUESTION 1 COMMENTS

What did you like most about the POWER unit?

1. Fluid POWER section. (#25)
2. Electrical section (#13)
3. The math problems were better. (#17)
4. Relief from the ENERGY unit, it seemed like an interruption in the flow of material. (#12)
5. No preference, the videos. (#33)
6. The unifying concepts were more obvious in this unit. Also, the subunits fluid and electrical were excellent. The math labs were great too. (#45)
7. Lab work (electrical and mechanical systems). (#58)
8. Again this unit tends to pull all previous units together for better and more complete understanding. (#38)
9. That it's over. (#08)
10. Better labs. (#62)
11. It seemed to be easier, the concepts were logical and everything seemed to fall into place. I thoroughly enjoyed POWER. (#11)
12. POWER concept particularly well done in electrical subunit. (#30)
13. The videos and labs for mechanical POWER. (#32)
14. I feel the whole unit was well prepared but the exercise on electricity costs was very good. (#63)
15. Everything. (#27)
16. POWER seems to be eaiser to understand than ENERGY. We didn't have time to complete this unit. (#36)

QUESTION 2 COMMENTS

What did you like least about the POWER unit?

1. Mistakes in the material. (#25)
2. Heat. (#13)
3. Thermal was not properly developed, i.e., there is a lot to be said for solar power. (#17)
4. Recovering momentum again, going back to WORK, RATE, FORCE, etc. We seem back on track after the E side trip. (#12)
5. No preference. (#33)
6. Not having the right equipment. (#45)
7. No equipment. (#42)
8. The equipment didn't get here. There were really no bad features except that. (#38)
9. The lack of equipment to do experiments with. (#08)
10. Exam, heavy on math and formula use. (#62)
11. Demonstrations. (#30)
12. Not enough applications, too many unit changes in problems. (#56)
13. The labs for electrical POWER. (#32)
14. No equipment. (#07)
15. Some of the errors in the teacher's guide answer sheets for the math labs. Most were or appeared to be typos. (#63)
16. Equipment limitations reduced hands-on labs to a minimum. Math labs were hard for the students. (#27)
17. Due to the year coming to an end we didn't have as much time to devote to this unit as we should, consequently there was not as much learning that took place as we would have liked. Again, we didn't have all the necessary equipment. (#36)

QUESTION 3 COMMENTS

In terms of their overall impact (instructional effectiveness, student interest, manageability) rank each of the components of the POWER unit.

1. Mistakes in math labs. (#25)

2. Math labs did not coincide with unit. Hands on labs were ridiculous. (#13)

3. Videos seemed to lack punch. A lot of redundant material. (#17)

4. Some students feel the math labs don't explain well enough. Did not do a lot of the hands-on labs. (#33)

5. Videos and teacher's guide can be improved a little more. But the rest was excellent. (#45)

6. Math labs do not relate. Hands-on labs, no equipment. Teacher's guide not much help. (#08)

7. Just needs to be more relevant and interesting. (#56)

8. Math labs were a bit difficult for some of my students. (#32)

9. The equipment required was not readily available for all labs, I feel alternative labs or suggested demos might help when equipment is not available. Teacher's guide needs to be edited a little more thoroughly. (#63)

10. Need student text to be less wordy. Need teacher guide to be more inclusive. (#37)

11. Same old problem -- lack of equipment. I think the concepts were good but equipment is needed to conduct a lab. (#36)

QUESTION 4 COMMENTS

Which of your students seem to be the most successful with the Unit 4 material?

1. All students are about the same. Some will have problems with one area and some with another. (#25)

2. The material in this unit is somewhat harder for students with lower abilities, really anyone that applies themselves. (#33)

3. Everyone did quite well on this unit. They said it was easy. (#11)

4. Previous comments apply pertaining to as-expected positive performance of better students and unusually good performance of average students. (#30)

5. Because average students have had experience to vocational or industrial arts courses they seem to get the overall concepts more quickly. (#63)

6. Math work was difficult for many students. (#27)

QUESTION 5 COMMENTS

Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for the POWER subunits?

1. Few teachers will be able to follow these ideal settings, I think. (#25)
2. Units went fairly fast. (#13)
3. I like it. (#17)
4. An extra day every second film. (#33)
5. We did not use the six day plan but we used more hours than this. (#58)
6. We meet every other day for 85 minutes. (#11)
7. I'm sure that if the lab equipment had been in place I would have needed more time. (#38)
8. More time is needed. (#32)
9. I feel more time is needed for lab work. The set-up and take down time is using up some of the 50-minutes allotted. (#63)
10. Some areas need a bit more time. (#37)

QUESTION 6 COMMENTS

On average, how much time did you spend preparing to teach each class in the unit on POWER?

1. Needed time to construct labs that I thought were more significant. (#13)
2. For me, the unit was easier to teach. (#17)
3. Spent lots of time in hardware stores. (#12)
4. Large time for the few labs where equipment was available. Class prep time for lecture/demo classes acceptable. (#30)
5. Most of my time is used in desperate search for altomative to labs that I am not equipped to handle. (#63)

QUESTION 7 COMMENTS

Overall, did you feel comfortable teaching the materials in the unit on POWER?

1. I enjoy the electrical but do not have as much experience in it as some of the other units. (#58)

2. I'm not a physics teacher. (#08)

QUESTION 8 COMMENTS

Do you think most of your students did the assigned readings at home?

1. We read in class as my students are here for 3 hours each day. (#17)
2. They don't unless the structure of the class forces them to read at home. (#12)
3. About 80% of them did. (#45)
4. We did all reading in class. (#58)
5. Students never took book home. (#08)
6. Not surprising. This is June. (#30)
7. Again, I feel that this area is the program's weakest link. Reading is essential but it will require time before the students will comply 100%. (#63)

QUESTION 9 COMMENTS

What, if anything, caused you the most problems in teaching the unit on POWER?

1. Hands-on labs. (#13)

2. Reading the kilowatt/hr meter. (#17)

3. Conversion of units. (#09)

4. Lab equipment, especially the hose connectors and little doodads like that. (#12)

5. Not having the lab equipment available. (#33)

6. Nothing really, maybe if we had a few more math problems it would have been easier. (#45)

7. Electrical. (#58)

8. Lack of equipment. (#42)

9. No equipment for labs. (#38)

10. Lack of equipment. (#08)

11. Formulas, psi = lb in^2. Use one or the other but be consistent. (#62)

12. Electrical. (#11)

13. Time to prepare labs, finding material. (#32)

14. Student apathy. (#56)

15. As before, unavailability of lab equipment was the most trying situation for teacher and students. Motivation always difficult during June. (#30)

16. Lack of equipment for suggested labs. (#63)

17. No labs. (#37)

18. Equipment. (#27)

19. Lack of equipment for labs. (#36)

QUESTION 10 COMMENTS

Do you feel the teacher's guide material provided you with enough information to help you successfully implement the unit?

1. More math examples without errors showing different ways to address problems. (#25)

2. Except kw/hr meter. (#17)

3. More background material. (#08)

4. More and better demonstrations suggested. (#30)

5. More explanation on student exercises and more detail on diagrams. (#37)

QUESTION 11 COMMENTS

Did you teach Unit VI: POWER on consecutive days for 26 days?

1. 3 days a week. (#25)
2. 2 days a week, 2 hours a day. (#13)
3. I explained the material before I left for 3 days. I had the students work on the student exercises. and math skills. (#33)
4. Two days a week most of the time. (#58)
5. Every other day for 95 minutes. (#11)
6. Skipped math labs and most hands on labs because of lack of equipment. (#08)
7. Double periods during alternate weeks. (#30)
8. We could not do the labs due to the lack of equipment. Therefore we had to work on other things during this time. (#07)

QUESTION 13 COMMENTS

Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

1. Didn't keep track. (#25)
2. Math labs and hands-on labs and in some cases C1 and C2. (#13)
3. C1 and C2 of fluid POWER, C1 and C2 of overview. (#45)
4. C1 and C2. (#38)
5. C1 and C2, M-L1, L2-Summary. (#11)
6. C1 with pretest and bookkeeping. C1 and C2, L1 and M1, L2 and CR (in cases where 2 labs were possible). (#30)
7. Fluid POWER, teacher lab with lab F2. (#32)
8. C1 and C2. (#07)
9. C2 and math lab in electrical unit. (#36)

QUESTION 16 COMMENTS

Do you have any other comments, concerns or suggestions for the unit on POWER?

1. More thermal! (#17)

2. It was excellent, materials were good and easy to understand for most of my students. (#45)

3. Alter the style; at this point the C1, C2, L1, L2 has become too familiar to have the problems and their method and solution. (#12)

4. Question 30 on test has no correct answer. Answer should be 0.6324555 amps. (#08)

5. Do not require so much unit conversion in the problems. (#07)

6. I feel the hands-on labs may need a little modification. There is a need for supplemental activities either in or out of class. (#63)

7. Teacher suggestions have become limited. Some additional comments on labs would help. (#27)

COMMENTS FOR OVERVIEW CLASS

1. Okay. (#17)

2. Okay. (#12)

3. Was excellent. (#45)

4. Could use some interesting and workable demonstrations. (#30)

COMMENTS FOR VIDEOS

1. All were good. (#13)

2. All were okay.

   Thermal: Needs more material. (#17)

3. We do not run on 50-minute classes so we have some extra time on some units and less on others. (#58)

4. All good. (#12)

5. All were good.

   Mechanical: It was good but can be improved by adding more practical applications. (#45)

6. Overview: No problem, good overview.

   Mechanical: Kids react well. Technician made good presentation.

   Fluid: Very practical. Students paid attention and commented on importance of topic.

   Electrical: Nice program; no difficulty that we noticed.

   Thermal: No problem.

   Summary: Good review. Kids watched and reacted well. Seemed to cover points of text sufficiently and emphasized importance of key concepts. (#30)

7. Excellent. (#63)

COMMENTS FOR C1 CLASSES

1. All were good and informative. (#13)

2. All were good.

   Thermal: Too short, needs more develcpment. (#17)

3. All were excellent. (#45)

4. Mechnical: Practice ft lb/sec--->N m/sec--->watts--->hp conversions to get that obstacle out of the way, then go on to power problems.

   Fluid: We've stopped reading the sample problems in the text. I've stubstituted some of my own where the students have to work on their own to find the answer. They tend to read the answer given and quit.

   Electrical: Page 103 chart. At least! print it on heavy stock and hand it out earlier. We blitzed through this subunit to make it to the end of the unit before school ended. (#12)

5. Thermal: Too short. (#08)

6. Electrical: You definitely need a more practical approach. Simply using RI, a voltmeter and ammeter would be easier. A small amprobe meter $45 to $60 could be used with heater carts for A/C, like electricians do it. (#62)

7. Mechanical: Running the lab experiment before the class is not a demo, but a pre-lab. A few good demos are in order. No problem with the text material.

   Fluid: Recommend a page added to teacher's edition which can be used to make an overhead transparency (full size) of such diagrams as figure 6-9.

   Electrical: Nice to see Ohm's law showed up again.

   Thermal: Good review. Combines well with review class since it is also a review of heat rate. (#30)

8. Mechanical: Page 19, heat power? (#07)

Comments for C2 Classes

1. All were good. (#13)

2. All were good. (#17)

3. All were excellent. (#45)

4. Mechanical: We went through this pretty fast, it seemed like review, which is why I think POWER should follow immediately after WORK. (#12)

5. Fluid: Page 67, example 6-6, P = 1444 not 1425 ft lb/sec. P = 2.63 Hp not 2.59 Hp. Page 68, part b, DP = 6240 lb/ft2, not 6.240. Page T-71a, P = 188.4 ft lb/sec not 182.4. (#42)

6. Fluid: Page T-71a #5, P=188.4 ft lb/sec, not 182.4.

   Electrical: Page T109, and 109a, #7 should be 3730 watts; #8 Pelec should be I=3.36A. (#38)

7. Mechanical: No problem.

   Fluid: Class material good; student exercises good.

   Electrical: I would have preferred to see a slightly clearer reference made to the point that a "power meter" really measures energy in the event that the laboratory equipment was not available. It was stressed during the 6E1 lab, however. (#30)

8. Mechanical: For C1 and C2, sample problems seem a bit complex to begin with. I'd like to see several straightforward problems to practice the concept first then give them something changing the units, etc.

   Fluid: Seems like too many problems. I would like more discussion, more applications.

   Electrical: Seems like too many problems, what happened to all the applications as in earlier chapters? They may be obvious with this unit but let's hear them anyway. (#56)

9. Fluid: Student exercises, problem 5, page T-71a, error.

   Electrical: Student exercises problem #2, c and d are the same. Problem 8, typo: "psig." Problem #8 has wrong answer, should be 4.38. (#07)

Comments for Math Lab Classes

1. As far as all math labs are concerned, they are not straightforward enough. The material in the reading is straightforward but when we get to the math problems the student is supposed to exhibit a level of understanding tht does not fit the text. This could be easily remedied by having more of the simpler problems right at the start of the lab or review, and indicating the simpler problems so that the student could get some satisfaction instead of frustration before going on to the more difficult questions. The questions in the reviews are turned around problems which, although they are clever and challenging, nonetheless turn the average and below average students off. It should be stated at the beginning of each section exactly what level of math understanding is required to do that section. For example, this unit requires a fundamental understanding of simple algebra and a little geometry. (#25)

2. Mechanical: Problems too few and not really appropriate. Students questioned what items used were. Takes a lot of my time creating new problems.

   Fluid: Need more problems.

   Electrical: Need more problems. Very good. (#13)

3. Mechanical: Problem 2b should be 73.3' (because .5HP = 275 ft lb/sec. 2c should be 23.98 ft lbs. Problem 4a should be .25 in. Took longer than 50 minutes. Excellent math.

   Fluid: Took longer than 50-minutes. Should shorten. Excellent math.

   Electrical: Excellent. (#17)

4. They were good but by having more mathematical formulas involving trig and geometry in problems, they could have been more suitable for advanced students. (#45)

5 Mechanical: Assigned individual problems as homework. These problems are tough to teach. Do them on the board and bore the kids to death or do them in class and some students become passive copiers. I stoppped teaching the math labs in the ENERGY unit.

   Fluid: Assigned individual problems as homework. Far more interesting than the student exercise.

   Electrical: Didn't do. (#12)

6. Mechanical: Errors:
   1) p32, problem #4(a), D=.25 in, not .166 in.
   2) problem #4(c) P = 564.9 n m/sec, not 376.3.
   3) problem #4(b) D = .635 cm not .42.
   4) problem #4(d) answer "c" is NOT equivalent.
   5) page 34, problem #6(a), 2nd step should be 7540 lb x 3.28 ft. (#42)

7. Since there was not lab equipment we took some extra time with student exercises and math labs in all three subunits.

   Mechanical: Page T-31, .05 hp = 275 ft lb/sec, not 225. (#38)

8. Mechanical: Word problems require more teacher input, so it was difficult to complete in 50 minutes. Of course, for student purposes, a complete math lab need not necessarily involve 6 problems and it is better to have too many than to have too few.

   Fluid: Again, ran over 50 minute period. Assigned two problems for homework assignments. Worked out well.

   Electrical: Very practical. The kids didn't seem to mind. We also programmed the local Apple to do the calculations as an additional math lab activity. (#30)

9. Unit conversions cause students to lose sight of the physics in the problems. Problems should be written with fewer conversions. It is very hard to solve the problems in the math lab without math errors.

   Mechanical: There are errors on page 31b, #2b; page 32T, #4a and b; page 34T, #6a; and the table on page 34. (#07)

10. Mechanical: Students had difficulty with the manipulation of math formulas. We took 2 periods (100 minutes) for work.

    Fluid: Students had difficulty with the manipulation of math formulas. We took 2 periods (100 minutes) for work. (#27)

Comments for Lab 1 Classes

1. Did not use any of them. (#13)

2. Mechanical: Okay.

   Fluid: Excellent.

   Electrical: Good. (#17)

3. They were all good. The only problem we had was not having the right equipment. (#45)

4. Fluid: Some narrative was wrong, I shared this with Keith Ross. Suggest possibly using a slant tube over a U tube manometer.

   Electrical: Lab equipment wasn't completely available. (#33)

5. Mechanical: Substitute for SPST (no) switch a telegraph key? We did our own version of this lab at the end of WORK and tried to compare electrical work to rotational to linear. The results were crummy. We never did this lab as a POWER lab.

   Fluid: This lab was a disaster. The pumps run at 4, 5, 6V, but they won't lift water until about 12V. At that point they blast the water right through the manometer. We need longer arm manometers and may have to use mercury in them.

   Electrical: Our watt hour meter apparatus has no "junction box" or "line voltage monitor." The design notes weren't specific about how you put this together when all you get from the power company is the meter, pigtail and 1 outlet to appliance. Where do you get all the other stuff? (#12)

6. Fluid: S-W water pumps would not operate at 4 volts or at 5 volts. (#42)

7. Mechanical: Page 43, part II, letter b, should be P=(68.6 N m)/(/ /sec) instead of P=(49 N m)(sec).

   Fluid: Did not work, used wrong pumps.

   Electrical: Had AP & L come in and do this lab. (#08)

8. Fluid: Better put Hg in manometer. (#56)

9. Mechanical: S-W pulley supplied inappropiate. Hook at top cannot support that mass. Needs hardware store pulley. String has to be coiled on motor shaft. We used 4.5 kg instead of 5, and lab supports instead of heavy-duty support stands which were not ready in time for lab. SPST switches seemed to work, but were too dangerous for continued work. Current went off-scale on power supply panel meters.

   Fluid: Used 1/2" Cu tubing. Pressure differential across the manometer set up and flow through the manometer. It was impossible to get useful data. If others had similar problems, a change to 3/4" or 1" plumbing might work. Pre-lab prep time was significant this year, but may not be bad for the next time through.

Electrical: Good lab. Equipment developed in-house so that we didn't have to await delivery. We noted that design specs for item #98 called for 4'x4'x5/8 plywood. 2'x4'x5/8 waferboard (varnished) would have been adequate, easier to store, less prone to tip over, and tougher for kids to hide behind while getting into trouble. Strongly recommend change. (#30)

10. Mechanical: Very poor lab. The weights will not remain when the current to the motor is interrupted. This is a very likely cause of injury in the classroom

    Fluid: No equipment available from S-W. We tried to use existing equipment from other units but could not keep from losing water from the manometer. Students worked on this lab off and on or 3 days.

    Electrical: No equipment from S-W. (#07)

11. For all labs we need supplemental, alternative or demonstration to replace the labs we are not equipped for. Labs need to be longer. (#63)

12. Electrical: Not done, equipment not available. (#27)

Comments for Lab 2 Classes

1. Did not use any of them. (#13)

2. All were good. (#17)

3. No lab equipment was available. (#33)

4. All were excellent. The only problem we had was not having the right equipment. (#45)

5. Mechanical: Skipped. We did all labs religiously the first 4 units. Now we're getting uppity and skipping ones we don't like the looks of. What's the string tied to? There are some important details hidden by the cradle-box, as drawn.

   Fluid: Air motors from Northern Hydraulics need close to 30 psi to run. Regulators from earlier pneumatic labs go from 0-25 psi. We bought some new 0-60 psi regulators and finally got results. Rotameter has to go upstream with air sanders. No need to put finger clamp rotameter to control motor since the air sander has a trigger. Bag the air tanks! The kids empty them in 20 seconds. I'm buying a compressor.

   Electrical: We never did order motor, generator sets, so we have no equipment for this lab. School's out! (#12)

6. No equipment for any of them. (#42)

7. Fluid: I don't know, this is the 3rd time for this basic set-up, maybe something different could be developed here. (#56)

8. Mechanical: Flywheel apparatus is still unavailable. No attempt made to complete 6M2.

   Fluid: Air motors have not arrived. 6F2 was a fluid system washout.

   Electrical: Motor generators did not arrive on time, very promising lab, however. (#30)

9. No equipment from S-W. (#07)

10. Mechanical: Not done, equipment not available.

    Fluid: Not done, compressor broke down.

    Electrical: Not done, equipment not available. (#27)

Comments for Summary Class

1. Appropriate. (#13)

2. Okay. Thermal needs to be developed more. Perhaps in terms of "alternative energy" sources such as solar. (#17)

3. Excellent. (#45)

4. I have commented in the past about the poorly prepared exams.

   #30 - 100 watt resistor.
   #31 - What electrician ever uses joules? (P.S. I have been an electrician for 38 years: N.H. Master Electrician).
   #28 - Formula taught is Power $=\Delta V \times i$, why use (Force x Rate), confusing.
   #14 - Too tricky, who remembers 100 kg mass = 980 Newtons?
   # 7 - Terrible!
   # 2 - Why here?

   Worst of the bunch!! (#62)

5. Video good, no problem with summary materials. Test question #30 incorrectly answered. (#30)

PRINCIPLES OF TECHNOLOGY

Unit 7: FORCE TRANSFORMERS

Pilot Test Findings

Agency for Instructional Technology
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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 and related print 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.

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INTRODUCTION

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 40 state and provincial education agencies (see Appendix A for a list of cooperating agencies). The course consists of fourteen units, each focusing on a principle that underlies today's technology. 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), from consortium representatives, and from teachers and students at classroom pilot test sites. The review team reviews preliminary drafts of the instructional materials before they are sent to consortium representatives and pilot test sites. Consortium representatives review the material concurrently with the classroom pilot testing. The data from all sources -- review team, consortium representatives, and pilot sites -- are analyzed and reported to the developers, who use these findings to revise the materials.

Thus, an important part of the overall formative evaluation is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working; and 2) to identify specific problems with the materials. All pilot test teachers were oriented to the *Principles of Technology* course and to the pilot test procedures at one of two meetings held in Dallas the summer of 1984.

This report details findings of the pilot test of Unit 7: FORCE TRANSFORMERS. The report makes some comparisons of these findings with those for Units 1-6, which are contained in separate reports (see "Unit 1: FORCE -- Pilot Test Findings," December 18, 1984; "Unit 2: WORK -- Pilot Test Findings," March 1, 1985; "Unit 3: RATE -- Pilot Test Findings," May 6, 1985; "Unit 4: RESISTANCE -- Pilot Test Findings," May 29, 1985; Unit 5: ENERGY -- Pilot Test Findings," July 15, 1985; and Unit 6: POWER -- Pilot Test Findings," August 19, 1985). It's important to

remember that all data are formative data; the developers are using the data, along with the review team and consortium representatives' reactions, as a basis for revising the materials.

PILOT TEST PROCEDURES

Unit 7: FORCE TRANSFORMERS pilot test materials were mailed to the teachers in mid-February, 1985. These materials consisted of:

1) Pretest/posttest (see Appendix C)
2) Computerized scoring sheets for the pretest/posttest
3) Student attitude questionnaires (see Appendix E)
4) Teacher questionnaires (see Appendix F)

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the same test as a posttest along with the student attitude questionnaires. All Unit 7 data evaluation materials were then mailed back to AIT.

Only five teachers completed Unit 7 in the first year of the pilot test. This posed a dilemma for the developers. For the delivery schedule to be maintained, revisions had to be made in the Unit 7 materials before most teachers had completed the unit. Therefore, the revisions in the unit were made with the data from these five teachers, the review team and the consortium representatives. However, because the first nine units of the course are sequential, it was necessary that the remainder of the teachers teach Unit 7 at the beginning of year two. This report contains all data received by November 1985.

LIMITATIONS OF THE METHODOLOGY

Two major limiting factors must be considered when the findings are interpreted: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered, including:

• Lack of matched control groups

The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in terms of time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

• The pretest/posttest format

The same test was used for both the pretest and the posttest. The effect that memory of the pretest might have on posttest performance was another concern. The research design addressed this concern in three ways:

1) Students were not given the correct answers to the pretest. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

3) A correlated *t* test was used to analyze the pretest/posttest data. This technique helps to partial out any variance that might result from an intruding correlation -- in this case memory.

• The pretest/posttest format (see section on development of the instrument, page 7)

The test cannot measure all objectives. Therefore objectives had to be sampled. Also, the items do not always directly match the intended objectives. The test was a cognitive test. Many of the objectives (particularly the lab objectives) are psychomotor objectives. One must consider each of these factors when assessing the validity of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results including:

• Equipment problems

As with the previous units, several teachers reported problems in securing necessary lab equipment.

• Student characteristics

Both teachers and students have reported what appears to be considerable variability in the kinds of students in the course. This variability encompasses students' academic backgrounds, ability levels, and socioeconomic levels. The project has made no attempt to control these variables.

• Teaching pattern

Teachers report considerable variability in the length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess the impact of the various conditions on the outcomes.

• School/project schedules

Unit 7 suffered from a unique scheduling problem. Most of the teachers did not teach the unit until the start of the second year. The three-month interval between Units 6 and 7 may have had an effect on these teachers and their students.

So, both research design and external constraints must be considered when the results are interpreted. It's important to remember that the pilot test was designed as a part of the overall formative evaluation, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

SAMPLE

The sample included 171 students in twelve sites. Student characteristics included:

• Grade§

10 = 3% 11 = 26% 12 = 71% (Most teachers in the sample taught Unit 7 at the start of year two.)

• Sex

Male = 88% Female = 12%

Teacher characteristics included:

• Physics background

As with previous units, there was a wide range in the teachers' physics backgrounds; 18% reported no college physics courses; 27% reported one college physics course; 37% reported 2-4 college physics courses; 9% reported 5-7 college physics courses; and 9% reported eight or more college physics courses.

• Mathematics background

All teachers reported having had two or more college mathematics courses; several (27%) have had five or more college mathematics courses.

• Teaching Pattern

The majority (58%) taught Unit 7 on consecutive days. Most (75%) taught sessions that were 60 minutes or shorter. Several (64%) indicated that they had combined classes into one session.

• Preparation time

The majority (82%) indicated they spent 60 minutes or less preparing to teach each subunit on FORCE TRANSFORMERS.

Unit 7 includes data from only twelve sites (compared to more than twenty for most of the first six units) and from only 171 students (compared to nearly 350 for most of the first six units). It's important to examine the characterisitcs of the reduced sample, both for students and for teachers.

The student sample continues to be predominantly male. For Unit 7, 88% were males; the first six units also averaged more than 80% males. The most pronounced change in student characteristics was the much larger percentage of twelfth graders for Unit 7 than for previous units

§Due to missing data, the pretest/posttest student demographics don't match the student attitude demographics.

(71% compared to about 20%). This preponderance of twelfth-grade students is explained by the fact that most teachers taught Unit 7 at the start of year two.

Teacher characteristics measured were negligibly different from those of teachers in earlier, larger samples. The mathematics and physics background, teaching pattern, and preparation time of the teachers were similar to those found for the first six units.

The most important issue of the smaller sample, of course is the effect it will have on the validity of the findings. Is the data base sufficient for making judgments about the materials? To judge the adequacy of the sample it's probably helpful to consider the primary goals of the evaluation: 1) to determine how well the materials are working; and 2) to identify specific problems with the materials. Even the reduced sample should provide an adequate data base for achieving these goals. Certainly, a student sample of 171 is sufficient to ensure reliable pretest/posttest results. The reduced sample will, however, limit the comparisons that can be made of the various conditions -- teacher background, teaching pattern, and to a lesser degree, student characterisitcs. There are simply not enough classes in the various conditions for these comparisons. Certainly, the project staff would have preferred a more stable sample. However, this sample should provide enough data to judge the materials.

PRETEST/POSTTEST AS AN INSTRUMENT

To understand the results, one must first understand the characteristics of the test as a measurement instrument, including the process by which the test was developed and what statistical analyses reveal about the reliability and validity of the instrument.

Over 50 test questions were generated at CORD by the content specialists. In a collaborative process between evaluators and content specialists, these questions were pruned and revised to the eventual 34 questions. Each item is tied as directly as possible to a specific objective from Unit 7. The item/objective match is not always exact. It's impossible to match items to some objectives because of the way those objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and that approximations objectives are often the best that cognitive test developers can do. With only 34 items, not all objectives could be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were determined based on the relative importance of the concepts. (Appendix C lists the objective each item is intended to address above the item.)

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?). On the Spearman-Brown Test of internal consistency, the reliability of this instrument is .87, which is acceptable by most standards. Validity is a bit more complicated to judge. Readers are encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?
2) Is a sufficient range of objectives addressed?
3) Overall, is the instrument a fair measure of Unit 7's instruction?

It should be pointed out that, in examining the pretest/posttest results for each of the first seven units, the developers and evaluators encountered a few items in each unit (no more than three per unit) that they considered, for various reasons, to be poor items. Of course there is always wisdom in hindsight. Ideally, each of these instruments would itself be pilot tested.

However, the project's schedule precludes the luxury of pilot testing the instrumentation. Thus, even with careful planning, it's probably inevitable that a few poor items will be included in each test.

PRETEST/POSTTEST RESULTS

Several different analyses of the pretest/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 34 items.

- Mean differences

The overall pretest mean was 13.15. The overall posttest mean was 19.88. This increase was statistically significant (correlated *t* test) at the .01 level.

The level of statistically significant learning gain (.01) is consistent with the gains shown for Units 1-6. Table 1 compares the pretest/posttest scores for Units 1-7.

Thus, Units 1, 4, 5, and 6 had fairly consistent pretest-posttest learning gains in terms of percentage correct. Learning gains for Units 2, 3, and 7, while somewhat lower, were still statistically significant, indicating that a change in the students' knowledge level has occurred for each unit.

Individual Items

For each unit the project team has established criteria for acceptable performance on each test item. These criteria included either:

1) 70%+ correct on an item, or

2) doubling of the pretest score on the posttest.

Against these criteria, the results for Unit 7 are:

More than70% or doubling of percentage correct -- items 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 17, 18, 19, 20, 21, 24, 26, 29, 31, 32.

Less than 70% and no doubling of percentage correct -- items 2, 6, 13, 14, 15, 16, 22, 23, 25, 27, 28, 30, 33, 34.

Because this formative evaluation is designed to improve the materials, it has proved particularly useful to examine the content of the items on which students performed especially poorly. First, let's consider the subunits.

Linear/Mechanical -- One of ten items did not meet criteria.
Rotational/Mechanical -- Four of five items did not meet criteria.
Fluid -- Five of thirteen items did not meet criteria.
Electrical -- Two of four items did not meet criteria.
Overview -- One of two items did not meet criteria.

Thus, students performed particularly poorly on the items dealing with the Rotational/Mechanical subunit. These were primarily mathematics-related items, which continue to cause students problems.

Also, the test contained a series of items on the effects of a hydraulic jack and the effects of a pressure intensifier. Students failed to meet the criteria on over half these items.

Even with the likely impact of the schedule on students' performance, there was an overall statistically significant gain for Unit 7. Consistent with the findings for previous units, mathematics-related items continue to cause students particular difficulty. Because most of the Rotational/Mechanical subunit items involved mathematics, it's probably not too surprising that students performed particularly poorly on this subunit. Probably more disturbing is students' poor performance on the items dealing with the effects of a hydraulic jack and a pressure intensifier, both of which are key concepts for the unit.

Table 1
Principles of Technology
Pretest and Posttest Scores, Units 1-7

Unit	Number of Items	Pretest Mean (% correct)	Posttest Mean (% correct)
1	30	12.5 (41%)	20.1 (67%)
2	33	13.6 (41%)	17.6 (53%)
3	30	14.9 (49%)	19.4 (65%)
4	36	16.4 (46%)	24.4 (68%)
5	35	13.2 (38%)	22.6 (65%)
6	30	11.5 (38%)	18.3 (61%)
7	34	13.2 (39%)	19.9 (59%)

PRETEST/POSTTEST BY SELECTED VARIABLES

The impact of several variables on students' test performance was examined including:

1) Student characteristics
   a) sex
   b) grade

2) Teaching pattern
   a) consecutive days
   b) length of class periods
   c) combined activities

3) Teacher background
   a) physics background
   b) mathematics background

These variables were analyzed with an analysis of covariance, which controlled for pretest scores. Table 2 examines the results of this analysis; all means reported in Table 2 are for the posttest.

Table 2

Main Effect	Level of Significance	Subset	M[illegible] core
Sex	.09	Male (149)	20.55
		Female (21)	14.86
Grade	.01	Tenth (5)	21.80
		Eleventh (56)	15.59
		Twelfth (102)	21.90
Consecutive days	.01	Yes (75)	22.88
		No (96)	17.54
Minutes per class	.01	LT50 (83)	22.34
		50-60 (21)	10.10
		60-90 [illegible]	20.04
		90+ (41)	20.02
Combining sessions	.01	Yes (39)	23.97
		No (132)	18.67
Phy[illegible] background	.01	No classes (41)	13.29
		1 class (41)	22.59
		2-4 classes (41)	22.59
		5-7 classes (11)	16.91
		8+ classes (37)	21.89
Mathematics background	.01	1 class (9)	11.11
		2-4 classes (90)	18.74
		5-7 classes (26)	22.73
		8+ classes ([illegible]6)	22.22

Due to the smaller sample, the data from Table 2 must be interpreted very cautiously. It's important to examine the numbers in parentheses in the column labelled "Subset." These numbers represent the numbers of students in each condition. The small numbers in several of the conditions indicate that the findings are likely affected by only one or two classes. Thus, the smaller sample severely limited our ability to make reliable comparisons of the various conditions. In past reports, the findings for these variables have been compared across units. With a sample half that of the previous units, these comparisons across units are no longer reasonable. Therefore, a table comparing variable findings across the first seven units will not be included in this report.

PRETEST/POSTTEST RESULTS BY SITE

Appendix D indicates the pretest/posttest results by site. Eleven sites showed statistically significant (.01) level increases; one site showed no statistically significant gain. Table 3 shows the number of sites showing no statistically significant gains for each of the first seven units.

Table 3

Unit	Sites showing no significant gains
1	1
2	4
3	4
4	0
5	1
6	3
7	1

These results, too, must be interpreteo cautiously. The reduced number of sites makes these comparisons across units difficult to make. It is encouraging to note, however, that only a single site showed no significant gain for Unit 7.

STUDENT ATTITUDE FINDINGS

The student attitude findings (Appendix E) indicated:

The majority of students (73%) liked Unit 7 either a lot (24%) or a little (49%).

The most appealing components were the video programs (28%) and the hands-on labs (24%). These were also the most appealing components for the first six units.

The least appealing components were the mathematics labs (26%) and the written material (18%). Again, these were also the least appealing components for the first six units.

Over half (57%) said some of the material was difficult for them to understand; 13% found most of it difficult.

Consistent with Units 3, 4, 5, and 6 students indicated the components most difficult for them to understand were the mathematics labs (35%) and the written material (17%). They indicated the component least difficult for them to understand was the video programs (54%). (Note: Items addressing the perceived difficulty of the components were not included for Units 1 and 2.)

Most students (88%) indicated they thought the material in the FORCE TRANSFORMERS unit was important for them to understand.

Table 4 examines the student attitude findings from the first seven units on three important variables -- appeal, difficulty, and perceived importance. As Table 4 indicates, the attitude findings for Unit 7 were slightly more positive than for Units 3-6. Perhaps most encouraging of all the attitude findings is that 88% of the students indicated they thought the material covered in the FORCE TRANSFORMERS unit was important for them to understand.

Table 4
Principles of Technology
Student Attitudes, Units 1-7

	Unit/Significant						
Category	1	2	3	4	5	6	7
Liked (a lot or a little)	80%	76%	62%	68%	63%	69%	73%
Difficult (most)	8%	8%	18%	11%	16%	14%	13%
Important (very or sort of)	89%	87%	77%	80%	77%	76%	88%

TEACHER RESULTS

Questionnaires were received from twelve teachers. Appendix F lists the teacher's detailed comments and should be examined carefully, because the wealth of data contained in these comments is difficult to encapsulate. Overall, the teacher findings included:

- Teacher comfort

Almost all teachers (92%) indicated they felt comfortable teaching the material in the FORCE TRANSFORMERS unit.

- Time

The majority (75%) indicated that the six-day plan of 50-minute class sessions per subunit is a realistic time allotment for Unit 7. One teacher indicated some of the hands-on labs required more than 50 minutes to set up, conduct, and discuss. This is consistent with the findings for the first six units.

- Student reading

Half (50%) indicated that their students may not be doing the assigned readings at home. It is interesting to note that this represents an improvement from what teachers reported for Units 3 (67%), 4 (72%), 5 (77%), and 6 (74%). This may indicate that the students who continued with *Principles of Technology* are more motivated students. It seems unlikely that the material itself motivated more students to want to read.

- Teacher's guide

Almost all teachers (90%) thought the teacher's guide provided them with enough information to successfully implement the unit. Two teachers, however, indicated that the guide should better explain the mathematics problems and formulas.

- Appropriateness for students

Generally, teachers tended to indicate that each day of instruction was appropriate for their students. For the videos and C1/C2 days of instruction they were unanimous in their responses. As with Unit 6, more than 90% also considered both the mathematics labs and the hands-on labs appropriate for their students.

- Problems

To the question, "What, if anything, caused you the most problems in teaching the unit on FORCE TRANSFORMERS?" ten teachers responded. The problems reported included:

- Hands-on labs, lack of equipment, etc. (six teachers).
- Mathematics and mathematics formulas (two teachers).
- The computer test (one teacher).

These findings are consistent with those teachers reported for Units 1-6. Availability of equipment for the hands-on labs continues to cause teachers the most problems. On the other hand, teachers continue to affirm the appropriateness of most of the material for their students.

Finally, many specific recommendations for changes, including pointing out errors in the text, are contained in the teacher's comments. Overall, the teachers tended to be fairly positive about Unit 7.

CONCLUSIONS

It is important to remember that the entire pilot test is part of the overall formative evaluation process. Data are being collected from the consortium review team, consortium representatives, and from the pilot test sites. These data are then used as a basis for revising the materials. To meet the delivery schedule, the revisions had to be made early in the fall of 1985. Most sites (7) did not teach the unit until the fall of 1985. Therefore, many of the data contained in this report arrived too late to affect the revisions. However, these data should prove useful in developing the remaining seven units, because Unit 7 appears to be the crucial link between year one and year two of the course.

Certainly, then, this report contains much useful information. Some of the key findings are:

1) Overall, a statistically significant (.01 level) learning gain took place, independent of students' sex. The students' grade had a significant (.01) impact on their scores, with tenth and twelfth graders performing better than eleventh graders. However, these data must be interpreted cautiously because of the small and possibly biased sample. It will be interesting to see whether these grade differences persist for future units.

2) Students performed least well on test items dealing with mathematics. This type of item also proved troublesome to students on the first six units. Also, students performed particularly poorly on the items dealing with the Rotational/Mechanical subunit. It should be pointed out that most of the items for this subunit involved mathematics, a fact which may help to explain students' poor performance on them.

3) Student attitudes were generally positive. In fact, the attitude findings were generally more positive than they were for Units 3-6. It may be that students reacted more favorably to this unit than to the earlier ones. On the other hand, since the majority of student data came from the start of year two it may be that students who returned for year two of the course are more positively pre-disposed to the course than those who chose not to.

4) Teachers affirmed the appropriateness of most of the material for their students. Again, this is consistent with the findings for the first six units.

5) Teachers' comments indicated that the most problems were encountered with the hands-on labs. This, too, is consistent with the findings for the first six units. It should be pointed out that most of the problems reported were with simply getting the equipment. Once teachers have the equipment, most of the labs seem to work satisfactorily.

6) Although the teachers were generally quite positive about the unit, they did recommend several specific changes.

Thus, Unit 7 data tended to be consistent with the data for the previous units. Students continue to show statistically significant learning gains and both students and teachers continue to be fairly positive about the materials. The teachers' major frustration continues to be the

availability of the lab equipment. This issue was much discussed at the July meeting in Dallas of the consortium, teachers, staff, and equipment vendors. It seems to be a complicated issue that will only be resolved with time. Unfortunately, this does little to relieve the frustrations of the teachers.

Perhaps the most interesting issues surrounding the Unit 7 findings surfaced not from the available data, but rather from the fact that a considerable amount of data was not available. The sample has been halved. It seems reasonable to wonder why the sites have been reduced from more than twenty to only twelve. And the total students responding are now at 171, compared to the 350 who submitted data for Unit 6. It's likely that school and student schedules, teacher availability, the time required for the pilot test procedures, and perhaps frustration at the equipment problems all worked together to reduce the sample. Although several explanations seem plausible, the issues surrounding the reduced sample deserve further examination. Indeed, this will become a focus of the year two evaluation, which will seek a better understanding of what it is reasonable to expect from the transition to year two of the course.

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

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

TVOntario

Tennessee State Department of Education
Division of Vocational 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

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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Appendix C

Student Test

Pre	Post	
		O1
		1. The action of "force transformers" can be represented by a unifying equation. Regardless of the energy system, the description always involves a source or input,
19	8	a. a coupling device and a distance multiplier.
52	78	** b. a coupling device and a load or output.
16	7	c. a coupling device and a pressure multiplier.
12	7	d. a coupling device and a voltage multiplier.
		O1, 2, ML1
		2. Force transformers are a class of machines or devices in mechanical, fluid and electrical energy systems
17	9	a. that change output values of force, movement or rate into different input values.
32	22	b. that change work input into larger values of work output.
46	67	** c. that change input values of force, movement or rate into different output values.
4	2	d. that always operate at efficiencies of 100%.
		ML6, MR1
		3. When a force transformer is 100% efficient,
61	85	** a. the output work equals the input work.
23	7	b. the output work is greater than the input work.
7	3	c. the output work is less than the input work.
8	5	d. energy is lost in overcoming friction.
		ML7
		4. An example of a first-class lever is
7	4	a. a pressure booster.
15	6	b. a nutcracker.
59	77	** c. a hammer or crowbar.
20	7	d. a voltage transformer.
		ML6
		5. The efficiency of a mechanical force transformer
12	3	a. is always equal to or greater than 100%.
15	6	b. does not depend on how much friction or resistance is present.
61	85	** c. is equal to the ratio (Work Out/Work In) x 100%.
10	6	d. is lowest when output work equals input work.

ML5

6. When a block and tackle force transformer has a work input of 200 ft lb and the load moves 6 inches (0.5 ft), what is the output force applied by the block and tackle transformer to the load? Assume that the block and tackle is frictionless.

Pre	Post		
41	41		a. 100 lb
19	9		b. 200 lb
28	47	**	c. 400 lb
11	3		d. 800 lb

ML6

7. The ideal mechanical advantage of a block and tackle force transformer is computed to be $MA_i = 2$. Examination of the forces involved shows that an input force of 22,000 lb was applied and an output or lift force of 20,000 lb resulted. The efficiency of the block and tackle force transformer is very close to: ($\%Eff = MA_a/MA_i \times 100$ and $MA_i = F_o/F_i$)

Pre	Post		
20	11		a. 100%
27	20		b. 95%
25	57	**	c. 91%
24	11		d. 80%

ML7, 8, 9

Match the "device" in the left column with the general type of force transformers described in the right column. For each statement in the left column, fill in the letter from the right column that best describes the term.

Pre	Post		
72	91	8. A Wedge	a. Linear force transformer
72	8[illegible]	9. C Belt and pulley system	b. Fluid pressure transformer
7	17	10. A Hydraulic jack	c. Rotational torque transfer
76	95	11. D Doorbell transformer	d. Electrical voltage transformer
63	86	12. B Power brake booster	

MR2

13. A wheel and axle is a force transformer that can be used to

Pre	Post		
23	27	**	a. amplify force (force out is greater than force in).
54	61		b. amplify angular speed (angular speed out is greater than angular speed in).
16	10		c. get rid of friction.

MR2

14. In a chain hoist that is 100% efficient, what is the actual mechanical advantage (MA_a) of the chain hoist if the input wheel is 8 inchs in diameter and the output or load wheel is 2 inches in diameter? ($MA_i = r_i/r_o$ and $MA_a = F_o/F_i$)

Pre	Post		
21	10		a. $MA_a = 1/4$
39	67	**	b. $MA_a = 4$
20	7		c. $MA_a = 8$
18	16		d. Not enough information given to answer the problem.

Pre	Post		
			MR3 15. An overhead crane hoist used in a metal fabricating shop is only 80% efficient due to internal resistance. The crane was designed to have an ideal mechanical advantage of 10 when rigged in a specified way. What is the actual output of force the crane can generate if the input force is 15 tons? ($\%Eff = MA_a/MA_i \times 100$, $MA_a = F_o/F_i$, $MA_i = D_i/D_o$)
13	11		a. 40 tons
27	11		b. 80 tons
33	58	**	c. 120 tons
25	19		d. Not enough information given to answer the problem.
			MR6 16. A belt-drive system has a mechanical advantage of 3. If the smaller wheel of the belt drive is on the input shaft, the output wheel (which is larger) will
21	11		a. develop less output torque than the input torque.
17	14		b. cause the output shaft to turn faster than the input shaft.
43	63	**	c. cause the output shaft to turn slower than the input shaft.
17	12		d. develop more output force than input force.
			MR4 17. What is the ideal mechanical advantage of a simple gear train made up of the following three gears? ($MA = N_o/N_i$)

Gear #	Number of teeth
#1 (input)	12 teeth
#2 (middle)	42 teeth
#3 (output)	30 teeth

Pre	Post		
20	4		a. 0.7
39	69	**	b. 2.5
28	21		c. 3.5
11	5		d. 5.0
			F5 18. What is the mechanical advantage in a hydraulic jack whose input force of 20 lb delivers a 300 lb output force to the load?
17	7		a. 0.67
21	9		b. 1.5
47	74	**	c. 15
13	9		d. 60
			F1 19. The hydraulic jack
11	29	**	a. is a linear mechanical force transformer.
60	35		b. is a pressure booster.
20	33		c. employs a mechanical coupling or transformer between input and output pistons.

Pre	Post	
		F4
		20. In a single-acting hydraulic booster with internal resistance, the pressure ratio of pressure out divided by pressure in is (308 psi/100 psi). If the ideal mechanical advantage for this booster is 4, its efficiency is: (Eff = MA_a/MA_i x 100)
34	67	** a. 77%
24	15	b. 85%
21	9	c. 90%
19	9	d. 97%
		F1, 2
		When using a hydraulic jack, mark those quantities which a) increase; b) remain the same; or c) decrease, from input to output. Use the letters from the right column for increase, same, or decrease.
19	39	21. B Pressure — a. Increase
42	65	22. A Force — b. Same
30	51	23. C Piston movemen — c. Decrease
18	40	24. A Piston area
30	43	25. B Volume displaced
		F2, 1
		When using a pressure intensifier, mark those quantities which a) increase; b) remain the same; or c) decrease, from input to output. Use the letters from the right column for increase, same, or decrease.
59	84	26. A Pressure — a. Increase
35	42	27. B Force — b. Same
33	55	28. B Piston movement — c. Decrease
17	45	29. C Piston area
38	47	30. C Volume displaced
		E1
		31. Electrical transformers can be used to step-up or step-down
30	14	a. voltage only.
16	7	b. current only.
44	78	** c. both voltage and current.
8	1	d. neither voltage nor current.
		E4, 3
		32. Find the ideal mechanical advantage for an electrical transformer that has (n_i = 500 turns, n_o=900 turns, V_i = 8V and I_i = 0.4A)
21	7	a. 0.5
43	77	** b. 1.8
22	9	c. 18
9	6	d. 28

E4

33. Find the output voltage of a transformer that has n_i=500 turns, n_o=900 turns, and v_i=8V. Assume that the transformer is 100% efficient.

23 18 a. 4.4V

29 8 b. 7.4V

34 66 ** c. 14.4V

11 7 d. 28.8V

E6

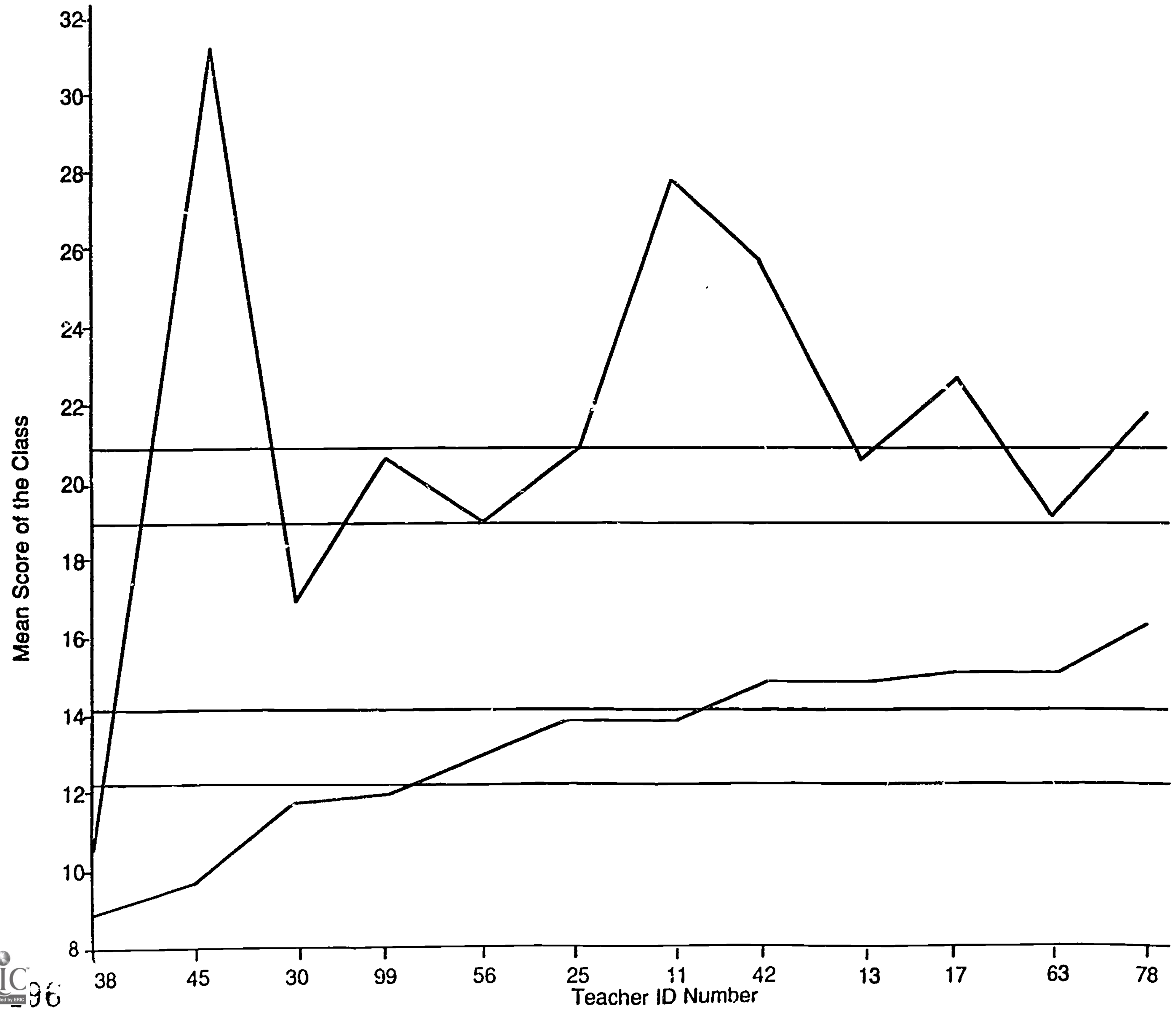
34. In an electrical transformer designed to step up voltage, if electrical resistance is present in the coil windings, the ideal mechanical advantage can always be found from:

42 68 ** a. $MA_i = n_o/n_i$ (ratio of coil windings)

23 17 b. $MA_i = V_o/V_i$ (ratio of voltages)

23 12 c. $MA_i = I_i/I_o$ (ratio of currents)

Appendix D
Pretest/Posttest Means



Appendix E

Student Attitude Questionnaire

All numbers in %
N = 311

Sex: (11) Female (89) Male

Grade: (3) 10th (26) 11th (71) 12th

1. Overall, did you like the unit on FORCE TRANSFORMERS?

(24) yes, a lot
(49) yes, a little
(19) no, not very much
(8) no, not at all

2. What component did you like *most* in the FORCE TRANSFORMERS unit?

(10) the written material
(28) the video programs
(6) the mathematics labs
(24) the hands-on labs
(26) no preference
(6) more than one component

3. What component did you like *least* in the FORCE TRANSFORMERS unit?

(18) the written material
(9) the video programs
(26) the mathematics labs
(9) the hands-on labs
(30) no preference
(8) more than one component

4. Overall, was the material that was covered in the FORCE TRANSFORMERS unit difficult for you to understand?

(13) yes, most of the material was difficult for me to understand.
(57) yes, some of the material was difficult for me to understand.
(30) no, most of the material was not difficult for me to understand.

5. Which component of the FORCE TRANSFORMERS unit was *most* difficult for you to understand?

(17) the written material
(6) the video programs
(35) the mathematics labs
(8) the hands-on labs
(27) no component was particularly difficult
(6) more than one component

6. Which component of the FORCE TRANSFORMERS unit was the *least* difficult for you to understand?

(9) the written material
(54) the video programs
(7) the mathematics labs
(13) the hands-on labs
(12) all components were equally difficult
(5) more than one component

7. Do you think the material in the FORCE TRANSFORMERS unit is important for you to understand?

(44) yes, very important
(44) yes, sort of important
(6) no, not very important
(6) no, not at all important

8. Do you have any comments about the FORCE TRANSFORMERS unit?

Appendix F

Teacher Questionnaire

All numbers in %
N =12

1. What did you like most about the FORCE TRANSFORMERS unit?

   See attached comments

2. What did you like least about the FORCE TRANSFORMERS unit?

   See attached comments

3. Which of your students seem to be the most successful with the Unit 7 material?

   (50) above average (5C) average (0) below average

4. Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for the FORCE TRANSFORMERS subunits?

   (33) yes, definitely
   (42) yes, probably
   (25) no, probably not
   (0) no, definitely not

   If no, please explain:

   See attached comments

5. On average, how much time did you spend preparing to teach each class in the unit on FORCE TRANSFORMERS?

   (64) 0-30 minutes
   (18) 31-60 minutes
   (18) 61-90 minutes
   (0) 91-120 minutes
   (0) 121-180 minutes
   (0) 181 or more

   Comments:

   See attached comments

6. Overall, did you feel comfortable teaching the materials in the unit on FORCE TRANSFORMERS?

   (50) yes, very comfortable
   (42) yes, sort of comfortable
   (8) no, not very comfortable
   (0) no, not at all comfortable

   If no, please specify:

   See attached comments

7. Do you enjoy teaching *Principles of Technology*?

   (100) yes, a lot
   (0) yes, sort of comfortable
   (0) no, not very much
   (0) no, not at all comfortable

   Comments:

   See attached comments

8. Do you ever show a video program more than once?

(25) yes, always (25) no, not usually
(50) yes, frequently (0) no, never

Comments:

See attached comments

9. Do you think your students did the assigned readings at home?

(8) definitely (42) probably (42) probably not (8) definitely not

Comments:

See attached comments

10. What, if anything caused you the most problems in teaching the unit on FORCE TRANSFORMERS?

See attached comments

11. Do you feel the teacher's guide material provided you with enough information to help you successfully implement the unit?

(40) definitely (50) probably (10) probably not (0) definitely not

If not, what should be added to make the guide more useful?

See attached comments

12. Did you teach Unit 7: FORCE TRANSFORMERS on consecutive days for 26 days?

(58) yes (42) no

If no, what pattern did you use (for example, 3 days a week)?

See attached comments

13. How much time per session did you teach?

(58) 50 minutes or less (8) 61-90 minutes
(17) 51-60 minutes (17) 91+ minutes

14. Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

(64) yes (36) no

If yes, which classes did you combine?

See attached comments

15. How many physics courses did you take in college (undergraduate and graduate)?

(18) none
(27) 1
(37) 2-4
(9) 5-7
(9) 8 or more

16. How many mathematics courses did you take in college (undergraduate and graduate)?

(0) none
(0) 1
(64) 2-4
(9) 5-7
(27) 8 or more

17. Do you have any other comments, concerns or suggestions for the unit on FORCE TRANSFORMERS?

See attached comments

The following chart lists each activity for the unit on FORCE TRANSFORMERS down the left column. Since there are no materials specifically for the subunit review classes, these classes have not been listed in the chart. For each activity, you should respond to the following questions by circling "yes" or "no."

1) Were the materials (readings, labs, or videos) appropriate for your students? Was the material at the right grade level? Was the amount of material appropriate for your students? *For any no responses*, please use the attached pages to describe your concerns.

2) Were you able to cover the material to your satisfaction in the 50-minute time period? (Since this question doesn't apply to the video, no response options have been provided for the column. Please do respond, however, to the other questions about the video.) *For any no responses*, use the attached pages to describe why you could not complete the material and/or what you chose to delete.

3) Were there any errors or inaccuracies in the material? *For any yes responses*, use the attached pages to specify the errors and recommended corrections.

4) Were there any problems managing the activity? For the labs, were all your students able to rotate through the labs? Did you experience any problems coordinating the labs? Did you experience any problems setting up or tearing down the labs? Did you experience any problems coordinating the activity? *For any yes responses*, use the attached pages to specify the problems you had, and if possible, suggest changes you feel would enable you to more easily manage the material.

5) Do you have any suggested modifications for the material? *For any yes responses*, use the additional pages to specify your suggestions. Include in this section any "teaching tips" -- special procedures you used or means you discovered to more easily convey the information to students. Include in this section any comments you may have for the teacher's guide.

We recommend that you take a few minutes each day to complete the chart and, most importantly, to write down your comments. If you need more space for comments, use the back of the comments pages and/or attach additional sheets.

	Appropriate for students?		Completed in 50 minutes?		Any errors or inaccuracies?		Any management problems?		Any suggested modifications?	
	yes	no	yes	no	yes	no	yes	no	yes	no
OVERVIEW										
Video	100					100		100	13	87
C0	88	12	89	11		100		100	22	78
MECHANICAL										
Video	100					100		100	10	90
C1	100		80	20	11	89		100	20	80
C2	100		70	30	11	89		100	20	80
Math Lab	100		50	50	38	62		100	44	56
7M1	100		83	17		100		100		100
7M2	100		83	17	20	80	17	83		100
FLUID										
Video	100					100		100	11	89
C1	100		78	22		100		100	11	89
C2	100		88	12		100		100	11	89
Math lab	78	22	88	12		100		100	11	89
7F1	100		75	25	25	75		100	25	75
7F2	100		80	20		100	20	80	25	75

	Appropriate for students?		Completed in 50 minutes?		Any errors or inaccuracies?		Any management problems?		Any suggested modifications?	
	yes	no	yes	no	yes	no	yes	no	yes	no
ELECTRICAL Video	100				11	89		100	11	89
C1	100		78	22		100		100	11	89
C2	100		78	22		100		100	11	89
Math lab	86	14	57	43		100		100	25	75
7E1	100		50	50	20	80	20	80	20	80
7E2	100		50	50	20	80	20	80	20	80
THERMAL Video	100					100		100		100
C1	100		67	33		100		100	33	67
C2	100		67	33		100		100		100
Math lab	100		67	33		100		100		100
7T1	100		[illegible]	50		100		100	50	50
7T2	100			100		100		100		100
SUMMARY Video	100				40	60	40	60	20	80

Comments for Overview Class

See attached comments

Comments for Videos

Overview Video: *See attached comments*

Mechanical Systems: *See attached comments*

Fluid Systems: *See attached comments*

Electrical Systems: *See attached comments*

Thermal Systems: *See attached comments*

Summary Video: *See attached comments*

Comments for C1 Classes

Mechanical Systems C1: *See attached comments*

Fluid Systems C1: *See attached comments*

Electrical Systems C1: *See attached comments*

Thermal Systems C1: *See attached comments*

Comments for C2 Classes

Mechanical Systems C2: *See attached comments*

Fluid Systems C2: *See attached comments*

Electrical Systems C2: *See attached comments*

Thermal Systems C2: *See attached comments*

Comments for Math Lab Classes

Mechanical Systems Math Lab: *See attached comments*

Fluid Systems Math Lab: *See attached comments*

Electrical Systems Math Lab: *See attached comments*

Thermal Systems Math Lab: *See attached comments*

Comments for Lab 1 Classes

Mechanical Systems Lab 1: *See attached comments*

Fluid Systems Lab 1: *See attached comments*

Electrical Systems Lab 1: *See attached comments*

Thermal Systems Lab 1: *See attached comments*

Comments for Lab 2 Classes

Mechanical Systems Lab 2: *See attached comments*

Fluid Systems Lab 2: *See attached comments*

Electrical Systems Lab 2: *See attached comments*

Thermal Systems Lab 2: *See attached comments*

Comments for Summary Class

See attached comments

Teacher Questionnaire Comments

Question 1 Comments

What did you like most about the FORCE TRANSFORMERS unit?

1. The labs we did were most effective and interesting. (#30)
2. Useful material that is normally not taught during high school. (#78)
3. The videos. (#42)
4. The Electrical subunit. (#36)
5. Seems to get closer to real world than some other units. (#38)
6. Okay. (#62)
7. The unifying equations and concepts. Good problems in each system (math lab). (#46)
8. The Electrical lab (7E1/7E2). (#17)
9. Math labs. (#13)
10. The title scared me at first, then I realized it was simple machines and it was quite enjoyable. (#11)

Question 2 Comments

What did you like least about the FORCE TRANSFORMERS unit?

1. Unit tended to be heavily detailed. Kids complained that there were too many formulas to calculate the same thing, such as MAa and MAi. (#30)
2. The math labs need to be written with more clarity, say what you mean. (#63)
3. Trying to build lab apparatus up in time. (#78)
4. Very poorly written unit. Too intense, too confusing, and too many errors. Sargent-Welch's price list for Unit 7 reached me 1 week before the finish of the unit. (#42)
5. "Very" mechanical -- above my head because I have such a limited industrial arts background. (#37)
6. Fluids subunit. (#36)
7. There is just too much material to cover. However, I don't know what I would take out. (#38)
8. Okay. (#62)
9. Test was not adequate. There were some mistakes. (#46)
10. Math labs, they were good questions but didn't keep to the unit subject. (#17)
11. Labs. (#13)
12. It seemed a little long. (#11)

Question 3 Comments

Which of your students seem to be the most successful with the Unit VII material?

1. We must remember that we are now dealing with seniors. (#30)
2. Unfair to judge since equipment was totally lacking. (#42)
3. The ones who read the assignments did well. (#46)
4. Above average, always! (#17)

Question 4 Comments

Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for the FORCE TRANSFORMERS subunits?

1. If the unit draws on much longer than 26 days, the kids tend to turn it off. Twenty-six is approximately the maximum attention span. (#30)
2. Need more time to really get students to the point that they feel confident. (#78)
3. Labs are too extensive. (#62)
4. Preparing outside problems relevant to the unit took some of the time. (#46)

Question 5 Comments

On average, how much time did you spend preparing to teach each class in the unit on FORCE TRANSFORMERS?

1. Preparing more problems and also advanced problems for the above-average students took 1 to 2 hours extra, per day. (#46)

Question 6 Comments

Overall, did you feel comfortable teaching the materials in the unit on FORCE TRANSFORMERS?

1. Units 1-7 are much more comfortable to teach than 8-16 will be since the lab materials are in-house. (#30)
2. Math is still a little problem for me. (#38)

Question 7 Comments

Do you enjoy teaching PRINCIPLES OF TECHNOLOGY?

1. I enjoyed 1-7 a lot. I do not enjoy telling the kids about the next lab because the materials haven't arrived yet. (#30)
2. When equipment for labs and demos is present. (#42)
3. I enjoy this because I wish I had the physics this way (unified equations and concepts) when I was in high school, or even college. It's easier than physics really looks. (#46)
4. It is "so good" to see science used with hands-on. (#17)

Question 8 Comments

Do you ever show a video program more than once?

1. It would be worth it to suggest in the teacher's guide that a review of the Unit 2 videos before the corresponding Unit 7 videos would be good. (#30)
2. Each subunit was shown before and after as called for. (#42)
3. Also use PBS programs that are relative. (#62)
4. Sometimes we looked at it more than two or three times, but at least I showed a video once at the beginning of the subunit and once after. (#46)
5. Some are very neat, you just have to show them again. Also good opportunity to teach a principle again. (#17)

Question 9 Comments

Do you think your students did the assigned readings at home?

1. There appears to be a significant correlation between "Overall, did you like the unit on..." and the amount of homework done by them. (#30)
2. The ones who did well, I am sure, did the assigned readings. (#46)
3. We do the work in class under my supervision. Students attent 3 hours a day, 5 days a week. (#17)

Question 10 Comments

What, if anything, caused you the most problems in teaching the unit on FORCE TRANSFORMERS?

1. Other than lab equipment not arriving, Unit 7 was somewhat long. Kids complained about so many "two-word names" like pressure-intensifier, force transformers, mechanical advantage, etc. (#30)

2. Too many specialized formulas and equations to keep up with. (#78)

3. Lack of equipment. (#42)

4. The mechanical part. (#37)

5. We were not able to compplete all the labs because we lacked the equipment. In fact, we didn't receive any Unit 7 equipment from Sargent-Welch. We constructed our own equipment for a couple of labs. (#36)

6. No equipment to speak of. Need more time, because I needed to review at the beginning of the year things got behind. However, there is still too much material. (#38)

7. Labs, math is tough. (#62)

8. The computer test. Some of the questions were not as clear as they should have been. (#46)

9. Nothing in particular. (#17)

10. Extra math problems, different labs. (#13)

Question 11 Comments

Do you feel the teacher's guide material provided you with enough information to help you successfully implement the unit?

1. Explanation of math problems. The authors assume all instructors have a physics background when in fact most vocational instructors lack a strong math background. (#63)

2. Be sure to start explaining how formulas or conclusions are arrived at for teachers. (#38)

3. Definitely, because it was enough to teach the unit. Probably, because it did not have some extra problems for the advanced students. (#46)

Question 12 Comments

Did you teach Unit 7: FORCE TRANSFORMERS on consecutive days for 26 days?

1. Two periods a day, alternate weeks. (#30)
2. Due to weather problems and school activities I averaged four days a week.(#63)
3. Material took 34 days to complete because of slow down to build up lab apparatus. (#78)
4. Not enough time -- I taught consecutive. (#38)
5. Two days a week, 2 hours a day. (#13)
6. 95 minutes every other day. (#11)

Question 14 Comments

Did you combine any classes into one session (for example, teach classes C1 and C2 in one session)?

1. All of them in this unit because we are running short of time by a few days. (#17)
2. C0, C1 and LC2; MS1 and L1; L2 and Review. (#30)
3. C1 and C2. (#63)
4. C1 and C2 in mechanical rotational, but then found we needed to spend 3 days on C1 and C2, we repeated. (#37)
5. Some of the C1 and C2 classes. Also, L1 and L2 in mechanical (linear). (#46)
6. C1-C2, math lab and lab. (#13)
7. Overview & C1, C1 and math, L1 and L2. (#11)

Question 17 Comments

Do you have any other comments, concerns or suggestions for the unit on FORCE TRANSFORMERS?

1. Several students complained that it was "harder to read" than the others. Reading level different? (#30)
2. Rewrite the unit. (#42)
3. I think the fluids subunit was a little above the level for our students. (#36)
4. There is too much material for the unit to be in a transitional position in the curriculu;m. (#38)
5. It has been an excellent course for me to teach, I learned how, by unification of the concepts, it can be easier to understand. Tests can be improved a lot. (#46)

Comments for Overview Class

1. It was excellent, students got more out of it by looking at it later in the course. (#46)
2. Very well presented. (#13)
3. Okay but kind of short. (#17)
4. I asked my kids how many had read the discussion on page 2, "A Technician Talks About Transformers." Perfect zero. If it's going to stay it needs illustration and definition. Cut length of entire overview segment. (#30)

Comments for Videos

1. They all were good. Students enjoyed them when they saw them second and third times. They can be improved by showing more examples and making them more scientific. (#$46)

2. All were good. (#13)

3. All were good, but short.

   Summary: Bad audio, another sound track over normal one, interference. (#17)

4. No problem with videos. (#36)

5. **Electrical:** There was a tv commercial on this portion of video. (#38)

6. All videos were excellent. (#78)

7. **Electrical:** Good illustration.

   Summary: Poor reproduction. Audio overprinted with a commercial. (#30)

Comments for C1 Classes

1. They were excellent. (#46)

2. They were fair. (#13)

3. All were good. It is a good procedure to separate linear from rotational. (#:7)

4. **Electrical:** Current is dependent on load, not on turns. (#62)

5. **Mechanical:** Very complicated in the rotational subunit, specifically MA = output/input or vice versa. I talked to CORD on the phone regarding this confusion.

   Fluid: Pressure intensifier needed more explanation. (#37)

6. **Mechanical:** Be consistent. In one place you tell the students that pulleys are not force transformers unless free, then turn around and say that a pulley is a basic linear transformer. (#38)

7. **Mechanical:** Problems where you have to "Find: a, b, c..." tend to confuse and frighten some kids who are less interested in the math. If we're keeping the reading simple, we should do that with at least the appearance of the math examples. The toughies and the multiple choice answer problems can go to the math labs. Larger number of devices covered between C1 and C2 classes. Pages containing formulas could be marked somehow (black band across top, etc.) to allow kids to refer to it more simply.

   Electrical: Nicely done. Short enough and well illustrated. Flag formulas page on 155.

   Fluid: Example 7-L way too complicated. If I were a kid studying appliance repair, I wouldn't even spend my time looking at it. Flag formula page. (#30)

Comments for C2 Classes

1. Excellent. (#46)
2. All were fair. (#13)
3. All were good. (#17)
4. **Mechanical:** There are so many math examples given in C2 that students have trouble focusing on the descriptive information on levers. By test time, they forgot which levers were which.

   Fluid: Example 7-M on page 120, required almost 2 full pages to calculate 5 things and included symbols like $MA_a = P_o(\text{actual})/P_i$. More complicated than necessary.

   Electrical: Example 7-P needs to be split and/or simplified. Page 159 is a good illustration. (#30)

Comments for Mathematics Lab Classes

1. They were good but not enough student problems. (#13)

2. They all were great. We can use some more problems for the interested students. (#46)

3. **Mechanical:** Problem 1a needs a picture. Problem 6a, answer should be 2 inches (D_o).

   Fluid: Good questions and problems for mechanical but what about having good problems on hydraulics and pneumatics?

   Electrical: Good questions of hydraulic and pneumatic but what about electrical? (#17)

4. **Mechanical:** Error on page T-1. (#36)

5. **Mechanical:** Page T-4, question 6b, figure b: $F_o = 240$ lb not F_i. $D_o = 20$ lb/240 lb x 24 in. $D_o = 2$ in, not 12 in.

   Fluid: Long but good, needs diagrams.

   Electrical: Seemed easier than mechanical or fluid. (#37)

6. Too much. (#38)

7. **Fluid:** Math lab 7MS3, need all fluid problems instead of a mixture of rotational and mechanical systems. One has to go back to previous unrelated section for useful formula and equations. (#78)

8. **Mechanical:** Long discussion along with example problem makes math lab too long and detailed. This math lab could be divided in half very easily. Suggest that we change multiple answer problems to several problems with no more than 3 solutions each, preferably fewer.

   Fluid: Math labs need to be modified by now. All three were nothing more interesting than extra student exercise problems. Time for some novelty to break up the engineering. (#30)

9. **Mechanical:** Worked fine.

   Fluid: I had some difficulty trying to get the two pneumatic rams hooked together but it does work quite well.

   Electrical: We used some materials from the electronics lab to do the lab with. They were different than specified but that made it even more meaningful to the students. (#11)

Comments for Lab 1 Classes

1. The labs were excellent. We didn't have the equipment for some of the labs and we couldn't do them but we went over them and fully understood. (#46)

2. Did not use. Devised labs of my own to fit my equipment. (#17)

3. Good. (#17)

4. We have received NO equipment from Sargent-Welch. We placed our order in June 1985. (#37)

5. **Mechanical:** Since we did not receive any lab equipment for Unit 7, lab activity was limited. The lab involving gears could not be done. It was difficult trying to find gears locally. The stepped belt-drum assembly was constructed locally and proved to be pretty successful.

   Fluid: No fluid lab, no equipment.

   Electrical: The construction of the transformer took a long time. It didn't work the first time. (#36)

6. Need the equipment. (#38)

7. **Fluid:** No equipment.

   Electrical: Every coil shorted itself when slid onto the post (which was a bolt). The ridges scraped the varnish from at least one out of every two coils. (#42)

8. **Mechanical:** Good idea. Especially useful device for these kids to study. BUT no wire listed in materials list to attach com-along to support stand.

   Fluid: Looks like an interesting lab. Certainly wish we could have tried it, but we were waiting, and continue to wait, for Sargent-Welch.

   Electrical: No equipment arrived. May reschedule later. Sounds like a good lab, but I am concerned with safety aspects.

   Rotational: Equipment supplied by Sargent-Welch inefficient. If monofilament line tied to index hole in gear train, the gear train is blocked by the knot on next revolution. Modify page 91, step7 to read "attach an 8" long length of monofilament line to the hub of the input drum with a strip of tape. Do not use the index hole on the rim if one is provided." (#30)

Comments for Lab 2 Classes

1. They were great. (#46)
2. Did not use. Devised labs of my own to fit my equipment. (#13)
3. Good. (#17)
4. We completed only one lab for each subunit because the equipment was unavailable. In the fluid subunit, we didn't complete any. (#36)
5. No equipment. (#42)
6. **Mechanical:** 7M2, page 54, Efficiency equation is wrong. Should be $Eff = MA_a/MA_i \times 100 =$ percent. 7M3, the gear system sold by Sargent-Welch is not compatible to lab writeup. The advantage is so great that only 20-40 grams will lift more than weights stacked on weight hangar. The lab tells us to start with 200 grams on input. (#78)
7. **Mechanical:** Pipe vice assembly needed to be supported by ring stands since no support was provided by Sargent-Welch version. Data came out okay.

   Fluid: Good except large cylinders arrived without hose connectors. There was no "coupling slug" and we replaced it quite well with a 3/8" SAE nut. It is impossible to obtain threaded PVC fittings or adapters locally. We didn't have enough clamps or pressure gauges on the original equipment list, but when effectively mickey-moused it worked.

   Electrical: Continues lab 1. Idea of continuing lab is not bad and would work especially well in Massachusetts schools with their double-periods, but if you don't have the equipment for L1, you don't have it for L2 either.

   Rotational: Looks like a good idea. Equipment not available, so we did not complete. Will reschedule later if time permits. (#30)

Comments for Summary Class

1. All were interested (happy to be ending school), showed an intent to really show what they learned, many questions about unit and also questions on whole program. (#13)
2. Good. (#46)
3. Okay. (#17)
4. Mistakes:

   page 6: F_o = output, force = 25 ft, should be 25 lb.
   page 32: line 6 from top, "is simply two equal ratios."
   page F40: last line, D_o = 12 inches should be 2 inches.
   page 44: line 6 from top, "see inset in figure 2," no inserts given.
   page 45: figure 3 lab set-up should be 90 degrees.
   page 50: last printed line, figure 1e, should be 1a.
   page 52: part 2, measuring #1, last 3 words,"disk, as shown..." is not shown.
   page 54: #3, Efficiency = MA_i/MA_a, shouldn't it be Efficiency = MA_a/MA_i?
   page T-80: problem #1, abc, diameters = 3", 4", 6"; radii = 1.5", 2", 3".
   page T-81: same as T-80.
   page 102: #3 "shown in figure 2" should be figure 7.
   page 120: example 7-M, there is no answer for B, should be 1050 lb/in^2.
   page T-160: #5, answer V_o = 20V should be 2V. (#42)

5. Video poorly duplicated. Dubbed with two video tracks and made unusable. With such a massive number of formulas included in this unit, review class would be a good place for a single page of formulas to be collected and reprinted. (#30)

PRINCIPLES OF TECHNOLOGY

Unit 8: MOMENTUM

Pilot Test Findings

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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 and related print 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.

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INTRODUCTION

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 40 state and provincial education agencies (see Appendix A for a list of cooperating agencies). The course consists of fourteen units, each focusing on a principle that underlies today's technology. 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), from consortium representatives, and from teachers and students at classroom pilot test sites. The review team reviews preliminary drafts of the instructional materials before they are sent to consortium representatives and pilot test sites. Consortium representatives review the material concurrently with the classroom pilot testing. The data from all sources -- review team, consortium representatives, and pilot sites -- are analyzed and reported to the developers, who use these findings to revise the materials.

Thus, an important part of the overall formative evaluation is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working, and 2) to identify specific problems with the materials. All pilot test teachers were oriented to the *Principles of Technology* course and to the pilot test procedures at one of two meetings held in Dallas the summer of 1984. Almost all pilot test teachers met again in a combined meeting with consortium representatives and AIT/CORD staff in Dallas the summer of 1985. At this meeting, staff members proposed several modifications in the pilot test procedures. Most of these changes were in the instrumentation for year two of the pilot test. (These changes are detailed in the instrumentation section of this report, pages 6-8.)

This report details the findings of the pilot test of Unit 8: MOMENTUM. The report makes some comparisons of these findings with those for Units 1-7, which are contained in separate reports (see "Unit 1: FORCE -- Pilot Test Findings," December 18, 1984; "Unit 2: WORK -- Pilot Test

Findings," March 1, 1985; "Unit 3: RATE -- Pilot Test Findings" May 6, 1985; "Unit 4: RESISTANCE -- Pilot Test findings," May 29, 1985; "Unit 5: ENERGY -- Pilot Test Findings," July 15, 1985; Unit 6: POWER -- Pilot Test Findings," August 19, 1985; and "Unit 7: FORCE TRANSFORMERS -- Pilot Test Findings," January, 1986). Since some of the year two instrumentation, beginning with Unit 8, was modified, exact comparisons with Units 1-7 data were no longer possible. There remains however, enough common elements from year one to year two instrumentation to make several comparisons. Finally, when reading this report it's important to remember that all data are formative data; the developers are using the data, along with reactions from the review team and consortium representatives, as a basis for revising the materials.

PILOT TEST PROCEDURES

Unit 8: MOMENTUM pilot test materials were mailed to teachers in mid-August 1985. These materials consisted of:

1) Parallel pretest/posttest (see Appendix C)
2) Computerized scoring sheets for the pretest/posttest
3) Student attitude questionnaires (see Appendix E)
4) Teacher questionnaires (see Appendix F)
5) Unit daily log (see Appendix G)

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the posttest along with the student attitude questionnaires. As requested by teachers at the summer meeting, parallel forms of the same test were used for the pretest and posttest. Unit 8 marks the first unit in the project to use parallel forms. All Unit 8 materials were then mailed back to AIT. This report contains all data received by December 1985.

LIMITATIONS OF THE METHODOLOGY

Two major limiting factors must be considered when the findings are interpreted: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered, including:

• Lack of matched control groups

The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

• The pretest/posttest format

Parallel forms of the same test were used for the pretest/posttest. The effect that memory of the pretest might have on posttest performance was a concern. The research design addressed this concern in four ways:

1) Students were not given the correct answers to the pretest. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

3) A correlated *t*-test was used to analyze the pretest/posttest data. This technique helps to partial out any variance that might result from an intruding correlation -- in this case, memory.

4) Parallel forms of the test were used. Although the items were identical, the order of the items was changed from pretest to posttest.

• The pretest/posttest as an instrument (see the section on instrumentation, pages 6-8)

The test cannot measure all objectives. Therefore, objectives had to be sampled. Also, the items do not always directly match the intended objectives. The test was a cognitive test. Many of the objectives (particularly the lab objectives) are psychomotor objectives. One must consider each of these factors when assessing the validity of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results, including:

• Equipment problems

As with the previous units, several teachers reported problems in securing the necessary lab equipment.

• Student characteristics

Both teachers and students have reported what appears to be considerable variability in the kinds of students in the course. This variability encompasses students' academic backgrounds, ability levels, and socioeconomic levels. The project has made no attempt to control these variables.

• Teaching pattern

Teachers report considerable variability in the length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess the impact of the various conditions on the outcomes.

So, both research design and external constraints must be considered when the results are interpreted. It's important to remember that the pilot test was designed as a part of the overall formative evaluation, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

INSTRUMENTATION

The instruments for Unit 8 were:

1) Parallel forms of a pretest/posttest

2) Student attitude questionnaires

3) A teacher questionnaire

4) A unit daily log

The student attitude questionnaire, teacher questionnaire and unit daily log were revised substantially from the instruments used for Units 1-7. These revisions reflected comments made at the July 1985 meeting in Dallas. Dr. Floyd McKinney of the National Center for Research in Vocational Education in Columbus, Ohio, who attended this meeting, has made substantive contributions to the revisions of these instruments. Before discussing the revisions, however, let's first examine the pretest/posttest instrumentation.

Pretest/Posttest

As with all previous units, the test questions were initiated at CORD by the content specialists. In a collaborative process between evaluators and content specialists, the original 45 questions were pruned and revised to the eventual 25 questions. Each item is tied as directly as possible to a specific objective from Unit 8. The item/objective match is not always exact. It's impossible to match items to some objectives because of the way those objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and that approximations objectives are often the best that cognitive test developers can do. With only 25 items, not all objectives could be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were based on the relative importance of the concepts. (Appendix C lists the objective each item is intended to address above the item.)

So is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?). On the Spearman-Brown Test of internal consistency, the reliability of this instrument is .88, which is

acceptable by most standards. Validity is a bit more complicated to judge. Readers are encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?

2) Is a sufficient range of objectives addressed?

3) Overall, is the instrument a fair measure of Unit 8's instruction?

It should be pointed out that, in examining the pretest/posttest results for each of the first seven units, the developers and evaluators encountered a few items in each unit (no more than three per unit) that they considered, for various reasons, to be poor items. Of course there is always wisdom in hindsight. Ideally, each of these instruments would itself be pilot tested. However, the project's schedule precludes the luxury of pilot testing the instrumentation. Thus, e[illegible] with careful planning, it's inevitable that a few poor items will be included in each test.

Student Questionnaire

The student questionnaire (Appendix E) was expanded from the one that was used for Units 1-7. The questionnaire has a series of items on students' reactions to the objectives, content, video, text, and labs; the difficulty of the unit; and students' overall satisfaction with the unit

Additionally, for Unit 8, students responded to a series of items about their backgrounds and future plans (these findings will be detailed in a separate report). Although the expanded student questionnaire no doubt takes more precious time to administer, the staff felt that the additional information could provide better insights into student reactions to the course.

Teacher Questionnaire/Unit Daily Log

Two distinct kinds of information must be collected from the teachers. First, it's important that they indicate their overall reactions to the unit. Additionally, it's important that they give their detailed reactions to each day of instruction, particularly noting problems or errors in the materials. To meet these dual needs, teachers completed both a teacher questionnaire (Appendix F) and a unit daily log (Appendix G). The teacher questionnaire was revised from those that were used for Units 1-7. The questionnaire has a series of items on teachers' reactions to the objectives, the

instructional activities, and the content, and on their instructional planning. Although several items from the first year 's instrument remain, several new items were added. The unit daily log is essentially the same as that used for Units 1-7, although it was sent as a separate instrument to make it easier for teachers to complete on a regular basis; for Units 1-7 it was merely attached to the teacher questionnaire.

Thus, the project is using the same kinds of instrumentation for year two as it did for year one of the pilot test. However, significant revisions of some of the instruments, notably the teacher and student questionnaires, should produce information that better addresses the overall goals of the pilot test.

SAMPLE

The sample included 215 students in 13 sites. Student characteristics included:

• Grade[1]
10 = 1% 11 = 20% 12 = 79% (Since it's year two of the course, it's certainly not surpris.g that the majority of students are in grade twelve.)

• Sex

Male = 84% Female = 16%

Teacher characteristics included:

• Physics background[2]

As with previous units, there was a wide range in the teachers' physics backgrounds; 18% reported no college physics courses; 27% reported one college physics course; 37% reported 2-4 college physics courses; 9% reported 5-7 college physics courses; and 9% reported eight or more college physics courses.

• Mathematics background

All teachers reported having had two or more college mathematics courses; several (27%) have had five or more college mathematics courses.

• Teaching pattern

The majority (63%) taught Unit 8 on consecutive days. Most (82%) taught sessions that were 60 minutes or shorter. About a third (36%) indicated they had combined classes into one session.

• Preparation Time

The average amount of time teachers indicated they spent in preparing each lesson for the unit was 60 minutes, with a range from 30 to 120 minutes.

The sample for Unit 8 was actually larger than that for Unit 7. The reason is probably that the data for Unit 8 were analyzed later than was originally planned. The project schedule did not permit this flexibility for Unit 7. The numbers of both students and sites are smaller for both Units 7 and 8 than they were for year one of the pilot test. For the purposes of the pilot test, there

[1]Due to missing data, the pretst/posttest student demographics don't match the student attitude demographics.

[2]To save valuable teacher time, the teacher questionnaire no longer contains items on the teachers' physics/mathematics backgrounds. The data reported below are from the Unit 7 data base; since the sample has stabilized, these data should remain accurate for year two.

remains a large enough sample to make judgments about the materials. Beyond the pilot test, it's probably reasonable to expect that year two enrollment will usually be less than year one enrollment. Many factors, such as student graduation, scheduling conflicts, school dropouts, and changes in career plans, will likely result in lower year two enrollments.

PRETEST/POSTTEST RESULTS

Several different analyses of the pretest/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 25 items.

• Mean differences

The overall pretest mean was 11.9. The overall posttest mean was 18.9. This increase was statistically significant (correlated *t*- test) at the .01 level.

The level of statistically significant learning gain (.01) is consistent with the gains shown for Units 1-7. Table 1 compares the pretest/posttest scores for Units 1-8.

Thus, Units 1, 4, 5, and 6 had fairly consistent pretest-to-posttest learning gains measured in percentage of correct answers. Learning gains for Units 2, 3, and 7, while somewhat lower, were still statistically significant. With Unit 8, students had both the highest posttest score of any unit (76%) and the greatest mean gain from pretest to posttest (28%). These findings probably bode well for both the Unit 8 material and the caliber of students who returned for year two of the pilot test.

Individual Items

For each unit the project team has established criteria for acceptable performance on each test item. These criteria included either:

1) 70%+ correct on an item, or

2) doubling of the pretest score on the posttest.

Only five Unit 8 items failed to meet these criteria. This is the best item-by-item performance of the entire pilot test. The items that did not meet the criteria were items 4, 6, 8, 23, and 25. Items 4, 6, 23, and 25 are mathematics-related items -- students are required to manipulate a formula to solve a problem. Mathematics-related items have proved the most troublesome to students in the past. Item 8, however, deals with a basic concept of the unit -- momentum. It's disappointing to note that about a third of the students (30%) thought that momentum tells us mostly about the potential energy the object has. Perhaps the test item itself is weak. Nonetheless, the coverage of the content in the material should be closely examined. It should also be noted, however, that

several other items on the test dealt with momentum and students met the criteria on each of these items.

With so few items that failed to meet the criteria, it's not surprising to note that students performed satisfactorily on the majority of items for each of the subunits. There was no subunit that seemed to cause the students particular problems. This is the first time in the pilot test that students met the criteria for a majority of items in each subunit.

Thus, the pretest/posttest results for Unit 8 were the most positive for any of the eight units that have been pilot tested. Students had the highest mean posttest score (76%) and the highest mean gain from pretest to posttest (28%), and they failed to meet the criteria on the fewest number of items (5). Although these are all quite positive findings, they probably indicate as much about the quality of the students in the second year of the pilot test as they do about the quality of the materials themselves. It seems reasonable to assume that the students who returned for year two of the course are likely to be more motivated students who perhaps have better academic backgrounds than those who do not. They also may be benefiting from their collective experiences in the first year of the course. In a formative evaluation, however, these results suggest that Unit 8 has no major problems. Further, if one accepts some of the above assumptions about the quality of the second-year students, one must conclude that when the materials are used with these kinds of students, the results are certainly impressive.

Table 1
Principles of Technology
Pretest and Posttest Scores, Units 1-8

Unit	Number of Items	Pretest Mean (% correct)	Posttest Mean (% correct)
1	30	12.5 (41%)	20.1 (67%)
2	33	13.6 (41%)	17.6 (53%)
3	30	14.9 (49%)	19.4 (65%)
4	36	16.4 (46%)	24.4 (68%)
5	35	13.2 (38%)	22.6 (65%)
6	30	11.5 (38%)	18.3 (61%)
7	34	13.2 (39%)	19.9 (59%)
8	25	11.9 (48%)	18.9 (76%)

PRETEST/POSTTEST BY SELECTED VARIABLES

For all previous units, the impact of several variables on students' test performance was examined, including:

1) Student characteristics
   a) sex
   b) grade

2) Teaching pattern
   a) consecutive days
   b) length of class periods
   c) combined activities

3) Teacher background
   a) physics background
   b) mathematics background

However, the smaller year two sample precludes making the comparisons among teacher background and teaching pattern; there are simply too few teachers in these various conditions to make reliable comparisons. So, the only valid comparisons are those comparing the student characteristics of sex and grade. These variables were analyzed with an analysis of covariance, which controlled for pretest scores. Table 2 examines the results of this analysis; the mean scores reported in Table 2 are for the posttest.

Table 2

Main Effect	Level of Significance	Subset	Mean Score
Sex	.777	Male (83)	18.83
		Female (21)	14.86
Grade	.096	Tenth (2)	21.00
		Eleventh (25)	17.44
		Twelfth (87)	19.41

As Table 2 illustrates, neither students' sex nor grade had a statistically significant effect on their performance (even at a level of .05, which is more liberal than the .01 level the project has established as its target).

PRETEST/POSTTEST RESULTS BY SITE

Appendix D indicates the pretest/posttest results by site. Twelve sites showed statistically significant (.01 level) increases; one site showed no statistically significant gain. Table 3 examines the number of sites showing no statistically significant gains for each of the first eight units.

Table 3

Unit	Sites showing no significant gains
1	1
2	4
3	4
4	0
5	1
6	3
7	1
8	1

Again, these results must be interpreted cautiously. The reduced number of sites makes comparisons across units difficult to make. Nonetheless, it is encouraging 'o note that only a single site showed no significant gain for Unit 8.

STUDENT ATTITUDE FINDINGS

As discussed earlier in this report (see the instrumentation section, pages 6-8), the student attitude questionnaire was completely revised for year two of the pilot test. Very little was retained from the questionnaire that was used during year one of the project. The new questionnaire (see Appendix E for questionnaire and frequencies of student responses) was revised with input from consortium representatives and teachers who met in Dallas and with significant assistance from staff of the National Center for Research in Vocational Education in Columbus, Ohio.

The new questionnaire contains a series of items for each of several categories. The categories include students' reactions to the unit's objectives, content, video, text, and laboratory activities; the difficulty of the unit; and students' satisfaction with the unit. Each category contains a series of statements to which students respond using a four-point Likert-type scale ("strongly agree" to "strongly disagree"). The new questionnaire provides more information about students' attitudes than the five-item questionnaire that was used during year one of the project. Of course, collecting more information requires additional, valuable classroom time, which is the major disadvantage of the new questionnaire.

There are a number of ways to analyze these data. The simplest is to report the frequency of responses to each item. To compare responses across categories, however, it helps to have a numerical total for each category. Since a four point scale was used (with four being the most positive and one the most negative), we can arrive at a mean score of between one and four for each statement. These mean scores can then be added and divided by the total number of items in the category to arrive at a mean score for each category. Both the frequencies for each item (in percentages) and a mean score for each category are reported below.

Unit Objectives

Generally, students indicated that they found the unit objectives helpful. Most (90%) agreed or strongly agreed that the objectives helped them understand what they were supposed to learn. Even more (94%) agreed or strongly agreed that they were glad the objectives were printed in the written materials. Fewer (65%) agreed or strongly agreed that they used the

objectives to guide them through the material. The overall mean score for the category was 3.03. (A perfect four is the most positive score possible.)

Unit Content

The majority of students (68%) disagreed or strongly disagreed that the unit had too much information. Most students (80%) agreed or strongly agreed that the unit gave examples that were helpful in understanding the concepts. The majority (72%) disagreed or strongly disagreed that the content of the unit was difficult for them to understand. The majority (72%) agreed or strongly agreed that the content will probably be useful in future jobs. The mean score for the category, with scoring of some items reversed to adjust for negative wording (i.e., "strongly disagreed" becomes a positive response to a negative item), was 2.82. Overall, then, the majority of the students indicated that the amount and difficulty of the material was appropriate for them. However, nearly a third of the students indicated that there was perhaps too much information and that the information was difficult for them to understand.

Unit Video

Most students (85%) agreed or strongly agreed that the video programs helped them better understand the material. Most (82%) agreed or strongly agreed that the video programs were interesting. Most (80%) agreed or strongly agreed that they used easy to understand graphics. And the majority (73%) agreed or strongly agreed that the video programs helped them to achieve the unit objectives. The overall mean score for the video category was 2.93.

Unit Text

Most students (82%) agreed or strongly agreed that the text materials helped them achieve the unit objectives. Most (78%) agreed or strongly agreed that the text will be a useful reference after taking the course. The majority (64%) disagreed or strongly disagreed that the text used language that was difficult for them to understand. The majority (71%) agreed or strongly agreed that the text had enough examples to help them understand the important concepts; even more (77%) agreed or strongly agreed that the text helped them understand the unit concepts. The overall mean score for the text category was 2.83.

Laboratory Activities

The majority of students (74%) agreed or strongly agreed that the lab activities helped them achieve the unit objectives. The majority (65%) disagreed or strongly disagreed that the lab activities were difficult. The majority (58%) agreed or strongly agreed that the time periods were not long enough to complete the work. The overall mean score for the category was 2.83. It's interesting to note that the majority of students indicated that the time periods were not long enough to complete the lab work, which is what the teachers also have been indicating in their comments.

Unit Difficulty

Almost half (47%) indicated that some of the things they were expected to learn were just too hard. And almost half (40%) agreed or strongly agreed that they had trouble reading the unit text. The overall mean score for the lab category was 2.58.

Student Satisfaction

The majority (53%) agreed or strongly agreed that they usually had a sense of satisfaction after leaving class each day. Few (19%) agreed or strongly agreed that they did not like coming to class. And the majority (78%) indicated that they would recommend the class to their friends. The overall mean score for the category was 2.85.

Table 4 shows the mean scores by category.

Table 4

Category	Mean Score for Category
Unit objectives	3.03
Unit content	2.82
Unit video	2.93
Unit text	2.83
Unit labs	2.83
Unit difficulty	2.58
Student satisfaction	2.85

In examining Table 4, it's important to remember that scores of 3 and 4 are the preferred responses. To interpret these data, it's important to look at both the mean scores for each category and the frequency of responses to the individual items for each category. What does

such an analysis reveal? Clearly, students are positive about the unit objectives. They also are fairly positive about the unit content, videos, text, and lab activities. However, both the category mean score and the frequencies for the individual items dealing with thedifficulty of the unit indicate that more than a third of the students had trouble reading the text and thought that some of the things they were expected to learn were too hard. Nonetheless, most students also indicated an overall sense of satisfaction with the unit.

TEACHER RESULTS

Questionnaires were received from sixteen teachers. As mentioned earlier in this report (see the instrumentation section, pages 6-8), the teacher questionnaire was revised substantially from the questionnaire that was used during year one of the project. Although many of the year one items were maintained, new items similar to those used for the student attitude questionnaire were added. These items focus on the teachers' reactions to the objectives, the instructional activities, and the level of difficulty. The unit daily log, with few modifications from the one that was used during year one of the project, was also part of the teacher instrumentation. The findings reported below include both the teacher questionnaire and the unit daily log. Appendices F and G, which list the detailed teacher comments, should be examined carefully. The wealth of data contained in these comments is difficult to encapsulate. Overall, the teacher findings were as follows:

Unit Objectives

The teachers unanimously affirmed the worth of the unit objectives. All agreed or strongly agreed that the objectives assisted them in assessing student progress, that the objectives helped them determine what to teach, and that the objectives were presented in a logical order. Almost all teachers also indicated that the objectives reflected what the unit was designed to teach. (Because so few teachers responded, these data were not examined by mean scores based on the four-point scale as were the student attitude data.)

Unit Instructional Activities

All teachers indicated that the unit instructional activities were related to the unit objectives and that the activiti were presented in the correct sequence. However, a quarter of the teachers (25%) indicated that the reading level of the instructional activities was too difficult for most of their students.

Unit Content

Most teachers (75%) disagreed or strongly disagreed tha the unit content was too detailed. Most (78%) thought the material was presented at the proper level of difficulty. Even more (87%)

thought it contained examples that were helpful to students in their understanding of unit concepts. However, a third (33%) of the teachers thought the content did not contain enough examples and did not provide enough summaries of important points. Finally, most (80%) indicated they thought the content provided information that will be useful for students in their future employment.

Teacher Comfort

Three teachers (31%) indicated that they did not feel comfortable teaching the material in the Momentum unit. One was uncomfortable because the lab equipment was not available, another, because he did not have a background in this area, and a third, because he was not used to the concept of slugs as a unit of mass.

Time

The majority (69%) indicated that the six-day plan of 50-minute class sessions per subunit is a realistic time allotment for Unit 8. One teacher reported that some of the hands-on labs required more than 50 minutes to set up, conduct, and discuss. This is consistent with the findings for the first seven units.

Student homework assignments

About a third (31%) indicated that half or less than half their students typically completed the homework assignments for the unit. Interestingly, even more (38%) indicated that fewer than half their students typically completed their homework assignments for other courses that they teach. It seems that students' completion of homework assignments is probably affected more by the students' motivation than by the nature of the materials.

Teacher's guide

The majority of teachers (75%) thought the teacher's guide provided them with enough information to successfully implement the unit. A few teachers thought some of the problems needed more explanation in the text.

Appropriateness for students

Generally, teachers tended to indicate that each day of instruction was appropriate for their students.

Problems

To the question, "What, if anything, caused you the most problems in teaching the unit on MOMENTUM?" ten teachers responded. The problems reported include:

- Hands-on labs, lack of equipment, etc. (seven teachers)
- Mathematics and mathematics formulas (three teachers)
- The concept of momentum being zero (one teacher)

These findings are consistent with those teachers reported for Units 1-7. Availability of equipment for the hands-on labs continues to cause teachers the most problems. On the other hand, teachers continue to affirm the appropriateness of most of the material for their students, and most of them felt the material was presented at the proper level of difficulty. Finally, many specific recommendations for changes, including errors in the text, are contained in the teacher's comments. Overall, the teachers tended to be fairly positive about Unit 8.

CONCLUSIONS

It is important to remember that the entire pilot test is part of the overall formative evaluation process. Data are being collected from the consortium review team, consortium representatives, and from teachers and students at the pilot sites. These data are then used as a basis for making revisions in the materials.

Certainly, then, this report contains much useful information.

1) Overall, a statistically significant (.01 level) learning gain took place. These learning gains were independent of students' sex and grade. Students had both the highest posttest score (76%) and the highest mean gain from pretest to posttest (28%) for any unit of the pilot test.

2) Students performed most poorly on items dealing with mathematics, as they did for the first seven units. Students failed to meet the project criteria for only five items, the fewest for any unit so far in the pilot test.

3) Student attitudes were generally positive, especially about the value of the unit objectives. They were also positive about the unit videos, text, labs, and overall content. However, about a third of the students indicated that they had trouble reading the text material and thought some of the things they were expected to learn were too hard. Nonetheless, most students also indicated an overall sense of satisfaction with the unit.

4) Teachers affirmed the appropriateness of most of the material for their students. Like their students, teachers also affirmed the value of the instructional objectives. However, a few teachers found the reading level of the instructional activities too difficult for most of their students. A few also thought the content did not contain enough examples and did not provide enough summaries of important points.

5) Teachers' comments indicated that the most problems were encountered with the hands-on labs. This is consistent with the findings for the first seven units. It should be pointed out that most of the problems reported were with simply getting the equipment. Once teachers have the equipment, most of the labs seem to work satisfactorily.

6) Although the teachers were generally quite positive about the unit, they did recommend several specific changes, which can be found in their attached comments.

Thus, in some respects the Unit 8 data were even more positive the than data for the previous seven units. Both students' posttest scores and the percentage gain from pretest to posttest were higher than for any previous unit. Although teachers pointed out several errors in the materials, their major complaint continues to be problems with the availability of lab equipment.

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

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

TVOntario

Tennessee State Department of Education
Division of Vocational 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

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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Appendix C

Student Test

Pre	Post	
		1MF-1
		1. Momentum _____ vector quantity.
·75	77	* a. is
18	21	b. is not
		1MF-3
		2. A hydraulic cylinder piston rod of mass 0.25 slugs moves out at a rate of 1.2 feet/sec to push boxes across a conveyor belt holding a table. The linear momentum of the rod is:
54	80	* a. 0.3 slug·ft/sec
28	11	b. 3.0 slug·ft/sec
15	6	c. 6.6 slug·ft/sec
		d. 9.6 slug·ft/sec
		1MF-5, 1MF-6
		3. The linear impulse of a 10 lb force acting on an object for 5 seconds is _____ a linear impulse of a 5 lb force acting on the same object for 10 seconds.
19	6	a. greater than
14	4	b. less than
65	86	* c. equal to
		1MF-C
		4. A 1500 lb force brings a truck to a stop in 30 seconds on a straight road. The truck experiences a change in velocity of 80 ft/sec during the time the force is applied. Find the mass of the truck. [Hint: use the relationship $F(\Delta t) = m(\Delta v)$]
18	9	a. 562.5 kg
45	63	* b. 562.5 slugs
28	16	c. 3,600,000 kg
9	12	d. 3,600,000 slugs
		O-1
		5. Linear momentum is equal to an object's mass
11	7	a. times its displacement.
15	--	b. divided by its displacement.
55	89	c. times its velocity.
18	4	* d. divided by its velocity.

Pre	Post	
		1MF-7
		6. When a hydraulic cylinder is activated for 5 seconds, the piston applies a force of 80 Newtons to the rod during that time period. The change in linear momentum of the fluid moved is (impulse equals change in momentum)
21	18	a. 16 kg·m/sec
21	11	b. 64 kg·m/sec
12	4	* c. 85 kg·m/sec
46	68	d. 400 kg·m/sec
		1MF-9
		7. A 50 kg girl stands in a row boat near a river bank. The boat and girl are initially at rest. The girl jumps from the boat to the bank with a speed of 2 m/sec. Conservation of momentum tells us that
9	7	a. the boat remains perfectly still.
14	5	b. the boat moves in the same direction as the girl.
73	88	* c. the boat moves in the opposite direction to the girl with a momentum of 100 kg·m/sec.
		O-1
		8. An object's momentum tells us mostly about
26	30	a. the potential energy the object has.
55	64	* b. the amount of motion the object has.
13	1	c. the physical size of the object.
5	4	d. the specific gravity of the object.
		O-2
		9. Which of the following will give you the full and correct information about a rotating object's angular momentum?
25	9	a. mass and angular velocity
41	75	* b. moment of inertia and angular velocity
17	14	c. mass and radius.
17	2	d. linear momentum and specific gravity
		O-2, 2MF-1
		10. Angular momentum is equal to a rotating object's
32	13	a. mass times its angular velocity
21	6	b. mass divided by its angular velocity
18	5	c. mass times its radius squared
27	76	* d. moment of inertia times its angular velocity
		1MF-9
		11. L_{mom}=
37	72	* a. I x w
28	21	b. m x I
22	5	c. m+I
12	2	d. mr^2

565

Pre	Post	
		O-5
		12. The law of conservation of momentum tells us that in an isolated system
30	74	* a. the total momentum before an interaction equals tha total momentum after the interaction.
19	5	b. the velocity before an interaction equals the velocity after the interaction.
27	13	c. the kinetic energy before an interaction equals the kinetic energy after the interaction.
24	7	d. the total momentum before an interaction never equals the total momentum after the interaction.
		O-4
		13. In mechanical systems, a large reduction in momentum is accomplished without damage to the machinery by
17	5	a. applying a large stopping force for a short time.
40	72	* b. reducing the momentum to zero in the largest possible time.
25	10	c. slowing down the machinery in the shortest possible time.
17	13	d. reducing the momentum to zero in the shortest possible time.

In the following four statements, match the lettered phrases on the right with the correct numbered definition on the left. On your answer sheet, fill in the blank with the letter of the phrase that corresponds to the numbered definition.

Pre	Post	Definition	Phrase
		1MF-1	
54	84	14. d Increases whenever the mass and speed of an object increases.	a. kg·m/sec
		1MF-4	b. slug·ft/sec
63	88	15. c Causes changes in the linear momentum of an object.	c. linear impulse
		1MF-5	d. linear momentum
61	87	16. b Are English units for linear momentum.	
		1MF-2	
58	88	17. a Are SI units for linear momentum.	

In the following four statements, match the lettered phrases on the right with the correct numbered definition on the left. On your answer sheet, fill in the blank with the letter of the phrase that corresponds to the numbered definition.

Pre	Post	Definition	Phrase
		1MF-4	
48	79	18. b A baseball bat applies a force (F) on a baseball for a time (Δt).	a. change in linear momentum
		1MF-4	b. linear impulse
63	88	19. d A wheel balance machine applies a torque (T) to the rim of a wheel for a time (Δt).	c. change in angular momentum
			d. angular impulse

Pre	Post	
		2MF-3
53	71	20. c A wheel of moment of inertia (I) changes its angular speed from zero radians per second to 66 radians per second.
		2MF-5
44	77	21. a A baseball of mass (m) changes its speed from zero feet per second to 132 feet per second.

a. change in linear momentum

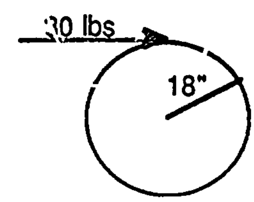
b. linear impulse

c. change in angular momentum

d. angular impulse

2MF-6

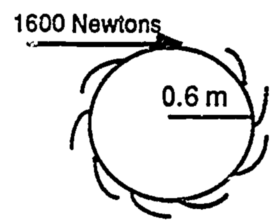
22. When balancing an automobile wheel that is mounted on the automobile, a 30 lb tangential force is applied to the tread of the tire for 15 seconds. The tire and wheel have a radius of 1.5 feet. The angular impulse of the wheel is (Angular Impulse = T x Δt where T = F x r)



Pre	Post	
8	5	a. 3 (lb-ft)-sec
25	17	b. 300 (lb-ft)-sec
35	13	c. 450 (lb-ft)-sec
31	66	* d. 675 (lb-ft)-sec

2MF-7

23. A steam turbine has a 0.6 m radius with steam striking the turbine blades with a force of 1600 N. If the steam is directed onto the turbine for 60 seconds, what is the angular impulse of the turbine?



Pre	Post	
22	13	a. 16 (N-m)-sec
38	21	b. 960 (N-m)-sec
33	61	* c. 57,600 (N-m)-sec
7	6	d. 159,960 (N-m)-sec

1MF-6

24. When a golf ball is hit, the linear impulse involved is the product of the force applied by the club to the ball and

Pre	Post	
21	11	a. the distance the golf ball moves.
38	71	* b. the time the club is in contact with the ball.
26	13	c. the mass of the golf ball.
15	4	d. the mass of the golf club.

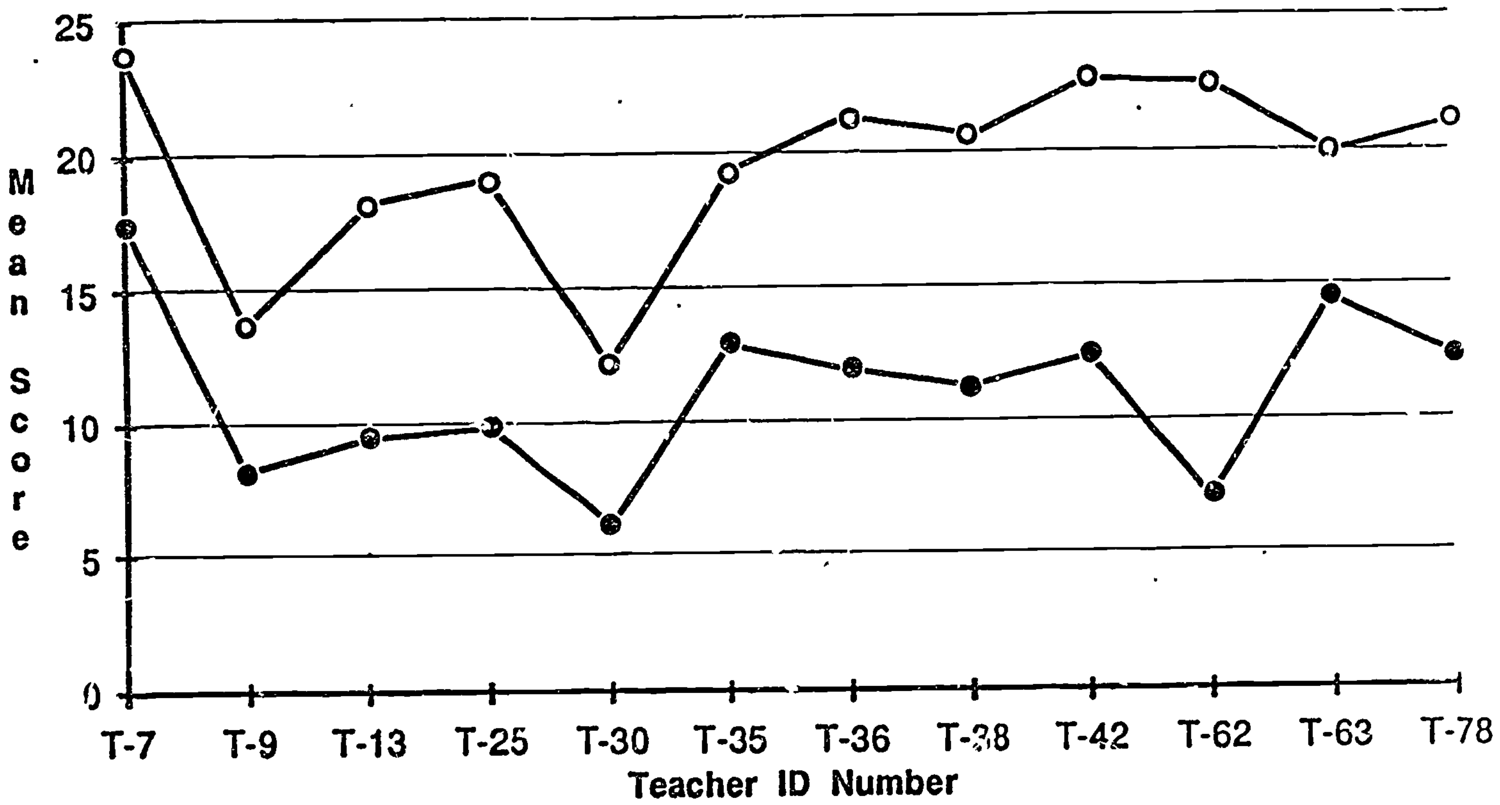
2MF-1

25. An electric motor shaft and rotor turning at 1750 rpm (183 rad/sec) has a moment of inertia of 0.14 kg m^2. The angular momentum of the motor shaft is ____ (Hint: use the equation $L_{m \cdot m} = I \times w$)

Pre	Post	
18	3	a. 2.56 kg·m^2/sec
40	67	* b. 25.62 kg·m^2/sec
19	14	c. 130.7 kg·m^2/sec
22	15	d. 245.0 kg·m^2/sec

Appendix D

Pretest/Posttest Means



568

569

Appendix E

Student Attitude Questionnaire

All numbers in %
N = 215
Mean scores in parentheses

Grade (12th = 79; 11th = 20; 10th = 1)
Sex (M = 84; F = 16)

PURPOSE
Your honest answers to the questions on this form will help improve this *Principles of Technology* unit for other students. Your responses to the follwoing items are appreciated.

DIRECTIONS
Below are a list of statements. Please read each statement and answer whether you strongly agree, agree, disagree, or strongly disagree by checking the appropriate box. Place a check mark [√] in only one box for each statement.

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT OBJECTIVES (x = 3.03)				
For this unit:				
1. the objectives helped me understand what I was supposed to learn (x=3.10)	8	82	8	2
2. I'm glad the objectives are printed in the written materials (x = 3.13)	21	73	5	1
3. I used the objectives to guide me through the material (x = 2.87)	15	60	22	3
General Comments on Unit Objectives:				
UNIT CONTENT (x = 2.82)				
The content of this unit:				
4. had too much information (x = 2.71)	9	23	56	12
5. gave examples helpful in understanding concepts (x = 2.93)	17	63	16	4
6. was too difficult for me to understand (x = 2.82)	8	21	54	17
7. will probably be useful in future jobs (x = 2 82)	21	51	20	8
General Comments on Unit Content:				

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT VIDEO ($x = 2.93$)				
The video programs for this unit				
8. helped me to better understand the text material ($x = 3.08$)	25	60	13	2
9. were interesting ($x = 2.97$)	18	64	15	3
10. used easy to understand graphics ($x = 2.97$)	16	67	15	2
11. helped me to achieve the unit objectives (x=2.73)	9	65	20	6
General Comments on Unit Video:				
UNIT TEXT ($x = 2.83$)				
The unit text materials:				
12. helped me to achieve the unit objectives ($x = 2.91$)	10	72	17	1
13. will be a useful reference after taking the course ($x = 2.96$)	20	58	20	2
14. used language difficult for me to understand ($x = 2.68$)	8	29	53	10
15. had enough examples to help me understand the important concepts ($x = 2.80$)	10	61	27	2
16. helped me to understand the unit concepts ($x = 2.84$)	10	67	20	3
General Comments on Unit Text:				
LABORATORY ACTIVITIES ($x = 2.77$)				
The unit lab activities:				
17. helped me achieve the unit objectives (x=2.82)	16	58	18	10
18. were difficult ($x = 2.70$)	8	27	52	13
19. time periods were not long enough to complete the work ($x = 2.81$)	17	41	32	10
20. in general, I liked them ($x = 2.91$)	14	65	11	10
General Comments on Laboratory Activities:				

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT DIFFICULTY (x = 2.58)				
For this unit:				
21. some of the things we were expected to learn were just too hard (x = 2.49)	14	33	43	10
22. I had trouble reading the unit text materials (x = 2.68)	6	34	46	14
General Comments on Unit Difficulty:				
STUDENT SATISFACTION (x = 2.85)				
For this unit:				
23. I usually had a sense of satisfaction after leaving class each day (x = 2.66)	9	54	31	6
24. I did not like coming to class (x = 3.00)	5	14	57	24
25. I would recommend it to my friends (x = 2.91)	19	59	16	6
General Comments on Student Satisfaction:				

Appendix F

Teacher Questionnaire

All numbers in %
N =16

PURPOSE
The primary purpose of this questionnaire is to provide teacher information for facilatating improvement of the *Principles of Technology* curriculum. Specifically, this form is designed to assess the appropriateness of *Principle's of Technology* unit objectives and the appropriateness of instructional activities, resources, curriculum content, and instructional planning needed to accomplish these objectives.

DIRECTIONS
Below are a list of statements. Please read each statement and indicate whether you strongly agree, agree, disagree, or strongly disagree by checking the appropriate box. Place a check mark [√] in only one box for each statement.

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT OBJECTIVES				
The unit objectives:				
1. assist me in assessing student progress	44	56	–	–
2. don't reflect what the unit is designed to teach	--	7	60	33
3. help me determine what to teach	44	56	–	–
4. are presented in logical order	44	56	–	–
General Comments on Objectives:				
See attached comments				
UNIT INSTRUCTIONAL ACTIVITIES				
The unit instructional activities:				
5. are related to unit objectives	38	62	–	–
6. are presented in the correct sequence	25	75	–	–
7. require a reading level that is too difficult for most students	6	19	50	25
General Comments on Instructional Activities:				
See attached comments				

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT CONTENT				
The unit content:				
8. was too detailed	6	18	63	13
9. was presented at the proper level of difficulty	19	69	6	6
10. contained examples that were helpful to students in their understanding of unit concepts	27	60	13	–
11. contained enough examples	20	47	33	–
12. provided enough summaries of important points	20	47	33	–
13. provided enough information that will be useful for students in their future employment	13	67	20	–

General Comments on Unit Content

See attached comments

PERCEPTIONS OF INSTRUCTIONAL PLANNING

14. On average, how many hours did you spend preparing to teach each lesson in this unit? (60 minutes)

15. Approximately how much time, on average did you expect students to spend on homework each day?

[ ] None
[21] About 15 mintues
[64] About half an hour
[15] About one hour
[ ] Two hours or more

16. What percentage of students typically completed your homework assignments for this unit?

[19] Fewer than 25%
[13] 26-49%
[31] 50-74%
[37] 75% and above

17. What percentage of students typically completed your homework assignments for other courses that you teach?

[7] Fewer than 25%
[29] 26-49%
[50] 50-74%
[14] 75% and above

18. Do you feel the teacher's guide material provided you with enough information to help you teach the unit?

    [25] Definitely   [50] Probably   [12] Probably not   [13] Definitely not

    If not, what should be added to the guide to make it more useful?

    See attached comments

19. Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for this unit?

    [19] Yes, definitely   [31] No, probably not
    [50] Yes, probably   [ ] No, definitely not

20. Overall, did you feel comfortable teaching the materials in this unit?

    [31] Yes, definitely   [31] No, probably not
    [38] Yes, probably   [ ] No, definitely not

    If no, please explain:

    See attached comments

21. What, if anything, caused you the most problems in teaching this unit?

    See attached comments

22. What did you like the most in teaching this unit?

    See attached comments

General Comments on Perceptions of Instructional Planning:

See attached comments

23. Did you teach this unit on consecutive days for 26 days?

    [63] Yes   [37] No

    If no, what pattern did you use (for examples,3 days a week)?

    See attached comments

24. How much time per class session did you devote to this unit?

    [63] 50 mintues or less   [6] 61-90 minutes
    [19] 51-60 minutes   [12] 91+ minutes

25. Did you combine any of the unit's classes into one session (for example, teach classes C1 and C2 in one session)?

    [36] Yes   [64] No

    If yes, which classes did you combine?

    See attached comments

26. Were there any special circumstances which, in your opinion, may have influenced the pre- or posttest scores (e.g., lack of time, faulty lab equipment, school holidays, fire drill)?

See attached comments

General Comments:

See attached comments

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Teacher Questionnaire Comments

General Comments on Objectives

1. Generally reflect major thrust of text material. (#30)
2. I use them as overview and review. (#38)
3. FORCE TRANSFORMERS was a fun unit, the only problem was with slugs and its importance. (#11)

General Comments on Instructional Activities

1. Units 7, 8, and 9 are extremely difficult for my students. (#42)

General Comments on Unit Content

1. Some examples were very "physics" i.e., gunshot problems. Could be replaced with something like unloading a 4-wheeler industrial cart. Examples with "Find a-, b-, etc." are intimidating. (#30)

2. New material for most students -- difficult for them to comprehend. (#78)

Question 18 Comments

Do you feel the teacher's guide material provided you with enough information to help you teach the unit? If not, what should be added to the guide to make it more useful?

1. There are a few times when a little more explanation on highly technical points would have helped. (#38)

2. More tie in to labs. (#25)

3. Teacher's guide material contained errors which caused some confusion and took time to determine what was correct. (#36)

4. More explanation. (#37)

5. More correct answers. (#42)

6. Teacher's guide material much improved. Better demos, more detailed notes. Teacher's guide much more useful than in previous units. (#30)

7. I needed a more complete explanation of the applications, and how they should help the student in a job situation. (#11)

8. Many solutions to math problems are not complete. Too often the steps used to convert units or complete calculations are left out. I feel each problem should list each step in finding the answer. (#63)

9. We skipped from Unit 3 to 8 and it was difficult to teach this unit. Some of the math examples needed a little more instruction. (#34)

Question 20 Comments

Overall, did you feel comfortable teaching the materials in this unit? If no, please explain.

1. Would have been more comfortable if some of the lab equipment had been in-house. (#30)

2. My background on the subject was almost nil. Consequently I was not as confident with it. (#36)

3. I could not get comfortable with the concept of slugs as a unit of mass. My understanding is that it isn't used much anymore. (#11)

Question 21 Comments

What, if anything, caused you the most problems in teaching this unit?

1. As usual, inability because of time constraints to produce laboratory materials and unavailability from vendors. (#30)
2. Lack of equipment. (#42)
3. The concept of momentum being zero. (#37)
4. No lab equipment. (#36)
5. We did not have the equipment for the labs as written. (#07)
6. It involved parts of course that were covered in first year. Most of my students were new this year. (#25)
7. The math remains a problem that I have to spend a great deal of time with. Lack of equipment continues to be a problem. (#38)
8. Not having lab equpment. (#35)
9. Math labs take longer than 50 minutes. (#18)
10. Working through problem calculations within the prescribed time frame. (#78)
11. Most problems were in the math, if each problem was worked out in its entirety, explanation to students would be easier. (#63)
12. Math examples, lab, reading. (#34)
13. Math labs are quite difficult. (#32)

Question 22 Comments

What did you like most in teaching this unit?

1. Teacher's guide improved my presentation. Short unit improved student attention, and the integration of mechanical and fluid topics was a nice change. (#30)

2. Section on L_{mom}. (#42)

3. The math was great. (#37)

4. The way it was presented in the text. (#36)

5. Physics concepts. (#07)

6. Examples -- problems. (#13)

7. Video. (#25)

8. No preference. (#38)

9. I liked the unit as a whole, it was fun to teach and brought a lot of things together for my class. (#11)

10. I liked all of it. (#18)

12. The labs. (#63)

13. Moved rapdily and held student attention. (#32)

General Comments on Perceptions of Instructional Planning

1. This seemed to be quite a long unit for the idea of momentum. (#25)

2. It takes a bunch. (#38)

3. This course is requiring extra p&d time for first time being taught. PT 1-7 unit classes required very little extra planning or set-up time. (#30)

4. Not really anything. I believe individual teachers know best how they need to prepare. (#37)

5. Very good. (#13)

6. All very good. (#18)

7. This study takes more than 14 days to cover for student understanding. (#78)

8. Well planned material. (#32)

Question 23 Comments

Did you teach this unit on consecutive days for 26 days? If no, what pattern did you use (for example, 3 days a week)?

1. Double periods each day during alternate weeks. (#30)

2. I taught each day for 55 minutes but because of no equipment it didn't take long. (#38)

3. Two days a week. (#13)

4. 95 minutes every other day. (#11)

5. Consecutively for 10 days. (#35)

6. Short unit. (#18)

Question 25 Comments

Did you combine any of the unit's classes into one session (for example, teach classes C1 and C2 in one session)?

1. Most C1 and C2 units were combined. (#07)
2. C0, C1 and C2. Math lab used double periods since no lab equipment was available by the time the unit was taught. (#30)
3. Maybe I don't keep track, take what I can. (#25)
4. Overview-C1; C2-Math lab; Lab 1 and Lab2; Summary. (#11)
5. Labs, this was due to lack of equipment. (#63)

Question 26 Comments

Were there any special circumstances which, in your opinion, may have influenced the pre- or posttest scores (e.g., lack of time, faulty lab equipment, school holidays, fire drill in the middle of the exam)?

1. Review class shortened so that evaluation could be sent in more timely fashion. Lab classes eliminated. Entire unit progressed very rapidly and absence from class by an individual would reflect inordinately low score. (#30)

2. Lack of equipment. As of today, there is no price list for Units 9, 10, etc. (#42)

3. I probably sound boring but we don't have the lab equipment. At this rate we are afraid this will always be our problem and we'll never get the equipment when we need it. (#37)

4. Posttest results were good and gratifying. (#36)

5. Topics intended to be covered by laboratory exposure or reinforced in the lab were weak due to inability to acquire special equipment on time. Adjustments due to be made soon. (#30)

6. Pretty good, well put together, leaves little to do in planning classes. (#13)

7. This is ridiculous -- Friday, November 12 I received the list from Sargent-Welch telling me what to order for labs. So labs are only being partially done. If this time table continues, the items needed for future units will not be available until well after the due date for completion. (#62)

8. Lack of equipment -- we are through with the unit and some of the equipment is still not here. This detracts from the practical aspect of the unit. (#18)

General Comments

1. We (teacher and students) seem to have gotten bogged down over this unit; units, terms and notation were problematic for students who had not been through PT 1. (#35)
2. I do not see how any school can be on schedule because of lack of equipment, if they are keeping this course practical. (#18)
3. Our students only meet 3 days a week, a lot of these factors could have influenced the pre-/posttest scores. Skipping from Unit 3 to Unit 8 definitely influenced the scores. (#34)
4. Good unit. (#32)

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Appendix G

Unit Daily Log

PURPOSE
The purpose of the Unit Daily Log is to provide a regular source of teacher information for improving the Principles of Technology curriculum.

DIRECTIONS
The left column on the following chart lists each activity for this particular unit. Since there are no materials specifically for the subunit review classes, these classes have not been listed in the chart.

For columns 1-5 on the attached chart:

1. Circle "Y" (yes) or "N" (no): Were the readings, labs, or ;videos appropriate (e.g., grade level, sufficient quantity of material) for your students? If not, specify modifications in column 5.

2. Circle "Y" (yes) or "N" (no): Were you able to cover the content in the 50-minute time period?

3. Briefly describe any errors or inaccuracies in the material.

4. Briefly describe any problems you had in managing the material. Among others, this may include problems in coordinating lab rotations, lab set-up, and maintaining student interest.

5. Briefly list suggestions for modifying the material. Describe "teaching tips" for future teachers.

We recommend that you take a few minutes each day to complete the charts. If you need more space for comments, use the back of the charts and/or attach additional pages.

Unit	Appropriate for students?	Completed in 50-60 minutes?	Did you discover any errors or inaccuracies? If so, please specify in the appropriate spaces below.	Did you have any management problems? If so, please specify in the appropriate spaces below.	Do you have any suggested modifications or general comments? If so, please specify in the appropriate spaces below.
Overview					
Video	Y N 92 8				
C0	Y N 92 8	Y N 92 8			
Mechanical & Fluid I					
Video	Y N 92 8				
C1	Y N 92 8	Y N 91 9			
C2	Y N 92 8	Y N 82 18			
Math Lab	Y N 83 17	Y N 46 54			
8M1	Y N 83 17	Y N 75 25			
8M2	Y N 67 33	Y N 67 33			

Unit	Appropriate for students?	Completed in 50-60 minutes?	Did you discover any errors or inaccuracies? If so, please specify in the appropriate spaces below.	Did you have any management problems? If so, please specify in the appropriate spaces below.	Do you have any suggested modifications or general comments? If so, please specify in the appropriate spaces below.
Mechanical & Fluid II Video	Y N 100				
C1	Y N 100	Y N 73 27			
C2	Y N 100	Y N 73 27			
Math Lab	Y N 89 11	Y N 46 54			
8F1/8F2	Y N 100	Y N 37 63			
Summary Video	Y N 100				

Unit Daily Log Comments

Overview -- Video

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Overview -- CO

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

1. As long as "mom" is used as a subscript for both linear and rotational, it doesn't differentiate. (#30)

Did you have any management problems?

1. My students had trouble with the material in this unit. We skipped from Unit 3 to Unit 8. Students had a pretty rough time trying to catch up. (#34)
2. The concepts of slugs and mass were difficult. (#11)

Do you have any suggested modifications or general comments?

1. Use P_{lin} and P_{rot} instead of P_{mom} and L_{mom}, or use P and L and forget the subscripts. (#30)

Did you discover any errors or ineccuracies?

1. Page T-33, errors in problems 1 and 3. (#38)
2. Page 25a, (-) sign not handled well in problem 9. Page 25c, problem 10 should be 20 cm, not 2. (#78)
3. Page 25a, #8 should be $P_{mom} = 148{,}500$. (#42)
4. T-25a, answer to #8 is wrong. (#32)

Did you have any management problems?

1. Had to take longer to discuss problems in student exercise. (#38)

Do you have any suggested modifications or general comments?

1. This will just take a longer time. The math must be explained. (#38)

Mechanical & Fluid Systems I -- Math Lab

Did you discover any errors or inaccuracies?

1. Problem #1, where did V = 0.27 m/sec come from? Problem #3, P_{mom} error. (#38)
2. Page T-34c, m = w/g = 4000/32 ft/s^2 = 125, not 12. (#78)
3. Page 35, impulse in wrong direction in problem 10. (#11)
4. Problem 6 does not give sufficient information to calculate I. (#63)
5. T-33a, problem 1, error in value of V. (#32)

Did you have any management problems?

1. Had to take longer to discuss and work math problems. (#38)
2. Took 2 periods, 100 minutes. (#78)
3. Took longer than 50 minutes to complete (I see no real problem with this, however). (#18)

Do you have any suggested modifications or general comments?

1. Too difficult. (#42)
2. Correct errors in teacher solutions of math problems. (#78)

Did you discover any errors or inaccuracies?

1. Page T-43, step 4, calculated data does not track with given information. (#78)

Did you discover any management problems?

1. No lab equipment. (#38)
2. Impossible to complete at this time due to lack of equipment. (#30)
3. "Mucho" trouble -- no equipment. (#37)
4. Equipment not available. (#35)
5. Complex lab apparatus -- difficult to measure .2 seconds on stopwatch. (#78)
6. Did not do -- no equipment. Talked our way through. (#18)

Do you have any suggested modifications or general comments?

1. Devise a way to make time (stopwatch) measurement that does not rely on reaction time. (#78)

Did you discover any errors or inaccuracies?

1. Did not use this lab. (#63)

Did you have any management problems?

1. No lab equipment. (#38)
2. Equipment didn't come with drive belts. (#42)
3. "Mucho" trouble -- no equipment. (#37)
4. Impossible to complete at this time due to lack of equipment. (#30)
5. Equipment not available. (#35)
6. Only one lab apparatus -- expensive and dangerous. Lab groups had to take turns. (#78)

Do you have any suggested modifications or general comments?

1. Corrections of safety of lab apparatus already in system. (#78)
2. Due to centrifugal forces produced I felt this lab would be unsafe. (#63)

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Good use of NASA footage for angular momentum. (#30)

Mechanical & Fluid Systems II - C1

Did you discover any errors or inaccuracies?

1. All formulas on figure 8-14 have 1 in place of I, except example g. (#18)
2. Notations on page 59, figure 8-14 (a-f). (#35)
3. Page 59, inertia formulas are written as $1 = MR^2$ (figure 8-14). They should be $I = MR^2$. (#63)

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Good idea to have repeated figure 8-14 from last year's series. (#30)

Did you discover any errors or inaccuracies?

1. Page T-70, #12c, F = 249 N, T = 238 N·m. (#42)
2. Example 8k, page 65-67, too long. (#30)
3. Student example, page 69, #5 should be kg·m/s^2. (#18)
4. Page 70, pictures missing. Page T-70, solution to #12 is messed up. (#32)

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Enlarge turbocharger part of figure 8-17 in a mg-box next to the illustration. (#30)
2. Figure 8-17 needs a flow diagram. (#42)

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Mechanical & Fluid Systems II -- Math Lab

Did you discover any errors or inaccuracies?

1. Page T-78a, #4, F = 100 lbs. Page T-78c, #6a, Angular impulse = 2.25 N·m·sec. (#42)
2. Problem #6, page 78, does not match teacher's version on page T-78c. (#18)
3. Page T-75, km in equation should be kg. Page T-78a, error in problem 4, it should be 100. (#78)
4. Page T-78a, #4 answer wrong. T-78c, #6; D_t = 1 minute? Page 78; part B missing #6. (#32)

Did you have any management problems?

1. The math just takes longer, it has to be done. (#30)
2. Took longer than 50 minutes. I see no real problem with this however. (#18)
3. Math lab too long. Took 2 1/2 periods to lead students through. (#78)

Do you have any suggested modifications or general comments?

1. Students had fewer complaints about this one for some reason. (#30)
2. Too hard. (#42)

Did you discover any errors or inaccuracies?

1. Page 90, #3 says, "See sketch below" -- no sketch. (#30)
2. No lab equipment. (#35)

Did you have any management problems?

1. No equipment. (#42)
2. No equipment. (#38)
3. Did not do -- no equipment. Talked our way through. (#18)
4. Had to dry lab this one, could not find anything flexible enough to allow any movement of a 90 degree pipe. (#78)

Do you have any suggested modifications or general comments?

1. Improve lab unit or help us find flexible hose. (#78)

Summary -- Video

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. The "hammer pun" could have been omitted. (#35)

PRINCIPLES OF TECHNOLOGY

Unit 9: WAVES AND VIBRATIONS

Pilot Test Findings

Agency for Instructional Technology
Box A
Bloomington, Indiana 47402

Center for Occupational Research and Development
601 C Lake Air Drive
Waco, Texas 76710

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 and related print 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.

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INTRODUCTION

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 40 state and provincial education agencies (see Appendix A for a list of cooperating agencies). The course consists of fourteen units, each focusing on a principle that underlies today's technology. 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), from consortium representatives, and from teachers and students at classroom pilot test sites. The review team reviews preliminary drafts of the instructional materials before they are sent to consortium representatives and pilot test sites. Consortium representatives review the material concurrently with the classroom pilot testing. The data from all sources -- review team, consortium representatives, and pilot sites -- are analyzed and reported to the developers, who use these findings to revise the materials.

Thus, an important part of the overall formative evaluation is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working; and 2) to identify specific problems with the materials. All pilot test teachers were oriented to the *Principles of Technology* course and to the pilot test procedures at one of two meetings held in Dallas the summer of 1984. Almost all pilot test teachers met again in a combined meeting with consortium representatives and AIT/CORD staff in Dallas the summer of 1985. At this meeting, staff members proposed several modifications in the pilot test procedures. Most of these changes were in the instrumentation for year two of the pilot test. (These changes are detailed in the instrumentation section of this report, pages 6-8.)

This report details the findings of the pilot test of Unit 9: WAVES AND VIBRATIONS. The report makes some comparisons of these findings with those for Units 1-8, which are contained in separate reports (see "Unit 1: FORCE -- Pilot Test Findings," December 18, 1984; "Unit 2: WORK

-- Pilot Test Findings," March 1, 1985; "Unit 3: RATE -- Pilot Test Findings" May 6, 1985; "Unit 4: RESISTANCE -- Pilot Test findings," May 29, 1985; "Unit 5: ENERGY -- Pilot Test Findings," July 15, 1985; Unit 6: POWER -- Pilot Test Findings," August 19, 1985; "Unit 7: FORCE TRANSFORMERS -- Pilot Test Findings," January, 1986; and "Unit 8: MOMENTUM -- Pilot Test Findings," February 1986). Since some of the year two instrumentation, beginning with Unit 8, was modified, exact comparisons with Units 1-7 data are no longer possible. There remain, however, enough common elements from year one to year two instrumentation to make several comparisons. Finally, when reading this report one must remember that all data are formative data; the developers are using the data, along with reactions from the review team and consortium representatives, as a basis for revising the materials.

PILOT TEST PROCEDURES

Unit 9: WAVES AND VIBRATIONS pilot test materials were mailed to teachers in mid-September 1985. These materials consisted of:

1) Parallel pretest/posttest (see Appendix C)
2) Computerized scoring sheets for the pretest/posttest
3) Student attitude questionnaires (see Appendix E)
4) Teacher questionnaires (see Appendix F)
5) Unit daily log (see Appendix G)

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the posttest along with the student attitude questionnaires. As requested by teachers at the summer meeting, parallel forms of the same test were used for the pretest and posttest. All Unit 9 materials were then mailed back to AIT. This report contains all data received by January 1986.

LIMITATIONS OF THE METHODOLOGY

Two major limiting factors must be considered when the findings are interpreted: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered, including:

• Lack of matched control groups

The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

• The pretest/posttest format

Parallel forms of the same test were used for the pretest/posttest. The effect that memory of the pretest might have on posttest performance was a concern. The research design addressed this concern in four ways:

1) Students were not given the correct answers to the pretest. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

3) A correlated *t*-test was used to analyze the pretest/posttest data. This technique helps to partial out any variance that might result from an intruding correlation -- in this case, memory.

4) Parallel forms of the test were used. Although the items were identical, the order of the items was changed from pretest to posttest.

• The pretest/posttest as an instrument (see the section on instrumentation, pages 6-8)

The test cannot measure all objectives. Therefore, objectives had to be sampled. Also, the items do not always directly match the intended objectives. The test was a cognitive test. Many of the objectives (particularly the lab objectives) are psychomotor objectives. One must consider each of these factors when assessing the validity of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results, including:

• Equipment problems

As with the previous units, several teachers reported problems in securing the necessary lab equipment.

• Student characteristics

Both teachers and students have reported what appears to be considerable variability in the kinds of students in the course. This variability encompasses students' academic backgrounds, ability levels, and socioeconomic levels. The project has made no attempt to control these variables.

• Teaching pattern

Teachers report considerable variability in the length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess the impact of the various conditions on the outcomes.

So, both research design and external constraints must be considered when the results are interpreted. It's important to remember that the pilot test was designed as a part of the overall formative evaluation, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

INSTRUMENTATION

The instruments for Unit 9 were:

1) Parallel forms of a pretest/posttest
2) Student attitude questionnaires
3) A teacher questionnaire
4) A unit daily log

The student attitude questionnaire, teacher questionnaire and unit daily log were similar to those used for Unit 8. The instrumentation for both Unit 8 and Unit 9 was substantially revised from the instrumentation used for Units 1-7. These revisions reflected comments made at the July 1985 meeting in Dallas. Before discussing the revisions, however, let's first examine the pretest/posttest instrumentation.

Pretest/Posttest

As with all previous units, the test questions were initiated at CORD by the content specialists. In a collaborative process between evaluators and content specialists, the original 50 questions were pruned and revised to the eventual 29 questions. Each item is tied as directly as possible to a specific objective from Unit 9. The item/objective match is not always exact. It's impossible to match items to some objectives because of the way those objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and that approximations of objectives are often the best that cognitive test developers can do. With only 29 items, not all objectives could be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were based on the relative importance of the concepts. (Appendix C lists the objective each item is intended to address above the item.)

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?). On the Spearman-Brown Test of internal consistency, the reliability of this instrument is .86, which is acceptable by most standards. Validity is a bit more complicated to judge. Readers are encouraged to make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?
2) Is a sufficient range of objectives addressed?
3) Overall, is the instrument a fair measure of Unit 8's instruction?

It should be pointed out that, in examining the pretest/posttest results for each of the first eight units, the developers and evaluators encountered a few items in each unit (no more than three per unit) that they considered, for various reasons, to be poor items. Of course there is always wisdom in hindsight. Ideally, each of these instruments would itself be pilot tested. However, the project's schedule precludes the luxury of pilot testing the instrumentation. Thus, even with careful planning, it's inevitable that a few poor items will be included in each test.

Student Questionnaire

The student questionnaire (Appendix E) was expanded from the one used for Units 1-7. The questionnaire has a series of items on students' reactions to the objectives, content, video, text, and labs; the difficulty of the unit; and students' overall satisfaction with the unit.

Although the expanded student questionnaire no doubt takes more precious time to administer, the staff felt that the additional information could provide better insights into students' reactions to the course.

Teacher Questionnaire/Unit Daily Log

Two distinct kinds of information must be collected from the teachers. First, it's important that they indicate their overall reactions to the unit. Additionally, it's important that they give their detailed reactions to each day of instruction, particularly noting problems or errors in the materials. To meet these dual needs, teachers completed both a teacher questionnaire (Appendix F) and a unit daily log (Appendix G). The teacher questionnaire was revised from those that were used for Units 1-7. The questionnaire has a series of items on teachers' reactions to the objectives, the instructional activities, and the content, and on their instructional planning. Although several items from the first year 's instrument remain, several new items were added. The unit daily log is essentially the same as that used for Units 1-7, although it was sent as a separate instrument to make it easier for teachers to complete on a regular basis; for Units 1-7 it was merely attached to the teacher questionnaire.

Thus, the project is using the same kinds of instrumentation for year two as it did for year one of the pilot test. However, significant revisions of some of the instruments, notably the teacher and student questionnaires, should produce information that better addresses the overall goals of the pilot test.

SAMPLE

The sample included 121 students in 11 sites. Student characteristics included:

• Grade[1]

10 = 0% 11 = 17% 12 = 83% (In year two of the course, it's certainly not surprising that the majority of students are in grade twelve.)

• Sex

Male = 81% Female = 19%

Teacher characteristics included:

• Physics background[2]

As with previous units, there was a wide range in the teachers' physics backgrounds; 18% reported no college physics courses; 27% reported one college physics course; 37% reported 2-4 college physics courses; 9% reported 5-7 college physics courses; and 9% reported eight or more college physics courses.

• Mathematics background

All teachers reported having had two or more college mathematics courses; several (27%) have had five or more college mathematics courses.

• Teaching pattern

The majority (64%) taught Unit 9 on consecutive days. Most (83%) taught sessions that were 60 minutes or shorter. About a third (36%) indicated that they had combined classes into one session. These numbers are nearly identical to the numbers for Unit 8, a finding that further indicates the stability of the sample.

• Preparation Time

The average amount of time teachers indicated they spent in preparing each lesson for the unit was 60 minutes, with a range from 30 to 120 minutes.

Thus, although there were two fewer sites reporting data for Unit 9 than for Unit 8 (11 for 9 and13 for 8), the characteristics of the sample for Unit 9 were nearly identical to the Unit 8 sample.

Approximately 100-150 students in 10-13 sites (depending on when the analysis is conducted)

[1]Due to missing data, the pretst/posttest student demographics don't match the student attitude demographics.

[2]To save valuable teacher time, the teacher questionnaire no longer contains items on the teachers' physics/mathematics backgrounds. The data reported below are from the Unit 7 data base; since the sample has stabilized, these data should remain accurate for year two.

constitute the year two sample. Although this is smaller than the year one sample, it remains a sufficient sample to permit judgments about the materials.

PRETEST/POSTTEST RESULTS

Several different analyses of the pretest/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 29 items.

• Mean differences

The overall pretest mean was 12.5. The overall posttest mean was 22.1. This increase was statistically significant (correlated *t*- test) at the .01 level.

The level of statistically significant learning gain (.01) is consistent with the gains shown for Units 1-8. Table 1 compares the pretest/posttest scores for Units 1-8.

Thus, Units 1, 4, 5, and 6 had fairly consistent pretest-to-posttest learning gains measured in percentage of correct answers. Learning gains for Units 2, 3, and 7, while somewhat lower, were still statistically significant. Yet the year two findings (Units 8 and 9) are clearly more positive than the year one findings. Why? It seems reasonable to assume that the smaller year two sample contains a higher caliber of students. Also, both teachers and students may be more comfortable with the materials, having had a full year to become familiar with the course approach. The materials also may have improved. Indeed, there is probably a combination of factors for the better year two performance. Whatever the reasons, the year two findings are certainly impressive.

<u>Individual Items</u>

For each unit the project team has established criteria for acceptable performance on each test item. These criteria included either:

1) 70%+ correct on an item, or

2) doubling of the pretest score on the posttest.

Only two Unit 9 items failed to meet these criteria. This is the best item-by-item performance of the entire pilot test. The items that did not meet the criteria were items 6 and 23. Item 23 came very close to meeting the criteria (67% correct on the posttest), which leaves only Item 6 as a concern. Item 6 deals with the constructive interference of light waves. Both the test item itself and/or the coverage of the material should be examined.

With so few items that failed to meet the criteria, it's not surprising to note that students performed satisfactorily on the majority of items for each of the subunits. No subunit seemed to cause the students particular problems. Only for Units 8 and 9 did students meet the criteria for a majority of items in each subunit. This is additional evidence of the improved test performance in year two.

Table 1
Principles of Technology
Pretest and Posttest Scores, Units 1-9

Unit	Number of Items	Pretest Mean (% correct)	Posttest Mean (% correct)
1	30	12.5 (41%)	20.1 (67%)
2	33	13.6 (41%)	17.6 (53%)
3	30	14.9 (49%)	19.4 (65%)
4	36	16.4 (46%)	24.4 (68%)
5	35	13.2 (38%)	22.6 (65%)
6	30	11.5 (38%)	18.3 (61%)
7	34	13.2 (39%)	19.9 (59%)
8	25	11.9 (48%)	18.9 (76%)
9	29	12.6 (33%)	22.1 (76%)

PRETEST/POSTTEST BY SELECTED VARIABLES

For all previous units, the impact of several variables on students' test performance was examined, including students' grade and sex, teaching pattern, and teachers' physics and mathematics background. However, the smaller year two sample precludes making the comparisons among teacher background and teaching pattern; there are simply too few teachers to make reliable comparisons. So, the only valid comparisons are those comparing the student characteristics of sex and grade. These variables were analyzed with an analysis of covariance, which controlled for pretest scores. Table 2 examines the results of this analysis; the mean scores reported in Table 2 are for the posttest.

Table 2

Main Effect	Level of Significance	Subset	Mean Score
Sex	.563	Male (89)	22.48
		Female (22)	20.95
Grade	.326	Tenth (1)	20.00
		Eleventh (21)	23.29
		Twelfth (92)	21.89

As Table 2 illustrates, neither students' sex nor grade had a statistically significant effect on their performance. These findings are consistent with those reported for Unit 8.

PRETEST/POSTTEST RESULTS BY SITE

Appendix D indicates the pretest/posttest results by site. All eleven sites showed statistically significant (.01 level) increases. Table 3 examines the number of sites showing no statistically significant gains for each of the first nine units.

Table 3

Unit	Sites showing no significant gains
1	1
2	4
3	4
4	0
5	1
6	3
7	1
8	1
9	0

Again, these results m[illegible] be interpreted cautiously. The reduced number of sites and the assumed differences in the composition of the year two sample make comparisons across units difficult to make. Nonetheless, it is encouraging to note that all sites showed significant gains for Unit 9.

STUDENT ATTITUDE FINDINGS

As discussed earlier in this report (see the instrumentation section, pages 6-8), the student attitude questionnaire was completely revised for year two of the pilot test. Very little was retained from the questionnaire that was used during year one of the project. The new questionnaire contains a series of items for each of several categories. The categories include students' reactions to the unit's objectives, content, video, text, and laboratory activities; the difficulty of the unit; and students' satisfaction with the unit. Each category contains a series of statements to which students respond using a four-point Likert-type scale ("strongly agree" to "strongly disagree"). The new questionnaire provides more information about students' attitudes than the five-item questionnaire that was used during year one of the project. Of course, collecting more information requires additional, valuable classroom time, which is the major disadvantage of the new questionnaire.

There are a number of ways to analyze these data. The simplest is to report the frequency of responses to each item. To compare responses across categories, however, it helps to have a numerical total for each category. Since a four-point scale was used (with four being the most positive and one the most negative), we can arrive at a mean score of between one and four for each statement. These mean scores can then be added and divided by the total number of items in the category to arrive at a mean score for each category. Both the frequencies for each item (in percentages) and a mean score for each category are reported below.

<u>Unit Objectives</u>

Generally, students indicated that they found the unit objectives helpful. Most (90%) agreed or strongly agreed that the objectives helped them understand what they were supposed to learn and that they are glad the objectives are printed in the written materials. Fewer (77%) agreed or strongly agreed that they used the objectives to guide them through the material. The overall mean score for the category was 3.00. (A perfect four is the most positive score possible.)

Unit Content

Most students (83%) disagreed or strongly disagreed that the unit had too much information. Most (86%) agreed or strongly agreed that the unit gave examples that were helpful in understanding the concepts. The majority (75%) disagreed or strongly disagreed that the content of the unit was difficult for them to understand. The majority (79%) agreed or strongly agreed that the content will probably be useful in future jobs. The mean score for the category was 2.78. Overall, then, the majority of the students indicated that the amount and difficulty of the material was appropriate for them. However, a quarter (25%) of the students indicated that the information was difficult for them to understand.

Unit Video

Most students (91%) agreed or strongly agreed that the video programs helped them better understand the material. Most (89%) agreed or strongly agreed that the video programs were interesting. Most (91%) agreed or strongly agreed that they used easy to understand graphics. And the majority (84%) agreed or strongly agreed that the video programs helped them to achieve the unit objectives. The overall mean score for the video category was 3.09.

Unit Text

Most students (87%) agreed or strongly agreed that the text materials helped them achieve the unit objectives. Most (83%) agreed or strongly agreed that the text will be a useful reference after taking the course. The majority (75%) disagreed or strongly disagreed that the text used language that was difficult for them to understand. Most (82%) agreed or strongly agreed that the text had enough examples to help them understand the important concepts; even more (89%) agreed or strongly agreed that the text helped them understand the unit concepts. The overall mean score for the text category was 2.96.

Laboratory Activities

The majority of students (78%) agreed or strongly agreed that the lab activities helped them achieve the unit objectives. The majority (60%) disagreed or strongly disagreed that the lab activities were difficult. The majority (65%) agreed or strongly agreed that the time periods were

not long enough to complete the work. The overall mean score for the category was 2.68. It's interesting to note that the majority of students indicated that the time periods were not long enough to complete the lab work, which is what the teachers also have been indicating in their comments.

Unit Difficulty

Over a quarter (28%) indicated that some of the things they were expected to learn were just too hard. Almost as many (27%) agreed or strongly agreed that they had trouble reading the unit text. The overall mean score for the category was 2.92.

Student Satisfaction

The majority (71%) agreed or strongly agreed that they usually had a sense of satisfaction after leaving class each day. Few (20%) agreed or strongly agreed that they did not like coming to class. And most (85%) indicated that they would recommend the class to their friends. The overall mean score for the category was 2.93.

Table 4 compares the mean category scores to those for Unit 8 (comparisons with Units 1-7 are impossible because the questionnaire was not used for those units).

Table 4

Category	Unit 8	Unit 9
Unit objectives	3.03	3.00
Unit content	2.82	2.78
Unit video	2.93	3.09
Unit text	2.83	3.96
Unit labs	2.83	2.68
Unit difficulty	2.58	2.92
Student satisfaction	2.85	2.93

In Table 4, it's important to remember that scores of 3 and 4 are the preferred responses. Considering that *Principles of Technology* is a fairly rigorous science course, the picture that Table 4 depicts for students' attitudes about Units 8 and 9 are amazingly positive. Why? A careful examination of Table 4 reveals that the highest scores were those for the video programs. One might assume that the video programs make the entire course much more palatable to students, by showing applications of the concepts in the real world. One other noteworthy finding of Table

4 is that the difficulty rating for Unit 9 (2.93) was more positive than for Unit 8 (2.58). In combination with the very positive pretest/posttest findings, this serves as additional evidence that the Unit was at the appropriate level for the target audience.

TEACHER RESULTS

Questionnaires were received from eleven teachers. As mentioned earlier in this report (see the instrumentation section, pages 6-8), the teacher questionnaire was revised substantially from the questionnaire that was used during year one of the project. Although many of the year one items were maintained, new items similar to those used for the student attitude questionnaire were added. These items focus on the teachers' reactions to the objectives, the instructional activities, and the level of difficulty. The unit daily log, with few modifications from the one that was used during year one of the project, was also part of the teacher instrumentation. The findings reported below reflect both the teacher questionnaire and the unit daily log. Appendices F and G, which list the detailed teacher comments, should be examined carefully. The wealth of data contained in these comments is difficult to encapsulate. Overall, the teacher findings were as follows:

Unit Objectives

The teachers unanimously affirmed the worth of the unit objectives. All agreed or strongly agreed that the objectives assisted them in assessing student progress, that the objectives helped them determine what to teach, and that the objectives were presented in a logical order. Almost all teachers also indicated that the objectives reflected what the unit was designed to teach. (Because so few teachers responded, these data were not examined by mean scores based on the four-point scale as were the student attitude data.)

Unit Instructional Activities

All teachers indicated that the unit instructional activities were related to the unit objectives and that the activities were presented in the correct sequence. However, two teachers (18%) indicated that the reading level of the instructional activities was too difficult for most of their students.

Unit Content

Most teachers (91%) disagreed or strongly disagreed that the unit content was too detailed. Most (91%) thought the material was presented at the proper level of difficulty and that the

material contained examples that were helpful to students in their understanding of unit concepts. All of these teachers felt the content contained enough examples and provided enough summaries of important points. Finally, all teachers indicated that they thought the content provided information that will be useful for students in their future employment. As we have already seen (see the Student Attitude section), the students themselves also thought the material contained information that will be useful to them in their future employment.

Teacher Comfort

All teachers indicated that they felt comfortable teaching the material in Unit 9.

Time

The majority (69%) indicated that the six-day plan of 50-minute class sessions per subunit is a realistic time allotment for Unit 9.

Student homework assignments

Almost half (46%) indicated that half or fewer than half their students typically completed the homework assignments for the unit. Interestingly, close to the same number (40%) indicated that fewer than half their students typically completed their homework assignments for other courses that they teach. It seems that students' completion of homework assignments is probably affected more by the students' motivation than by the nature of the materials.

Teacher's guide

The majority of teachers (73%) thought the teacher's guide provided them with enough information to successfully implement the unit. A few teachers thought some of the problems needed more explanation in the text.

Appropriateness for students

Generally, teachers tended to indicate that each day of instruction was appropriate for their students.

Problems

To the question, "What, if anything, caused you the most problems in teaching the unit on WAVES AND VIBRATIONS?" twelve teachers responded. The problems reported include:

- Hands-on labs, lack of equipment, etc. (ten teachers)
- Mathemat[illegible] and mathematics formulas (one teacher)
- Material ne[illegible] to instructor (one teacher)

These findings are consistent with those teachers reported for Units 1-8. Availability of equipment for the hands-on labs continues to cause teachers the most problems. On the other hand, teachers continue to affirm the appropriateness of most of the material for their students, and most of them thought the material was presented at the proper level of difficulty. Finally, many specific recommendations for changes, including errors in the text, are contained in the teacher's comments. Overall, the teachers tended to be fairly positive about Unit 9.

CONCLUSIONS

It is important to remember that the entire pilot test is part of the overall formative evaluation process. Data are being collected from the consortium review team, consortium representatives, and from teachers and students at the pilot sites. These data are then used as a basis for making revisions in the materials.

Certainly, then, this report contains much useful information.

1) Overall, a statistically significant (.01 level) learning gain took place. This learning gain was independent of students' sex and grade. Students equaled the highest posttest score (76%; the same as for Unit 8) and had the greatest mean gain from pretest to posttest (33%) for any unit of the pilot test.

2) Students failed to meet the project criteria for only two items, the fewest for any unit so far in the pilot test.

3) Student attitudes were generally positive, especially about the value of the unit objectives. They were also positive about the unit videos, text, labs, and overall content. However, about a quarter of the students indicated that they had trouble reading the text material and that some of the things they were expected to learn were too hard. Nonetheless, most students also indicated an overall sense of satisfaction with the unit and thought that the content of the unit will probably be useful in future jobs.

4) Teachers affirmed the appropriateness of most of the material for their students. Like their students, teachers also affirmed the value of the instructional objectives. However, two teachers found the reading level of the instructional activities too difficult for most of their students.

5) Teachers' comments indicated that the most problems were encountered with the hands-on labs. This is consistent with the findings for the first eight units. It should be pointed out that most of the problems reported were with simply getting the equipment. Once teachers have the equipment, most of the labs seem to work satisfactorily.

6) Although the teachers were generally quite positive about the unit, they did recommend several specific changes, which can be found in their attached comments.

Overall, the Unit 9 findings were the most positive yet for the *Principles of Technology* pilot test. These positive findings spanned the pretest/posttest results, the student attitude findings, and the teacher reactions. There is much to be encouraged about in this report. As with all formative evaluations, teachers also pointed out errors and/or perceived inaccuracies in the materials. As usual, the developers should closely consider these findings.

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

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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Appendix C

Student Test

O-3, I-1, I-2, I-3, I-4, I-5, I-7
Use the following respones to answer items 1-5. When completed, the following statements include the important characteristics used to describe mechanical waves.

a. The distance between any pair of adjacent particles that are in phase.

b. The number of seconds that it takes each wavelength to pass a fixed point.

c. The number of wavelengths that pass by any fixed position each second.

d. The distance the molecules are displaced from their neutral position during wave motion.

e. Equal to the product of the wavelength and frequency of the wave.

Pre	Post	
14	79	1. The amplitude of a mechanical wave is _d_.
12	84	2. The wavelength of a mechanical wave is _a_.
25	77	3. The frequency of a mechanical wave is _c_.
21	74	4. The period of a mechanical wave is _b_
27	75	5. The wave speed of a mechanical wave is _e_ .

II-4
6. An optical flat and light waves are used to measure the flatness of a machined surface. The bright area or bands seen in an interference pattern of light waves are the result of ____.

Pre	Post	
27	6	a. light intensity
31	57	* b. constructive interference of light waves
25	17	c. destructive interference of light waves
15	19	d. reverberations

II-4
7. A "dead spot" in an auditorium is caused by ____of sound waves.

Pre	Post	
12	3	a. beats
21	8	* b. constructive interference
43	74	c. destructive interference
14	15	d. reverberations

II-7
8. Damping pads and shock absorbers are placed on machines to prevent damage due to _____within the machine.

Pre	Post	
11	3	a. thermal overheating
33	10	b. sound wave interference
27	87	* c. resonant vibrations

Pre	Post	
		9. The traffic failure of the Tacoma Narrows Bridge is an example of ______.
10	82	* a. wind gusts in phase with a natural frequency of vibration of the bridge
12	13	b. wind gusts out of phase with a natural frequency of vibration of the bridge
53	3	c. the complete absence of resonance
24	3	d. no transfer of energy from the wind to the bridge

II-1, II-2, II-3, II-5, II-6
Use the following responses to answer items 10-14. When completed, the following statements include the important characteristics used to describe the interaction of waves.

a. Wave interference.

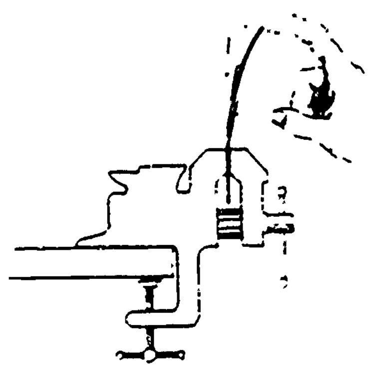
b. Constructive interference.

c. Destructive interference.

d. Natural frequency.

e. Resonance.

Pre	Post	
15	68	10. When forced vibration matches the natural frequency of an object and transfers energy efficiently to the object, the condition known as __e__ exists.
18	67	11. When two or more waves in a medium pass through the same point at the same time, the medium responds to each wave. The waves overlap and create a condition known as __a__.
46	81	12. When two identical waves interfere at a point, they produce the same effect as twice that of one of the waves. This effect is known as __b__.
12	79	13. When two identical waves interfere at a point they produce the same effect as no wave at all. this effect is known as __c__.
41	78	14. One end of a hacksaw blade is clamped in a vise as shown. The other end is displaced and released. The blade vibrates back and forth as at a rate known as _d_.



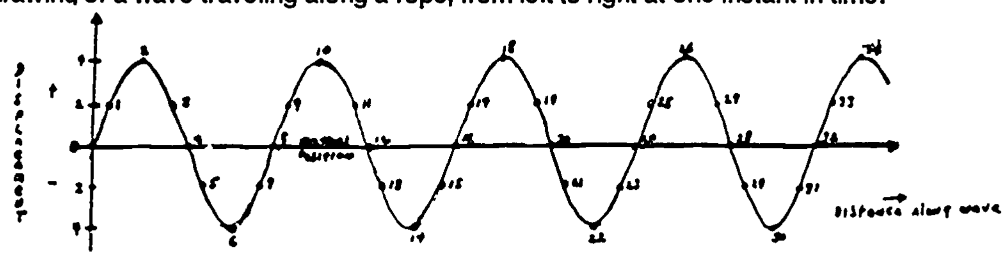
Pre	Post	
		15. A swing holding a child makes a complete oscillation (away and back again) every four seconds. The natural frequency of the swing is ______.
43	12	a. 4 cycles/sec
34	9	b. 2 cycles/sec
14	78	* c. 0.25 cycles/sec
6	2	d. 10 cycles/sec

638

Pre	Post	
		I-1
		16. For a wave to be considered a harmonic wave (sine wave) ______.
12	7	a. it must transmit energy with a single nonrepeating pulse.
24	89	* b. it must transmit energy with a repeating pulse of constant waveform.
23	4	c. it must transmit energy with a nonuniform pulse.

I-8, I-9, I-10

Use the graph of the continuous sine wave shown below to complete items 17-22. The graph is a drawing of a wave traveling along a rope, from left to right at one instant in time.



Pre	Post	
		17. The distance between point 8 and point 16 is _____.
40	5	a. the amplitude (A) of the wve
22	6	b. the frequency (f) of the wave
17	76	* c. the wavelength (λ) of the wave
11	13	d. the period (T) of the wave
		18. The vertical distance between the zero line (neutral position) and point 2 is ______.
15	89	* a. the amplitude (A) of the wave
50	3	b. the frequency (f) of the wave
20	3	c. the wavelength ( ) of the wave
10	5	d. the period (T) of the wave
		19. The particles represented by points 1, 9, and 33 are ______.
22	6	a. located in troughs of the sine wave
23	88	* b. in phase with each other
21	1	c. out of phase with each other
7	5	d. located on peaks of the sine wave
		20. When you watch the wave above move along the rope, you observe that five cycles (wavelengths) move past point 16 every two seconds. The frequency of the wave is ______.
15	6	a. 5 cycles/sec
15	81	* b. 2.5 cycles/sec
65	6	c. 10 cycles/sec
3	7	d. 80 cycles/sec
		21. It takes 0.4 seconds for one cycle (wavelength) in the wave above to pass by point 16. The speed of the wave is ______.
18	10	a. 0.2 seconds
50	82	* b. 0.4 seconds
14	3	c. 0.1 seconds
16	5	d. 0.3 seconds

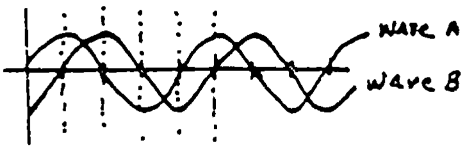
Pre	Post	
		22. Each crest on the wave above moves a horizontal distance of 60 centimeters in three seconds. The speed of the wave is _____.
22	7	a. 60 cm/sec
46	19	b. 180 cm/sec
19	13	c. 30 cm/sec
11	61	* d. 20 cm/sec

In the following three statements, match the lettered phrases on the right with the correct description on the left. On your answer sheet fill in the appropriate response.

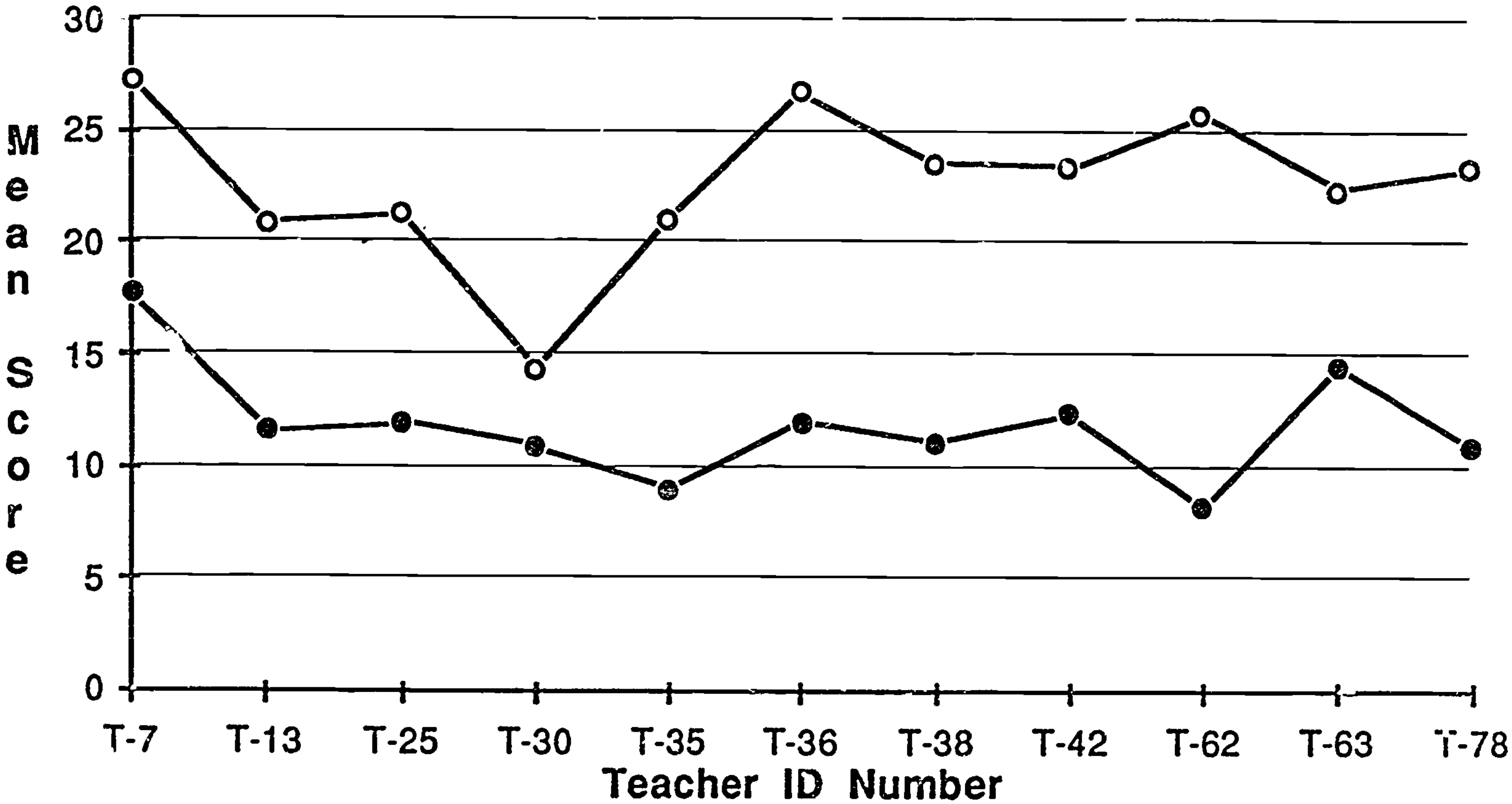
		O-1	
60	67	23. _B_ The transfer of energy from one place to another without the transfer of matter	a. electromagnetic waves
			b. wave motion
		O-2	c. mechanical waves
14	72	24. _A_ The transfer of energy through a vacuum.	
		O-2	
25	67	25. _C_ The transfer of energy through elastic mediums.	

		O-4, I-11
		26. When a mechanical wave is passing through an elastic medium, if the vibrations of the individual particles are <u>perpendicular</u> to the motion of wave propagation (movement) the wave is called _____.
12	20	a. a longitudinal wave
21	6	b. a sound wave
43	74	* c. a transverse wave
		O-4, I-11
		27. When a mechanical wave is passing through an elastic medium, if the vibrations of the individual particles are parallel to the direction of wave propagation (movement) the wave is called ____.
12	77	* a. a longitudinal wave
16	5	b. an electromagnetic wave
11	18	d. a transverse wave

Pre	Post	
		I-8 28. The distance between similar points on two separate sine waves, often measured in degrees, is ___ .
10	15	a. the phase
12	12	b. the frequency
53	70	* c. the phase difference
24	3	d. the frequency difference
		I-8 29. In the diagram of the sine waves shown below the two waves are out of phase with each other by ____.
43	75	* a. 1/4 wavelength or 90°
34	15	b. 1/2 wavelength or 180°
14	6	c. 3/4 wavelength or 270°
6	5	d. 1 wavelength or 360°



Appendix D
Pretest/Posttest Means



Appendix E

Student Attitude Questionnaire

All numbers in %
N = 133
Mean scores in parenthe es

Grade (12th = 83; 11th = 15; 10th = 1)
Sex (M = 81; F = 19)

PURPOSE
Your honest answers to the questions on this form will help improve this *Principles of Technology* unit for other students. Your responses to the following items are appreciated.

DIRECTIONS
Below are a list of statements. Please read each statement and answer whether you strongly agree, agree, disagree, or strongly disagree by checking the appropriate box. Place a check mark [√] in only one box for each statement.

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT OBJECTIVES (x = 3.00)				
For this unit:				
1. the objectives helped me understand what I was supposed to learn (x=3.08)	17	72	10	1
2. I'm glad the objectives are printed in the written materials (x = 3.11)	23	67	8	2
3. I used the objectives to guide me through the material (x = 2.83)	10	67	19	4
General Comments on Unit Objectives:				
UNIT CONTENT (x = 2.72)				
The content of this unit:				
4. had too much information (x = 2.55)	2	15	70	13
5. gave examples helpful in understanding concepts (x = 2.91)	9	78	11	2
6. was too difficult for me to understand (x = 2.79)	1	17	55	27
7. will probably be useful in future jobs (x = 2.90)	15	63	17	5
General Comments on Unit Content:				

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT VIDEO (x = 3.09)				
The video programs for this unit				
8. helped me to better understand the text material (x = 3.10)	21	69	9	1
9. were interesting (x = 3.04)	19	70	9	2
10. used easy to understand graphics (x = 3.13)	21	69	8	1
11. helped me to achieve the unit objectives (x=3.09)	9	75	16	--
General Comments on Unit Video:				
UNIT TEXT (x = 2.96)				
The unit text materials:				
12. helped me to achieve the unit objectives (x = 3.01)	14	73	12	1
13. will be a useful reference after taking the course (x = 2.99)	16	66	17	1
14. used language difficult for me to understand (x = 2.92)	2	23	56	19
15. had enough examples to help me understand the important concepts (x = 2.88)	6	76	17	1
16. helped me to understand the unit concepts (x = 2.98)	8	80	11	1
General Comments on Unit Text:				
LABORATORY ACTIVITIES (x = 2.68)				
The unit lab activities:				
1 helped me achieve the unit objectives (x=2.80)	8	66	18	6
18. were difficult (x = 2.68)	3	36	49	12
19. time periods were not long enough to complete the work (x = 2.28)	12	52	29	7
20. in general, I liked them (x = 2.97)	14	62	21	3
General Comments on Laboratory Activities:				

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT DIFFICULTY (x = 2.92)				
For this unit:				
21. some of the things we were expected to learn were just too hard (x = 2.93)	3	25	48	24
22. I had trouble reading the unit text materials (x = 2.91)	3	24	52	21
General Comments on Unit Difficulty:				
STUDENT SATISFACTION (x = 2.93)				
For this unit:				
23. I usually had a sense of satisfaction after leaving class each day (x = 2.75)	8	63	25	4
24. I did not like coming to class (x = 2.98)	7	13	55	25
25. I would recommend it to my friends (x = 3.07)	22	63	14	1
General Comments on Student Satisfaction:				

Appendix F

Teacher Questionnaire

All numbers in %
N =12

PURPOSE
The primary purpose of this questionnaire is to provide teacher information for facilatating improvement of the *Principles of Technology* curriculum. Specifically, this form is designed to assess the appropriateness of *Principles of Technology* unit objectives and the appropriateness of instructional activities, resources, curriculum content, and instructional planning needed to accomplish these objectives.

DIRECTIONS
Below are a list of statements. Please read each statement and indicate whether you strongly agree, agree, disagree, or strongly disagree by checking the appropriate box. Place a check mark [√] in only one box for each statement.

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT OBJECTIVES				
The unit objectives:				
1. assist me in assessing student progress	18	82	–	–
2. don't reflect what the unit is designed to teach	–	20	20	60
3. help me determine what to teach	50	40	10	–
4. are presented in logical order	27	73	–	–
General Comments on Objectives:				
See attached comments				
UNIT INSTRUCTIONAL ACTIVITIES				
The unit instructional activities:				
5. are related to unit objectives	18	82	–	–
6. are presented in the correct sequence	18	82	–	–
7. require a reading level that is too difficult for most students	9	9	64	18
General Comments on Instructional Activities:				
See attached comments				

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	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT CONTENT				
The unit content:				
8. was too detailed	–	9	82	9
9. was presented at the proper level of difficulty	–	91	9	–
10. contained examples that were helpful to students in their understanding of unit concepts	18	73	9	–
11. contained enough examples	18	82	–	–
12. provided enough summaries of important points	–	100	–	–
13. provided enough information that will be useful for students in their future employment	27	73	–	–

General Comments on Unit Content

See attached comments

PERCEPTIONS OF INSTRUCTIONAL PLANNING

14. On average, how many hours did you spend preparing to teach each lesson in this unit? (60 minutes)

15. Approximately how much time, on average did you expect students to spend on homework each day?

[ ] None
[50] About 15 mintues
[30] About half an hour
[10] About one hour
[10] Two hours or more

16. What percentage of students typically completed your homework assignments for this unit?

[27] Fewer than 25%
[19] 26-49%
[27] 50-74%
[27] 75% and above

17. What percentage of students typically completed your homework assignments for other courses that you teach?

[20] Fewer than 25%
[20] 26-49%
[40] 50-74%
[20] 75% and above

18. Do you feel the teacher's guide material provided you with enough information to help you teach the unit?

[18] Definitely [55] Probably [27] Probably not [--] Definitely not

If not, what should be added to the guide to make it more useful?

See attached comments

19. Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for this unit?

[33] Yes, definitely [ ] No, probably not
[67] Yes, probably [ ] No, definitely not

20. Overall, did you feel comfortable teaching the materials in this unit?

[58] Yes, definitely [ ] No, probably not
[42] Yes, probably [ ] No, definitely not

If no, please explain:

See attached comments

21. What, if anything, caused you the most problems in teaching this unit?

See attached comments

22. What did you like the most in teaching this unit?

See attached comments

General Comments on Perceptions of Instructional Planning:

See attached comments

23. Did you teach this unit on consecutive days for 26 days?

[64] Yes [36] No

If no, what pattern did you use (for examples,3 days a week)?

See attached comments

24. How much time per class session did you devote to this unit?

[67] 50 mintues or less [17] 61-90 minutes
[16] 51-60 minutes [ ] 91+ minutes

25. Did you combine any of the unit's classes into one session (for example, teach classes C1 and C2 in one session)?

[36] Yes [64] No

If yes, which classes did you combine?

See attached comments

26. Were there any special circumstances which, in your opinion, may have influenced the pre- or posttest scores (e.g., lack of time, faulty lab equipment, school holidays, fire drill)?

See attached comments

General Comments:

See attached comments

Teacher Questionnaire Comments

General Comments on Objectives

1. Objectives are helpful, especially to teacher. My impression is that they are largely ignored by students.
2. Good, I like. (#17)

General Comments on Instructional Activities

1. There should not be a problem if any effort is made by the students. (#30)

General Comments on Unit Content

1. Good. (#62)
2. Too many errors in print. (#63)
3. Some students like the examples given in boxes as in the past units. (#36)
4. We may not use all of the examples or sample problems provided, in this and other units, but it's good for them to be there if and when they're needed. (#35)
5. No problem. (#17)

Question 18 Comments

Do you feel the teacher's guide material provided you with enough information to help you teach the unit? If not, what should be added to the guide to make it more useful?

1. More math help. (#25)
2. When problems are calculated all steps are not included in teacher manual. (#63)
3. More explanation of everything, like the math problem on page 89 (#6). I know how, but it's been a while for me since I've done this, I would have liked to check my work. (#37)

Question 20 Comments

Overall, did you fee[illegible] [illegible]e teaching the materials in this unit? If no, please explain.

no comments

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Question 21 Comments

What, if anything, caused you the most problems in teaching this unit?

1. Some of the material was new for me, no equipment continues to be a problem. (#38)
2. Labs -- poor design. (#25)
3. Delivery of equipment needed -- example accelerometers arrived on day of lab. (#78)
4. Lack of equipment. (#42)
5. Lab 9*3. (#63)
6. Lab equipment. (#07)
7. Lack of proper equipment for the labs. (#[illegible])
8. Labs -- we can't do many at all. (#37)
9. Getting trig across to students. (#13)
10. Not having proper lab equipment and not having enough time for the students to absorb the material. (#35)
11. As always, acquisition of materials is most time-consuming and frustrating, especially when hours are invested in searching for unobtainable components. (#30)
12. No lab equipment for this unit. (#17)

Question 22 Comments

What did you like most in teaching this unit?

1. Learning new conceptsl (#38)
2. Something I hadn't studied much before. (#25)
3. I worked in industry for four years on vibration testing and analysis -- gave me a chance to check my knowledge. (#78)
4. I found the entire unit fun to teach and very challenging. (#63)
5. Labs. (#07)
6. The way it was presented. I was familiar with the subject of waves so therefore this unit was rather easy for me to teach. (#36)
7. The concept and applications. (#37)
8. The flow of information. #13)
9. Really useful and interesting applications are available in this unit. Many are possible using student interest in music. (#30)
10. Clear and good ideas. (#17)

General Comments on Perceptions of Instructional Planning

1. I really have to dig and I'm sure most teachers are in the same boat. (#38)

2. G ,d. (#25)

3. Good unit. (#/8)

4. My problem is not having time to complete each lab prior to conducting a class on the lab. (#63)

5. Very well thought out. (#13)

6. This course is very time-intensive. Lecture planning with demo set ups, lab set ups and breakdowns, materials acquistions, testing, and lab/test correction require even more time and always will. (#30)

Question 23 Comments

Did you teach this unit on consecutive days for 26 days? If no, what pattern did you use (for example, 3 days a week)?

1 Tow - three days a week. (#25

2. Short unit. Took 20 days to cover thoroughly, instead of 15 as suggested. (#78)

3. Two days a wek, two hours a day. (#13)

4. We did Unit 9 in 9 class sessions, including testing. (#35)

5. Double periods per day, alternating weeks. (#30)

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Question 25 Comments

Did you combine any of the unit's classes into one session (for example, teach classes C1 and C2 in one session)?

1. Labs 9*3 and 9*4 were done simultaneously due to limited equipment. (#63)
2. C1 and C2. (#07)
3. Combined some lecture; integrated some of the math material into C1 and C2 sessions. (#35)
4. C0, C1, and C2; MS1, L1, L2. (#30)

Question 26 Comments

Were there any special circumstances which, in your opinion, may have influenced the pre- or posttest scores (e.g., lack of time, faulty lab equipment, school holidays, fire drill in the middle of the exam)?

1. No equipment. (#38)
2. Lack of equipment by Sargent-Welch, Scientific Labs, or anybody. (#62)
3. Posttest, lack of time, assembly took part of hour leaving only 25 minutes for completion of tst. (#78)
4. No lab equipment. (#42)
5. Lab equipment not available. (#63)
6. We did not do lab 9*2 or 9*4. (#07)
7. Posttest scores were good except for one students. If the proper lab equipment had been available, his score may have been improved. (#36)
8. Faulty lab equipment is a gross problem for us this year. The kids and the course are missing out on a lot due to this. (#37)
9. The pretest scores in some instances do not reflect the "best guesses" of the students. I noticed some "E" choices of answers for questions where that wasn't a possibility. (#35)
10. Senior-itis continually present in at least 4 cases. Tomorrow is high school Superbowl game in which 3 senior football players are participating; last night was the Superbowl dinner. Skipping labs due to lack of equipment produces very concentrated class meetings and attendance has been a problem with at least 3 Senior-itis ladies. (#30)
11. Did not do labs. (#17)

General Comments

1. On the whole a good unit. (#36)

2. In general. I found this to be a very timely, useful and well-written unit. The videos had broad usefulness and will be shown in other classes as well as PT. (#30)

Appendix G

Unit Daily Log

PURPOSE
The purpose of the Unit Daily Log is to provide a regular source of teacher information for improving the Principles of Technology curriculum.

DIRECTIONS
The left column on the following chart lists each activity for this particular unit. Since there are no materials specifically for the subunit review classes, these classes have not been listed in the chart.

For columns 1-5 on the attached chart:

1. Circle "Y" (yes) or "N" (no): Were the readings, labs, or videos appropriate (e.g., grade level, sufficient quantity of material) for your students? If not, specify modifications in column 5.

2. Circle "Y" (yes) or "N" (no): Were you able to cover the content in the 50-minute time period?

3. Briefly describe any errors or inaccuracies in the material.

4. Briefly describe any problems you had in managing the material. Among others, this may include problems in coordinating lab rotations, lab set-up, and maintaining student interest.

5. Briefly list suggestions for modifying the material. Describe "teaching tips" for future teachers.

We recommend that you take a few minutes each day to complete the charts. If you need more space for comments, use the back of the charts and/or attach additional pages.

Unit	Appropriate for students?	Completed in 50-60 minutes?	Did you discover any errors or inaccuracies? If so, please specify in the appropriate spaces below.	Did you have any management problems? If so, please specify in the appropriate spaces below.	Do you have any suggested modifications or general comments? If so, please specify in the appropriate spaces below.
OVERVIEW					
Video	Y N 100				
C0	Y N 100	Y N 100			
WAVE CHARACTERISTICS					
Video	Y N 100				
C1	Y N 100	Y N 83 17			
C2	Y N 100	Y N 100			
Math Lab	Y N 100	Y N 67 33			
Lab 9*1	Y N 100	Y N 71 29			
Lab 9*2	Y N 100	Y N 67 33			

Unit	Appropriate for students?	Completed in 50-60 minutes?	Did you discover any errors or inaccuracies? If so, please specify in the appropriate spaces below.	Did you have any management problems? If so, please specify in the appropriate spaces below.	Do you have any suggested modifications or general comments? If so, please specify in the appropriate spaces below.
WAVE APPLICATIONS					
Video	Y N 100				
C1	Y N 100	Y N 100			
C2	Y N 100	Y N 100			
Math Lab	Y N 100	Y N 100			
Lab 9*3	Y N 100	Y N 25 75			
Lab 9*4	Y N 100	Y N 20 80			
SUMMARY					
Video	Y N 100				

Unit Daily Log Comments

Overview -- Video

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Kids were most interested in bridge sequence. (#30)
2. The videos seemed to be more helpful for this unit than for some of the others. Students volunteered that videos are better when they're not straining for humor. (#35)

Overview -- CO

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Wave Characteristics -- Video

Did you discover any errors or inaccuracies?

1. Page 30, question 15, peak to peak is only 2 divisions, not 4 as stated in the teacher guide, page T-30, 15a. (#63)

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Good use of "noise" signal to grab attention. Kids attention did get grabbed. (#30)

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. New area took longer to explain. (#13)

Do you have any suggested modifications or general comments?

no comments

Wave Characteristics -- C2

Did you discover any errors or inaccuracies?

1. Page 116 and 117, figure 9-32 and 9-33 are labelled incorrectly. (#37)

2. Error in solution example 9-B. Errors in examples 9-C and 9-F. (#38)

3. In #15 of student exercises, the answers to parts a and b seem to refer to the drawing in #13 instead of the one provided in #15. (#35)

Did you have any management problems?

1. Did not do. 9DM1 demo, lack of a long spring. (#78)

Do you have any suggested modifications or general comments?

1. Box formula on page 22. (#30)

Wave Characteristics -- Math Lab

Did you discover any errors or inaccuracies?

1. Quite difficult for my students. (#25)
2. Table 5, page 40, the sine for 310° is .766, teacher's manual does not list 300° as a required sine problem. (#63)
3. Problem 5 gave students problem on a different plane. (#13)
4. Sine table on page 44 has incorrect sine values. (#30)

Did you have any management problems?

1. Kids needed a lot of explanation. Took 2 days. (#37)
2. Had to spend some extra time in explanation. (#38)
3. We skipped it because most students have already had exposure to trig functions; we were also short on time. This will have to be reviewed later however. (#35)
4. Used two periods to go through trig functions. (#78)

Do you have any suggested modifications or general comments?

no comments

Wave Characteristics -- Lab 9*1

Did you discover any errors or inaccuracies?

1. Page 46 illustration of set-up a, length of string is marked 1", should be 1m. (#63)
2. This machine didn't work well. Had to modify. (#35)

Did you discover any management problems?

1. No equipment. (#38)
2. No, except for some missing equipment. (#30)

Do you have any suggested modifications or general comments?

1. Rather than use a link to motor I put unbalanced weight on motor and let motor vibrate whole box. (#25)
2. This worked well and results were excellent. Students ran the lab to determine the constants of the springs we used. (#35)

Wave Characteristics -- Lab 9*2

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. No lab equipment. (#38)
2. Did not do -- no equipment. (#07)
3. Took two periods. (#78)
4. Didn't do. (#35)
5. Did not complete -- no vibration transducer. (#30)

Do you have any suggested modifications or general comments?

1. Need a better vibration table than one purchased if we are to get a good sine wave. It is interesting to use a strip chart recorder to show how industry collects vibration data. (#78)
2. Used 3" from under and separated both transducers. (#25)

Wave Applications -- Video

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Videos were too similar to each other. (#37)
2. Video was excellent. Can also be used in other physics and physical science classes, thus providing a good advertisement for PT. (#30)

Did you discover any errors or inaccuracies?

1. Page 116-117, figure labelled incorrectly. (#37)

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. One might mention accoustical ceilings used in many industrial sites to absorb ambient noise. (#30)

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Could also mention harmonics. Use volunteer synthesizer to demo interference: strobe, speakers, etc. (#30)

Wave Applications -- Mathematics Lab

Did you discover any errors or inaccuracies?

1. Problem 1, teacher manual, Lambda = 4', not 5', as stated in answer. Remember peak-peak. (#63)
2. Error in problem #1 solution, page T-86, Lambda = 4 feet. (#38)
3. Page T-86, error in problem 1, wavelength should be 4 units, or 4 feet, not 5 feet. (#78)

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Different math lab. Kids responded positively. (#30)

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Wave Applications -- Lab 9*3

Did you discover any errors or inaccuracies?

1. Your suggestions for mic hook up (page T-95) should specify that a battery is necessary for condensor mics only. (#63)

Did you have any management problems?

1. The lab is difficult because of the outside interference. I suggest that teachers palce the experiment in an insulated cardboard box. This will eliminate outside interference. (#63)
2. Did not complete. Hollow tubes and mics not available locally. (#30)
3. Took two periods. (#78)
4. No equipment. (#38)
5. Skipped it. (#35)
6. Needed two periods to get good results. (#07)

Do you have any suggested modifications or general comments?

nc comments

Wave Applications -- Lab 9*4

Did you discover any errors or inaccuracies?

1. The mega ohm resistors are referred to as "msl," as in figure 4, part b, page 106. (#35)

Did you have any management problems?

1. We ended up using an extra day here; some students needed help with the concepts of bradboarding and using oscilloscopes. And, we modified the lab activity to accomodate input from electronics students.
2. Did not complete. Insufficient numbers of capacitors and resistors available. locally. (#30)
3. Did not do (equipment). (#07)
4. No equipment. (#38)

Do you have any suggested modifications or general comments?

no comments

Summary -- Video

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Glossaries continue to be worthwhile. (#35)
2. Good quick review. (#30)
3. Light waves were not covered, but there was a question about them on test. (#37)

PRINCIPLES OF TECHNOLOGY

Unit 10: ENERGY CONVERTORS

Pilot Test Findings

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Box A
Bloomington, Indiana 47402

Center for Occupational Research and Development
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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 and related print 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.

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INTRODUCTION

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 (CCRD), and a consortium of 41 state and provincial education agencies (see Appendix A for a list of cooperating agencies). The course consists of fourteen units, each focusing on a principle that underlies today's technology. 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), from consortium representatives, and from teachers and students at classroom pilot test sites. The review team reviews preliminary drafts of the instructional materials before they are sent to consortium representatives and pilot test sites. Consortium representatives review the material concurrently with the classroom pilot testing. The data from all sources—review team, consortium representatives, and pilot sites—are analyzed and reported to the developers, who use these findings to revise the materials.

Thus, an important part of the overall formative evaluation is a pilot test of each unit in actual classroom settings. The primary purposes of the pilot test are: 1) to determine how well the materials are working; and 2) to identify specific problems with the materials. All pilot test teachers were oriented to the *Principles of Technology* course and to the pilot test procedures at one of two meetings held in Dallas the summer of 1984. Almost all pilot test teachers met again in a combined meeting with consortium representatives and AIT/CORD staff in Dallas the summer of 1985. At this meeting, staff members proposed several modifications in the pilot test procedures. Most of these changes were in the instrumentation for year two of the pilot test. (These changes are detailed in the instrumentation section of this report, pages 6-8.)

This report details the findings of the pilot test of Unit 10: ENERGY CONVERTORS. The report makes some comparisons of these findings with those for Units 1-9, which are contained in separate reports (see "Unit 1: FORCE—Pilot Test Findings," December 18, 1984;

"Unit 2: WORK—Pilot Test Findings," March 1, 1985; "Unit 3: RATE—Pilot Test Findings" May 6, 1985; "Unit 4: RESISTANCE—Pilot Test findings," May 29, 1985; "Unit 5: ENERGY—Pilot Test Findings," July 15, 1985; Unit 6: POWER—Pilot Test Findings," August 19, 1985; "Unit 7: FORCE TRANSFORMERS—Pilot Test Findings," January, 1986; "Unit 8: MOMENTUM—Pilot Test Findings," February 1986; and "Unit 9: WAVES AND VIBRATIONS—Pilot Test Findings," March 1986). Since some of the year two instrumentation, beginning with Unit 8, was modified, exact comparisons with Units 1-7 data are no longer possible. There remain, however, enough common elements from year one to year two instrumentation to make several comparisons. Finally, when reading this report one must remember that all data are formative data; the developers are using the data, along with reactions from the review team and consortium representatives, as a basis for revising the materials.

PILOT TEST PROCEDURES

Unit 10: ENERGY CONVERTORS pilot test materials were mailed to teachers in mid-November 1985. These materials consisted of:

1) Parallel pretest/posttest (see Appendix C)
2) Computerized scoring sheets for the pretest/posttest
3) Student attitude questionnaires (see Appendix E)
4) Teacher questionnaires (see Appendix F)
5) Unit daily log (see Appendix G)

Teachers administered the pretest before any teaching. As they taught the unit, teachers recorded their reactions to the unit on a detailed questionnaire. At the conclusion of the unit, teachers administered the posttest along with the student attitude questionnaires. As requested by teachers at the summer meeting, parallel forms of the same test were used for the pretest and posttest. All Unit 10 materials were then mailed back to AIT. This report contains all data received by March 1986. To meet the pressing project deadlines, the preliminary results for Unit 10 were reported to the staff on February 16, 1986. Data from only 36 students in four classes were available at that time. Since so few classes were on a schedule that met the project's developmental needs, the evaluation procedures for Units 11-14 have been significantly modified, relying primarily on detailed teacher reviews of the course components. Therefore, this Unit 10 report will be the final report to contain student and teacher data.

LIMITATIONS OF THE METHODOLOGY

Two major limiting factors must be considered when the findings are interpreted: research design and external variables beyond the project's control.

Research Design Constraints

Several factors in the research design must be considered, including:

- Lack of matched control groups

  The design allows one to draw conclusions only about the *Principles of Technology* course, but not to compare these results to other comparable teaching methods. The costs in time, resources, and further administrative impositions on the pilot test schools prohibited the establishment of matched control groups. It's also difficult to match *Principles of Technology* to other courses. Would they be physics courses or vocational courses? Thus, in addition to the fiscal and administrative constraints, the matching process itself would be problematic.

- The pretest/posttest format

  Parallel forms of the same test were used for the pretest/posttest. The effect that memory of the pretest might have on posttest performance was a concern. The research design addressed this concern in four ways:

  1) Students were not given the correct answers to the pretest. The effect of memory was limited, immediately, to the nature of the questions without accompanying knowledge of the correct answers.

  2) The posttest was administered more than one month after the pretest. In the intervening time students had many experiences, both academic and personal, that would mitigate the effects of memory.

  3) A correlated *t*-test was used to analyze the pretest/posttest data. This technique helps to partial out any variance that might result from an intruding correlation—in this case, memory.

  4) Parallel forms of the test were used. Although the items were identical, the order of the items was changed from pretest to posttest.

- The pretest/posttest as an instrument (see the section on instrumentation, pages 6-8)

  The test cannot measure all objectives. Therefore, objectives had to be sampled. Also, the items do not always directly match the intended objectives. The test was a cognitive test. Many of the objectives (particularly the lab objectives) are psychomotor objectives. One must consider each of these factors when assessing the validity of the instrument. It's important to remember, however, that the test is but one of several means being used to assess the unit.

External Constraints

Some factors beyond the project's control probably affected the results, including:

- Equipment problems

  As with the previous units, several teachers reported problems in securing the necessary lab equipment.

- Student characteristics

  Both teachers and students have reported what appears to be considerable variability in the kinds of students in the course. This variability encompasses students' academic backgrounds, ability levels, and socioeconomic levels. The project has made no attempt to control these variables.

- Teaching pattern

  Teachers report considerable variability in the length of classes and number of class sessions. The project has made no attempt to control these situations, but has instead attempted to assess the impact of the various conditions on the outcomes.

So, both research design and external constraints must be considered when the results are interpreted. It's important to remember that the pilot test was designed as a part of the overall formative evaluation, not as rigidly controlled research. Nonetheless, the validity of the various data collection procedures must be considered.

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INSTRUMENTATION

The instruments for Unit 10 were:

1) Parallel forms of a pretest/posttest
2) Student attitude questionnaires
3) A teacher questionnaire
4) A unit daily log

The student attitude questionnaire, teacher questionnaire, and unit daily log were similar to those used for Units 8 and 9. The instrumentation for Units 8-10 was substantially revised from the instrumentation used for Units 1-7. These revisions reflected comments made at the July 1985 meeting in Dallas. Before discussing the revisions, however, let's first examine the pretest/posttest instrumentation.

Pretest/Posttest

As with all previous units, the test questions were initiated at CORD by the content specialists. In a collaborative process between evaluators and content specialists, the original 50 questions were pruned and revised to the eventual 34 questions. Each item is tied as directly as possible to a specific objective from Unit 10. The item/objective match is not always exact. It's impossible to match items to some objectives because of the way those objectives are worded ("recognize," "define," etc.). It's important to remember that the instrument is attempting to measure manifestations of learning, and that approximations of objectives are often the best that cognitive test developers can do. With only 34 items, not all objectives could be tested. Therefore, objectives had to be sampled. Generally, priorities for this sampling were based on the relative importance of the concepts. (Appendix C lists the objective each item is intended to address above the item.)

So, is it a "good" test? Generally, instruments are judged based on reliability (consistency, accuracy, dependability) and validity (roughly, is it measuring what you think it's measuring?). On the Spearman-Brown Test of internal consistency, the reliability of this instrument is .88, which is acceptable by most standards. Validity is a bit more complicated to judge. Readers are

encouraged tc make their own judgments about the validity of the instrument. Pertinent questions include:

1) Do the items adequately address the intended objectives?
2) Is a sufficient range of objectives addressed?
3) Overall, is the instrument a fair measure of Unit 10's instruction?

It should be pointed out that, in examining the pretest/posttest results for each of the first ten units, the developers and evaluators encountered a few items in each unit (no more than three per unit) that they considered, for various reasons, to be poor items. Of course there is always wisdom in hindsight. Ideally, each of these instruments would itself be pilot tested. However, the project's schedule precludes the luxury of pilot testing the instrumentation. Thus, even with careful planning, it's inevitable that a few poor items will be included in each test.

Student Questionnaire

The student questionnaire (Appendix E) was expanded from the one used for Units 1-7. The questionnaire has a series of items on students' reactions to the objectives, content, video, text, and labs; the difficulty of the unit; and students' overall satisfaction with the unit.

Although the expanded student questionnaire no doubt takes more precious time to administer, the staff felt that the additional information could provide better insights into students' reactions to the course.

Teacher Questionnaire/Unit Daily Log

Two distinct kinds of information must be collected from the teachers. First, it's important that they indicate their overall reactions to the unit. Additionally, it's important that they give their detailed reactions to each day of instruction, particularly noting problems or errors in the materials. To meet these dual needs, teachers completed both a teacher questionnaire (Appendix F) and a unit daily log (Appendix G). The teacher questionnaire was revised from those that were used for Units 1-7. The questionnaire has a series of items on teachers' reactions to the objectives, the instructional activities, and the content, and on their instructional planning. Although several items from the first year's instrument remain, several new items were added. The unit daily log is essentially the same as that used for Units 1-7, although it was sent as a separate instrument to

make it easier for teachers to complete on a regular basis; for Units 1-7 it was merely attached to the teacher questionnaire.

Thus, the project is using the same kinds of instrumentation for year two as it did for year one of the pilot test. However, significant revisions of some of the instruments, notably the teacher and student questionnaires, should produce information that better addresses the overall goals of the pilot test.

SAMPLE

The sample included 70 students in seven sites. Student characteristics included:

- Grade[1]

  10 = 0% 11 = 9% 12 = 90% (In year two of the course, it's certainly not surprising that the majority of students are in grade twelve.)

- Sex

  Male = 84% Female = 16%

Teacher characteristics included:

- Physics background[2]

  There was a wide range in the teachers' physics backgrounds; 18% reported no college physics courses; 27% reported one college physics course; 37% reported 2-4 college physics courses; 9% reported 5-7 college physics courses; and 9% reported eight or more college physics courses.

- Mathematics background

  All teachers reported having had two or more college mathematics courses; several (27%) have had five or more college mathematics courses.

- Teaching pattern

  The majority (64%) taught Unit 10 on consecutive days. Most (83%) taught sessions that were 60 minutes or shorter. About a third (36%) indicated that they had combined classes into one session. These numbers are nearly identical to the numbers for Unit 8, a finding that further indicates the stability of the sample.

- Preparation Time

  The average amount of time teachers indicated they spent in preparing each lesson for the unit was 60 minutes, with a range from 30 to 120 minutes.

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1 Due to missing data, the pretst/posttest student demographics don't match the student attitude demographics.

2 To save valuable teacher time, the teacher questionnaire no longer contains items on the teachers' physics/mathematics backgrounds. The data reported below are from the Unit 7 data base; since the sample has stabilized, these data should remain accurate for year two.

Thus, although there were four fewer sites reporting data for Unit 10 than for Units 8 and 9 (11 for 9 and13 for 8), the characteristics of the sample for Unit 10 were nearly identical to the Units 7-9 samples. Overall, then, the sample is the smallest that it has been for any unit of the pilot test, both in students (70) and sites (7). Although this small sample is probably adequate for making overall judgments about the unit, it obviously does not allow these judgments to be made with the degree of confidence that the larger samples for previous units allowed.

PRETEST/POSTTEST RESULTS

Several different analyses of the pretest/posttest have been conducted. The reader should keep in mind that all reported numbers are mean scores on the test, which contained 34 items.

- Mean differences

  The overall pretest mean was 11.47. The overall posttest mean was 24.4. This increase was statistically significant (correlated *t*- test) at the .01 level.

  The level of statistically significant learning gain (.01) is consistent with the gains shown for Units 1-9. Table 1 compares the pretest/posttest scores for Units 1-10.

Thus, the Unit 10 pretest to postest gain (38%) was the largest percentage gain for any unit of the pilot test. Even though the posttest score (72%) was somewhat lower than either Unit 8 or 9 (both at 76%), the Unit 10 findings continue the pattern of better student test performance in year two of the pilot test. Why? It seems reasonable to assume that the smaller year two sample contains a higher caliber of students. Also, both teachers and students may be more comfortable with the materials, having had a full year to become familiar with the course's approach. The materials also may have improved. Indeed, there is probably a combination of factors for the better year two performance. Whatever the reasons, the Unit 10 findings continue the pattern, set by Units 8 and 9, of improved student test performance.

Individual Items

For each unit the project team has established criteria for acceptable performance on each test item. These criteria included either:

1) 70%+ correct on an item, or

2) doubling of the pretest score on the posttest.

For Unit 10, students failed to meet this criteria on the following items: 2, 6, 7, 8, 9, 10, 11, 12, 13, 16, 17, 21, 24, 25, 26, and 34. This finding is both troubling and somewhat baffling because the overall findings were quite positive. The sixteen items that failed to meet the criteria are the most for any of the year two units tested. What could explain students' failing to meet the criteria for so many items? To answer this question we should take a detailed look at the test items, starting with the items by subunit.

By subunit, students failed to meet the criteria for the following items:

Mechanical—two of five items did not meet the critera.
Thermal—four of six items did not meet the criteria.
Electrical—one of five items did not meet the criteria.
Fluid—three of four items did not meet the criteria.
Overview—six of fourteen items did not meet the criteria.

Thus, students performed particularly poorly on the thermal and fluid subunits, which continues a pattern of most of the other units in the pilot test. In addition to the subunits, it's helpful to look at the actual content of the items students missed.

As with all previous units, students failed to meet the criteria of several items that included formulas or mathematical manipulations (items 8, 9, 10, and 34). So mathematics-related items accounted for 25% of the items on whcih students failed to meet the criteria. Many of the items on the test required students to identify the systems involved in an energy conversion process or to identify an example of a specific energy convertor. Students failed to meet the criteria for several of these items (items, 2, 6, 11, 12, 13, 16, 17, 18, and 21). These types of items accounted for over half of the items on which students failed to meet the criteria. It's perhaps not surprising that students had trouble with these items. They require students to know and understand specific apparatus and how the apparatus interacts with various energy systems. Students must remember many details to answer these questions, which probably explains why they failed to meet the criteria for so many of them.

Thus, the analyses of the test results reveal a mixed bag. Even though students failed to meet the criteria on a higher percentage of items than for any of the year two units, the overall results were positive and in keeping with the improved test performance of year two.

Table 1
Principles of Technology
Pretest and Posttest Scores, Units 1-10

Unit	Number of Items	Pretest Mean (% correct)	Posttest Mean (% correct)
1	30	12.5 (41%)	20.1 (67%)
2	33	13.6 (41%)	17.6 (53%)
3	30	14.9 (49%)	19.4 (65%)
4	36	16.4 (46%)	24.4 (68%)
5	35	13.2 (38%)	22.6 (65%)
6	30	11.5 (38%)	18.3 (61%)
7	34	13.2 (39%)	19.9 (59%)
8	25	11.9 (48%)	18.9 (76%)
9	29	12.6 (33%)	22.1 (76%)
10	34	11.4 (34%)	24.4 (72%)

PRETEST/POSTTEST BY SELECTED VARIABLES

For year one, the impact of several variables on students' test performance was examined, including students' grade and sex, teaching pattern, and teachers' physics and mathematics background. However, the smaller year two sample precludes making the comparisons among teacher background and teaching pattern; there are simply too few teachers to make reliable comparisons. So, the only valid comparisons are those comparing the student characteristics of sex and grade. These variables were analyzed with an analysis of covariance, which controlled for pretest scores. Table 2 examines the results of this analysis; the mean scores reported in Table 2 are for the posttest.

Table 2

Main Effect	Level of Significance	Subset	Mean Score
Sex	.010	Male (43)	25.14
		Female (8)	18.62
Grade	.034	Tenth (0)	--
		Eleventh (5)	20.00
		Twelfth (46)	24.96

As Table 2 indicates, both sex and grade had a significant effect on students' test scores. However, each of these findings must be very cautiously interpreted since there were only eight females and five eleventh graders included in the sample. Actually, this is another example of how the small sample makes these kinds of comparisons difficult to make with reliability.

PRETEST/POSTTEST RESULTS BY SITE

Appendix D indicates the pretest/posttest results by site. All seven sites showed statistically significant (.01 level) increases. Table 3 examines the number of sites showing no statistically significant gains for each of the first ten units.

Table 3

Unit	Sites showing no significant gains
1	1
2	4
3	4
4	0
5	1
6	3
7	1
8	1
9	0
10	0

Again, these results must be interpreted cautiously. The reduced number of sites and the assumed differences in the composition of the year two sample make comparisons across units difficult to make. Nonetheless, it is encouraging to note that all sites showed significant gains for Unit 10.

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STUDENT ATTITUDE FINDINGS

As discussed earlier in this report (see the instrumentation section, pages 6-8), the student attitude questionnaire was completely revised for year two of the pilot test. Very little was retained from the questionnaire that was used during year one of the project. The new questionnaire (Appendix E) contains a series of items for each of several categories. The categories include students' reactions to the unit's objectives, content, video, text, and laboratory activities; the difficulty of the unit; and students' satisfaction with the unit. Each category contains a series of statements to which students respond using a four-point Likert-type scale ("strongly agree" to "strongly disagree"). The new questionnaire provides more information about students' attitudes than the five-item questionnaire that was used during year one of the project. Of course, collecting more information requires additional, valuable classroom time, which is the major disadvantage of the new questionnaire.

There are a number of ways to analyze these data. The simplest is to report the frequency of responses to each item. To compare responses across categories, however, it helps to have a numerical total for each category. Since a four-point scale was used (with four being the most positive and one the most negative), we can arrive at a mean score of between one and four for each statement. These mean scores can then be added and divided by the total number of items in the category to arrive at a mean score for each category. Both the frequencies for each item (in percentages) and a mean score for each category are reported below.

<u>Unit Objectives</u>

Generally, students indicated that they found the unit objectives helpful. All (100%) agreed or strongly agreed that the objectives helped them understand what they were supposed to learn and that they are glad the objectives are printed in the written materials. Almost all (93%) agreed or strongly agreed that they used the objectives to guide them through the material. The overall mean score for the category was 3.34. (A perfect four is the most positive score possible.)

Unit Content

Almost all students (90%) disagreed or strongly disagreed that the unit had too much information. Most (76%) agreed or strongly agreed that the unit gave examples that were helpful in understanding the concepts. The majority (69%) disagreed or strongly disagreed that the content of the unit was difficult for them to understand. The majority (89%) agreed or strongly agreed that the content will probably be useful in future jobs. The mean score for the category was 2.78. Overall, then, the majority of the students indicated that the amount and difficulty of the material was appropriate for them. However, a quarter (25%) of the students indicated that the information was difficult for them to understand. Also, almost all (90%) thought there was too much material.

Unit Video

The majority of students (78%) agreed or strongly agreed that the video programs helped them better understand the material. Most (83%) agreed or strongly agreed that the video programs were interesting. Most (89%) agreed or strongly agreed that the programs used easy-to-understand graphics. And most (85%) agreed or strongly agreed that the video programs helped them to achieve the unit objectives. The overall mean score for the video category was 3.01.

Unit Text

Most students (86%) agreed or strongly agreed that the text materials helped them achieve the unit objectives. Most (84%) agreed or strongly agreed that the text will be a useful reference after taking the course. Most (85%) disagreed or strongly disagreed that the text used language that was difficult for them to understand. Most (83%) agreed or strongly agreed that the text had enough examples to help them understand the important concepts. It's troubling to report, however, that only about a third (30%) agreed or strongly agreed the text helped them to understand the unit concepts. The overall mean score for the text category was 2.64.

Laboratory Activities

The majority of students (79%) agreed or strongly agreed that the lab activities helped them achieve the unit objectives. Most (84%) disagreed or strongly disagreed that the lab activities

were difficult. More than half (59%) agreed or strongly agreed that the time periods were not long enough to complete the work. The overall mean score for the category was 2.46. As with the text, it's troubling to note that most of the students found the labs difficult. And, for the first time in the pilot test, fewer than half the students indicated that they liked the labs.

Unit Difficulty

Over half (52%) indicated that some of the things they were expected to learn were just too hard. Even more (67%) agreed or strongly agreed that they had trouble reading the unit text. The overall mean score for the category was 2.39.

Student Satisfaction

Only a third (34%) agreed or strongly agreed that they usually had a sense of satisfaction after leaving class each day. However, fewer (31%) agreed or strongly agreed that they did not like coming to class. And the majority (72%) indicated that they would recommend the class to their friends. The overall mean score for the category was 2.64.

Table 4 compares the mean category scores to those for Units 8 and 9 (comparisons with Units 1-7 are impossible because the questionnaire was not used for those units).

Table 4

Category	Unit 8	Unit 9	Unit 10
Unit objectives	3.03	3.00	3.34
Unit content	2.82	2.78	2.78
Unit video	2.93	3.09	3.01
Unit text	2.83	3.96	2.64
Unit labs	2.83	2.68	2.46
Unit difficulty	2.58	2.92	2.39
Student satisfaction	2.85	2.93	2.64

In Table 4, it's important to remember that scores of 3 and 4 are the preferred responses. The ratings for three categories (text, labs, and overall difficulty) were less positive for Unit 10 than for Units 8 and 9.

Student attitude findings indicate that they found the text, the labs, and therefore the overall unit more difficult. This may explain why students failed to meet the criteria for 16 items on the test. There are multiple interpretations for these findings. They may indicate that the text and labs

are too difficult for the students. On the other hand, it may be reasonable to expect that the last units of a two-year course should be more challenging for students. Nonetheless, the developers should carefully examine the content of the text and labs.

TEACHER RESULTS

Questionnaires were received from seven teachers. As mentioned earlier in this report (see the instrumentation section, pages 6-8), the teacher questionnaire was revised substantially from the questionnaire that was used during year one of the project. Although many of the year one items were maintained, new items similar to those used for the student attitude questionnaire were added. These items focus on the teachers' reactions to the objectives, the instructional activities, and the level of difficulty. The unit daily log, with few modifications from the one that was used during year one of the project, was also part of the teacher instrumentation. The findings reported below reflect both the teacher questionnaire and the unit daily log. Appendices F and G, which list the detailed teacher comments, should be examined carefully. The wealth of data contained in these comments is difficult to encapsulate. Because there were so few teachers responding, the data reported below are in frequencies and not percentages.

Unit Objectives

The teachers unanimously affirmed the worth of the unit objectives. All agreed or strongly agreed that the objectives assisted them in assessing student progress, that the objectives helped them determine what to teach, and that the objectives were presented in a logical order. Almost all teachers also indicated that the objectives reflected what the unit was designed to teach.

Unit Instructional Activities

All teachers indicated that the unit instructional activities were related to the unit objectives and that the activities were presented in the correct sequence. Also, all agreed or strongly agreed that the reading level of the instructional activities was too difficult for most of their students.

Unit Content

All teachers disagreed that the unit content was too detailed. All thought the material was presented at the proper level of difficulty and that the material contained examples that were helpful to students in their understanding of unit concepts. However, one teacher indicated that the unit did not contain enough examples. All these teachers indicated that they thought the

content provided information that will be useful for students in their future employment. As we have already seen (see the Student Attitude section), the students themselves also thought the material contained information that will be useful to them in their future employment.

Teacher Comfort

All teachers indicated that they felt comfortable teaching the material in Unit 10.

Time

All but one teacher indicated that the six-day plan of 50-minute class sessions per subunit is a realistic time allotment for Unit 10. That teacher commented that the mathematics labs required more time.

Student homework assignments

Four teachers indicated that half or fewer than half their students typically completed the homework assignments for the unit. Interestingly, close to the same number (4) indicated that fewer than half their students typically completed their homework assignments for other courses that they teach. It seems that students' completion of homework assignments is probably affected more by the students' motivation than by the nature of the materials.

Teacher's guide

Three of the teachers thought the teacher's guide probably did not provide them with enough information to help them teach the unit. One commented that the guides for Units 1-7 were decidedly better. One also said that the guide should not assume "we have the same core of knowledge."

Appropriateness for students

Generally, teachers tended to indicate that each day of instruction was appropriate for their students.

Problems

To the question, "What, if anything, caused you the most problems in teaching the unit on ENERGY CONVERTORS?" seven teachers responded. The problems reported include:

- Hands-on labs, lack of equipment, etc. (six teachers)
- Preparation time caused by lack of mathematics background (one teacher)

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These findings are consistent with those for Units 1-9. Availability of equipment for the hands-on labs continues to cause teachers the most problems. On the other hand, teachers continue to affirm the appropriateness of most of the material for their students, and all of them thought the material was presented at the proper level of difficulty. Finally, many specific recommendations for changes, including errors in the text, are contained in the teacher's comments. Overall, the teachers tended to be fairly positive about Unit 10.

CONCLUSIONS

It is important to remember that the entire pilot test is part of the overall formative evaluation process. Data are being collected from the consortium review team, consortium representatives, and from teachers and students at the pilot sites. These data are then used as a basis for making revisions in the materials.

Certainly, then, this report contains much useful information.

1) Overall, a statistically significant (.01 level) learning gain took place. Both students' sex and grade had a significant impact on their test scores, but these findings are tempered by the small sample size in some of the conditions.

2) Students failed to meet the project criteria for sixteen items. Students seemed to have problems distinguishing among the various examples of energy convertors. Also, students continue to have problems with mathematics-related items, as they have for all units in the pilot test.

3) Six of seven classes reporting showed statistically significant learning gains.

4) Student attitudes were generally positive, especially about the value of the unit objectives. They were also positive about the unit videos, text, labs, and overall content. However, about a quarter of the students indicated that they had trouble reading the text material and that some of the things they were expected to learn were too hard. Nonetheless, most students also indicated an overall sense of satisfaction with the unit and thought that the content of the unit will probably be useful in future jobs.

5) Teachers affirmed the appropriateness of most of the material for their students. Like their students, teachers also affirmed the value of the instructional objectives. However, two teachers indicated that the teacher's guide probably did not provide enough information to help them teach the unit.

6) Teachers' comments indicated that the most problems were encountered with the hands-on labs. Again, this is consistent with the findings for the first nine units. It should be pointed out that most of the problems reported were with simply getting the equipment. Once teachers have the equipment, most of the labs seem to work satisfactorily.

7) Although the teachers were generally quite positive about the unit, they did recommend several specific changes, which can be found in their attached comments.

The Unit 10 findings were somewhat less positive than those for Units 8 and 9. Even though students had a statistically significant learning gain, they failed to meet the project criteria on sixteen items, which is the most for any of the year two units. It should be pointed out that for many of these items students had to remember a specific energy convertor and how it related to the energy systems. Given this amount of detail it is probably not too surprising that students had trouble with these items.

Overall, both students and teachers continue to see the relevance of the materials to students' future employment. This is perhaps the most encouraging finding of the pilot test.

Due to the ever-decreasing sample, Unit 10 will be the final unit for which a complete report, with both student and teacher data, will be published. The considerable efforts of the teachers and students involved in the pilot test have contributed to a finished project designed to meet the needs of vocational education for years to come.

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

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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

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Appendix B

Content Review Team

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Richmond, Virginia

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Division of Vocational Education
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Stillwater, Oklahoma

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Raleigh, North Carolina

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Teacher
Hinds Junior College
Rankin Center
Pearl, Mississippi

Don Tornsy
Superintendent of Youth Programming
TVOntario
Toronto, Ontario

Jim Wilson
Assistant Superintendent
Francis Tuttle Area VOTech Center
Oklahoma City, Oklahoma

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Appendix C

Student Test

Pre	Post	1-1 1. A mechanical energy convertor changes
9	6	a. mechanical energy to mechanical power.
28	6	b. mechanical energy to a different form of mechanical energy.
30	77	* c. mechanical energy to thermal, electrical or fluid energy.
33	11	d. fluid, electrical or thermal energy to mechanical energy.

1-4
2. In an alternator, mechanical energy of the rotating rotor is converted to electrical energy. An alternator is ________.

Pre	Post	
42	59	* a. a mechanical energy convertor
24	2	b. a fluid energy convertor
22	39	c. an electrical energy convertor
11	--	d. a thermal energy convertor

2-2, 1
3. The wind pushes against the blades of a windmill. The shape of the blades produces a side thrust on the baldes as the wind strikes them. This thrust causes the blades to spin. The sequence of events just described is an example of converting ________.

Pre	Post	
23	89	* a. fluid energy to mechanical energy
35	2	b. fluid energy to electrical energy
21	4	c. fluid energy to another form of fluid energy
14	6	d. mechanical energy to fluid energy

4-5
4. The common unit of thermal energy in the SI system is the ________.

Pre	Post	
27	78	* a. calorie
27	4	b. watt sec
27	15	c. joule
12	4	d. N m

4-5
5. The overall efficiency of an oil-fired boiler rated at 25 hp and using 35 Btu/sec of thermal power is about ________. (One Btu = 778 ft lb; 1 hp = 550 ft lb/sec)

Pre	Post	
14	35	a. 38%
20	41	* b. 50%
48	19	c. 68%
17	6	d. 87%

1-5
6. An inertia welder converts ________ energy to thermal energy.

Pre	Post	
27	44	* a. mechanical
36	30	b. fluid
20	20	c. electrical
17	6	d. heat

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Pre	Post	
		4-2
		7. A bimetallic strip bends because
43	39	a. the two metals are bonded together and expand at the same rate.
27	44	* b. the two metals are bonded together and expand at different rates.
20	17	c. the two metals are not exposed to the same temperature.
		4-2
		8. When 2 calories of heat energy are absorbed by a bimetallic strip it bends 6.35×10^{-3} m with an applied force of 1200 N. The percent efficiency of the strip is about ________. (1 cal = 4.184 joule; 1 N m = 1 joule)
9	10	a. 60%
28	60	b. 70%
30	12	c. 80%
33	19	* d. 91%
		0-6
		9. The efficiency of an energy conversion process can be calculated if both energy-in (E_{in}) and energy-out (E_{out}) are known. The correct formula is:
40	19	a. % Eff = (E_{in} + E_{out}) x 100%
13	4	b. % Eff = (E_{in} x E_{out}) x 100%
28	48	* c. % Eff = (E_{out} + E_{in}) x 100%
		0-6
		10. The efficiency of an energy convertion process can be calculated if both power-in (P_{in}) and power-out (P_{out}) are known. The correct formula is:
34	6	a. % Eff = (P_{out} + E_{in}) x 100%
34	44	* b. % Eff = (P_{out} + P_{in}) x 100%
25	48	c. % Eff = (P_{in} + P_{out}) x 100%
		2-2
		11. A vane type of water pump uses rotating vanes to pull water through the pump and force it out at a higher pressure. The water pump is an example of:
42	54	* a. mechanical to fluid energy convertor.
24	32	b. fluid to mechanical energy convertor
22	15	c. fluid to electrical energy convertor
11	--	d. mechanical to electrical energy convertor
		4-4
		12. Which of the devices identified below is a thermal energy convertor?
27	32	a. electric motor
36	23	* b. heart pacemaker
20	2	c. water pump
17	43	d. inertia welder

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Pre	Post	
		2-3 13. A turbine converts
27	7	a. electrical energy to thermal energy
27	41	* b. fluid energy to electrical energy
27	33	c. fluid energy to mechanical energy
12	19	d. electrical energy to fluid energy

In the folloiwng five statements, match the lettered phrases on the right with the correct description on the left. On your answer sheet, fill in the appropriate response.

Pre	Post		
5	57	0-1 14. The general purpose of energy convertors is to convert (D)	a. mechanical energy to fluid energy
22	59	0-5 15. The purpose of a Thermo-Photo Voltaic (TPV) generator as an energy convertor is to convert (C)	b. electrical energy into mechanical energy c. heat energy into electrical energy
27	46	0-2 16. The purpose of a water pump as an energy convertor is to convert (A)	d. one form of energy into another form
46	46	0-2 17. The purpose of a hydraulic motor as an energy convertor is to convert (F)	e. mechanical energy to electrical energy
28	55	0-4 18. The purpose of an electric motor as an energy convertor is to convert (B)	d. fluid energy into mechanical energy

3-3
19. A solenoid that is 60% efficient requires 60 watt sec of electrical energy to move the solenoid plunger. The output of the solenoid device is ______ mechanical energy.

Pre	Post	
32	26	a. 36 J/sec
27	41	b. 72 J/sec
15	32	* c. 36 N m
12	2	d. 72 N m

3-4
20. Ten kilowatt seconds of electrical energy is the same as ______ joules of electrical energy.

Pre	Post	
20	15	a. 10
39	7	b. 100
37	41	c. 1,000
3	37	* d. 10,000

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3-4
21. A calrod (an electrical heating element) is used in a small steam engine to produce steam. The steam in turn drives a piston that produces rotating mechanical energy. The sequence of energy conversion—from initial input to final output is ________.

Pre	Post	
24	6	a. electrical to mechanical to thermal
22	43	* b. electrical to thermal to fluid to mechanical
31	7	c. thermal to electrical to thermal
20	44	d. thermal to electrical to fluid to mechanical

3-4
22. Which of the devices below converts electrical energy to thermal energy?

Pre	Post	
25	2	a. automobile alternator
39	93	* b. soldering iron
20	4	c. turbine
15	2	d. windmill generator

1-3
23. The revolving blades of a ventilator fan pull air through the fan and push air away on the other side. The fan blades are a ________.

Pre	Post	
32	4	a. mechanical to thermal energy convertor
27	43	b. fluid to mechanical energy convertor
15	9	c. electrical to fluid energy convertor
12	43	* d. mechanical to fluid energy convertor

0-1
24. When fluid energy is converted to electrical energy, mechanical energy is __________invovled.

Pre	Post	
9	28	a. always
28	39	* b. sometimes
30	4	c. never

3-5
25. A 0.5 hp electric motor delivers 373 watts of output mechanical pwoer. The motor is 93.2% efficient. The amount of input of electrical power needed to run the motor is__________.

Pre	Post	
43	33	a. 200 watts
27	15	b. 278 watts
20	52	* c . 400 watts
10	--	d. 578 watts

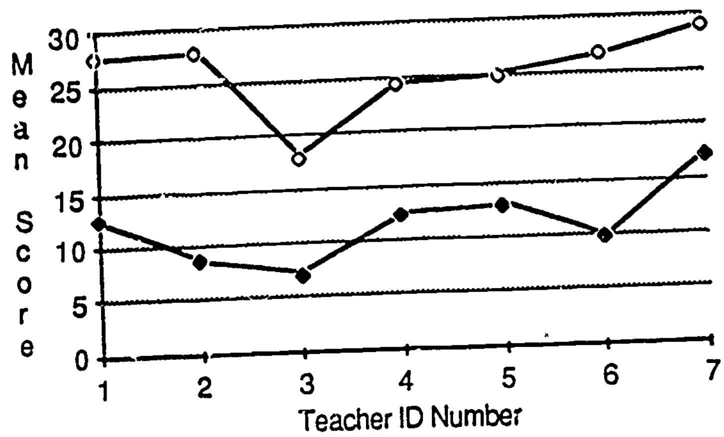
In the following four statements, match the lettered phrases on the right with the correct description on the left. On your answer sheet, fill in the appropriate response.

Pre	Post			
22	32	26. 1 hp (B)	a. 10 joules	d. 1000 J/sec
17	48	27. 1 joule (E)	b. 746 joules	e. watt sec
17	42	28. 1 kw (D)	c. 4.814 joules	f. 778 ft lb
20	43	29. 10 N m (A)		

Pre	Post	
		0-6 30. Efficiency is the measure of ____________.
27	33	a. output of an energy convertor and may exceed 100%
27	13	b. output of an energy convertor and never exceeds 100%
27	4	c. the comparison between input and output of an energy convertor and may exceed 100%
12	50	* d. the comparison between input and output of an energy convertor and never exceeds 100%
		3-1 31. An electrical energy convertor changes
27	9	a. electrical energy to electrical power
36	7	b. electrical energy to a different form of electrical energy
20	48	* c. electrical energy to mechanical, fluid or thermal energy
17	35	d. mechanical fluid or thermal energy to electrical energy
		1-4 32. The percent efficiency of a mechanical-to-electrical energy convertor that has a rotating shaft input of 60 N m of energy and a generator output of 45 J is ________.
20	2	a. 25%
39	9	b. 50%
37	87	* c. 75%
3	2	d. 90%
		0-6 33. The conversion of electrical energy to thermal energy into a heating element is most likely to be
14	6	a. near 10%
20	17	b. near 50%
48	78	* c. near 90%
17	--	d. near 150%
		2-6 34. An MHD generator is provided with 50,000 joules of fluid kinetic energy to move an ionized liquid metal in a magnetic field. The MHD generator produces 20 kilowatt second of electrical energy. The MHD generator is efficient.
24	13	a. 20%
22	43	* b. 40%
31	35	c. 60%
20	9	d. 70%

Appendix D

Pret...t/Posttest Means



Appendix E

Student Attitude Questionnaire

All numbers in %
N = 70
Mean scores in parentheses

Grade (12th = 88; 11th = 12)
Sex (M = 86; F = 14)

PURPOSE
Your honest answers to the questions on this form will help improve this *Principles of Technology* unit for other students. Your responses to the follwoing items are appreciated.

DIRECTIONS
Below are a list of statements. Please read each statement and answer whether you strongly agree, agree, disagree, or strongly disagree by checking the appropriate box. Place a check mark [√] in only one box for each statement.

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT OBJECTIVES (x = 3.34)				
For this unit:				
1. the objectives helped me understand what I was supposed to learn (x=3.87)	12	88	–	–
2. I'm glad the objectives are printed in the written materials (x = 3.14)	14	86	-	–
3. I used the objectives to guide me through the material (x = 3.01)	9	84	7	–
General Comments on Unit Objectives:				
UNIT CONTENT (x = 2.78)				
The content of this unit:				
4. had too much information (x = 3.11)	24	66	9	1
5. gave examples helpful in understanding concepts (x = 2.82)	7	69	22	1
6. was too difficult for me to understand (x = 2.25)	6	25	57	12
7. will probably be useful in future jobs (x = 2.94)	12	72	15	1
General Comments on Unit Content:				

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT VIDEO (x = 3.01)				
The video programs for this unit				
8. helped me to better understand the text material (x = 2.87)	13	65	15	3
9. were interesting (x = 2.91)	13	70	13	4
10. used easy to understand graphics (x = 3.23)	35	54	12	–
11. helped me to achieve the unit objectives (x=3.05)	22	63	13	1
General Comments on Unit Video:				
UNIT TEXT (x = 2.64)				
The unit text materials:				
12. helped me to achieve the unit objectives (x = 3.07)	22	64	14	–
13. will be a useful reference after taking the course (x = 3.01)	18	66	16	–
14. used language difficult for me to understand (x = 2.01)	14	71	13	1
15. had enough examples to help me understand the important concepts (x = 2.91)	12	71	14	3
16. helped me to understand the unit concepts (x = 2.24)	7	23	57	13
General Comments on Unit Text:				
LABORATORY ACTIVITIES (x = 2.46)				
The unit lab activities:				
17. helped me achieve the unit objectives (x=2.87)	12	67	19	3
18. were difficult (x = 2.02)	14	72	12	1
19. time periods were not long enough to complete the work (x = 2.48)	11	48	22	19
20. in general, I liked them (x = 2.50)	19	28	38	15
General Comments on Laboratory Activities:				

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT DIFFICULTY (x = 2.39)				
For this unit:				
21. some of the things we were expected to learn were just too hard (x = 2.93)	19	33	30	19
22. I had trouble reading the unit text materials (x = 2.30)	15	52	19	13
General Comments on Unit Difficulty:				
STUDENT SATISFACTION (x = 2.64)				
For this unit:				
23. I usually had a sense of satisfaction after leaving class each day (x = 2.28)	4	30	56	10
24. I did not like coming to class (x = 2.81)	3	28	55	41
25. I would recommend it to my friends (x = 2.85)	15	57	27	1
General Comments on Student Satisfaction:				

Appendix F

Teacher Questionnaire

N = 7

PURPOSE
The primary purpose of this questionnaire is to provide teacher information for facilatating improvement of the *Principles of Technology* curriculum. Specifically, this form is designed to assess the appropriateness of *Principles of Technology* unit objectives and the appropriateness of instructional activities, resources, curriculum content, and instructional planning needed to accomplish these objectives.

DIRECTIONS
Below are a list of statements. Please read each statement and indicate whether you strongly agree, agree, disagree, or strongly disagree by checking the appropriate box. Place a check mark [√] in only one box for each statement.

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT OBJECTIVES				
The unit objectives:				
1. assist me in assessing student progress	3	3	–	–
2. don't reflect what the unit is designed to teach	–	–	3	3
3. help me determine what to teach	4	2	–	–
4. are presented in logical order	4	2	–	–

General Comments on Objectives:

See attached comments

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT INSTRUCTIONAL ACTIVITIES				
The unit instructional activities:				
5. are related to unit objectives	3	3	–	–
6. are presented in the correct sequence	2	3	1	–
7. require a reading level that is too difficult for most students	–	–	3	3

General Comments on Instructional Activities:

See attached comments

	Strongly Agree	Agree	Disagree	Strongly Disagree
UNIT CONTENT				
The unit content:				
8. was too detailed	--	--	5	1
9. was presented at the proper level of difficulty	1	5	--	--
10. contained examples that were helpful to students in their understanding of unit concepts	1	56	--	--
11. contained enough examples	1	4	1	--
12. provided enough summaries of important points	1	4	1	--
13. provided enough information that will be useful for students in their future employment	2	4	--	--

General Comments on Unit Content

See attached comments

PERCEPTIONS OF INSTRUCTIONAL PLANNING

14. On average, how many hours did you spend preparing to teach each lesson in this unit? (60 minutes)

15. Approximately how much time, on average did you expect students to spend on homework each day?

[ ] None
[1] About 15 mintues
[4] About half an hour
[1] About one hour
[ ] Two hours or more

16. What percentage of students typically completed your homework assignments for this unit?

[1] Fewer than 25%
[3] 26-49%
[2] 50-74%
[ ] 75% and above

17. What percentage of students typically completed your homework assignments for other courses that you teach?

[2] Fewer than 25%
[2] 26-49%
[2] 50-74%
[ ] 75% and above

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18. Do you feel the teacher's guide material provided you with enough information to help you teach the unit?

[2] Definitely [1] Probably [3] Probably not [--] Definitely not

If not, what should be added to the guide to make it more useful?

See attached comments

19. Based on your experiences, do you think the 6-day plan, per subunit, of 50-minute class sessions is realistic for this unit?

[2] Yes, definitely
[3] Yes, probably
[1] No, probably not
[ ] No, definitely not

20. Overall, did you feel comfortable teaching the materials in this unit?

[22] Yes, definitely
[4] Yes, probably
[ ] No, probably not
[ ] No, definitely not

If no, please explain:

See attached comments

21. What, if anything, caused you the most problems in teaching this unit?

See attached comments

22. What did you like the most in teaching this unit?

See attached comments

General Comments on Perceptions of Instructional Planning:

See attached comments

23. Did you teach this unit on consecutive days for 26 days?

[1] Yes [5] No

If no, what pattern did you use (for examples,3 days a week)?

See attached comments

24. How much time per class session did you devote to this unit?

[3] 50 mintues or less
[1] 51-60 minutes
[--] 61-90 minutes
[2] 91+ minutes

25. Did you combine any of the unit's classes into one session (for example, teach classes C1 and C2 in one session)?

[1] Yes [5] No

If yes, which classes did you combine?

See attached comments

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26. Were there any special circumstances which, in your opinion, may have influenced the pre- or posttest scores (e.g., lack of time, faulty lab equipment, school holidays, fire drill)?

See attached comments

General Comments:

See attached comments

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Teacher Questionnaire Comments

General Comments on Objectives

no comments

General Comments on Instructional Activities

1. Well selected. (#30)
2. It appears that the labs are misplaced. (#38)

General Comments on Unit Content

1. Although I recognize that efficiency is the most important feature of an energy convertor, I believe that there were too many efficiency problems in the unit. (#30)

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Question 18 Comments

Do you feel the teacher's guide material provided you with enough information to help you teach the unit? If not, what should be added to the guide to make it more useful?

1. Units 1-7 decidedly better than Unit 10. (#30)
2. Explain how convertors are used in industry besides automobile. (#25)
3. Make it more detailed and do not assume we have the same core of knowledge. (#37)

Question 20 Comments

Overall, did you feel comfortable teaching the materials in this unit? If no, please explain.

1. Lecture, lecture, math lab is an ineffective technique. (#30)

Question 21 Comments

What, if anything, caused you the most problems in teaching this unit?

1. Sargent-Welch Company. (#30)
2. No major problems. (#25)
3. Could not get lab equipment from suppliers. (#78)
4. No equipment. (#38)
5. No lab equipment. (#37)
6. More time was necessary to prepare in some cases. This was primarily because of my limited background in math. (#36)
7. Equipment. (#13)

Question 22 Comments

What did you like most in teaching this unit?

1. CORD/AIT materials continue to be interesting and useful. (#30)
2. Examples were easy to relate to. (#25)
3. The math is very challenging. (#38)
4. The math labs. (#37)
5. I didn't have any specific likes or dislikes. (#63)
6. Material content was exciting to me. (#78)
7. Math referring to physics. (#13)

General Comments on Perceptions of Instructional Planning

1. Good job. (#78)
2. Very good for teaching the concept. (#13)

Question 23 Comments

Did you teach this unit on consecutive days for 26 days? If no, what pattern did you use (for example, 3 days a week)?

1. Daily double periods, alternative weeks. (#30)
2. Took 35 days to complete. (#78)
3. Two days a week. (#13)

Question 25 Comments

Did you combine any of the unit's classes into one session (for example, teach classes C1 and C2 in one session)?

1. C0, C1, C2, M/S. Due to lack of equipment, we tried to alternate lecture-demo days with math lab activities. 84 minutes typically given to math labs. (#30)
2. There was some overlap in general. That is, if C1 was too short we would start C2 before the class period was over. (#36)
3. Labs and C1 and C2. (#13)

Question 26 Comments

Were there any special circumstances which, in your opinion, may have influenced the pre- or posttest scores (e.g., lack of time, faulty lab equipment, school holidays, fire drill in the middle of the exam)?

1. No lab equipment. (#38)
2. Accidental fire drill during posttest. Most students were finished by the evacuation signal. (#30)
3. Two students were absent on day posttest taken. (#78)

General Comments

1. Liked this book. (#25)

2. One student suggested that an index would be helpful; I agree. (#35)

3. Pretest answer sheet had no provision for entering a response of "F." Students were instructed to darken both A and F spaces to indicate an F response. (#20)

4. Same old story, little or no equipment to do the labs. We're cheating the students out of a great deal here. I think the labs are generally good in their concept. We manufacture or purchase locally some of the items, but in many cases this cannot be done. I don't like to teach this way. So far all we've gotten from the supplier is talk and promises but very little action. The equipment is usually late and/or incomplete. I personally think a better job could be done. (#36)

5. Very well presented. (#13)

Appendix G

Unit Daily Log

All numbers in %

N = 6

PURPOSE
The purpose of the Unit Daily Log is to provide a regular source of teacher information for improving the Principles of Technology curriculum.

DIRECTIONS
The left column on the following chart lists each activity for this particular unit. Since there are no materials specifically for the subunit review classes, these classes have not been listed in the chart.

For columns 1-5 on the attached chart:

1. Circle "Y" (yes) or "N" (no): Were the readings, labs, or videos appropriate (e.g., grade level, sufficient quantity of material) for your students? If not, specify modifications in column 5.
2. Circle "Y" (yes) or "N" (no): Were you able to cover the content in the 50-minute time period?
3. Briefly describe any errors or inaccuracies in the material.
4. Briefly describe any problems you had in managing the material. Among others, this may include problems in coordinating lab rotations, lab set-up, and maintaining student interest.
5. Briefly list suggestions for modifying the material. Describe "teaching tips" for future teachers.

We recommend that you take a few minutes each day to complete the charts. If you need more space for comments, use the back of the charts and/or attach additional pages.

Unit	Appropriate for students?	Completed in 50-60 minutes?	Did you discover any errors or inaccuracies? If so, please specify in the appropriate spaces below.	Did you have any management problems? If so, please specify in the appropriate spaces below.	Do you have any suggested modifications or general comments? If so, please specify in the appropriate spaces below.
OVERVIEW					
Video	Y 100 N				
C0	Y 100 N	Y 100 N			
MECHANICAL					
Video	Y 100 N				
C1	Y 100 N	Y 100 N			
C2	Y 100 N	Y 100 N			
Math Lab	Y 100 N	Y 50 N 50			
Lab 10*1	Y 100 N	Y N 100			
Lab 10*2	Y 100 N	Y N 100			

Unit	Appropriate for students?	Completed in 50-60 minutes?	Did you discover any errors or inaccuracies? If so, please specify in the appropriate spaces below.	Did you have any management problems? If so, please specify in the appropriate spaces below.	Do you have any suggested modifications or general comments? If so, please specify in the appropriate spaces below.
FLUID Video	Y 100 N				
C1	Y 100 N	Y 100 N			
C2	Y 100 N	Y 100 N			
Math Lab	Y 100 N	Y 25 N 75			
Lab 10*3	Y 100 N	Y N 100			
Lab 10*4	Y 100 N	Y N 100			
ELECTRICAL Video	Y 100 N				
C1	Y 100 N	Y 100 N			

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Unit	Appropriate for students?	Completed in 50-60 minutes?	Did you discover any errors or inaccuracies? If so, please specify in the appropriate spaces below.	Did you have any management problems? If so, please specify in the appropriate spaces below.	Do you have any suggested modifications or general comments? If so, please specify in the appropriate spaces below.
ELECTRICAL					
C2	Y 100 N	Y 100 N			
Math Lab	Y 100 N	Y 25 N 75			
Lab 10*5	Y 100 N	Y N 100			
Lab 10*6	Y 100 N	Y N 100			
THERMAL					
Video	Y 100 N				
C1	Y 100 N	Y 100 N			
C2	Y 100 N	Y 100 N			
Math Lab	Y 100 N	Y N 100			

Unit	Appropriate for students?	Completed in 50-60 minutes?	Did you discover any errors or inaccuracies? If so, please specify in the appropriate spaces below.	Did you have any management problems? If so, please specify in the appropriate spaces below.	Do you have any suggested modifications or general comments? If so, please specify in the appropriate spaces below.
THERMAL					
Lab 10*7	Y 100 N	Y N 100			
Lab 10*8	Y 100 N	Y N 100			
SUMMARY					
Video	Y 100 N				

Unit Daily Log Comments

Overview—Video

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. For some reason, very high attention rate on this video. (#30)

Do you have any suggested modifications or general comments?

no comments

Overview—C0

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Not having an "f" choice on the pretest sheets is a little inconvenient. (#35)

Did you discover any errors or inaccuracies?

1. The barometric pressure gauge is not a vacuum tank. It would collapse. It must have a neutral pressure inside. (#25)

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Mechanical—C1

Did you discover any errors or inaccu

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Mechanical—C2

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Mechanical—Mathematics Lab

Did you discover any errors or inaccuracies?

1. I'm sorry—I didn't write it down but I think there were typing errors and/or decimal errors. (#37)

Did you have any management problems?

1. Used about 30 or 45 minutes more time. (#38)
2. Without equipment to test labs, there is no motivation to read three math labs. (#30)

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you discover any management problems?

1. No equipment. (#38)

Do you have any suggested modifications or general comments?

no comments

Mechanical—Lab 10*2

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. No equipment. (#30)

Do you have any suggested modifications or general comments?

no comments

Fluid—Video

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Fluid—C1

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. MHD discussion a good place to introduce the technical terms "catalyst" in reference to the organic liquid. (#30)

Fluid—Mathematics Lab

Did you discover any errors or inaccuracies?

1. Check for decimal errors. (#37)

Did you have any management problems?

1. Lack of equipment allowed extra time for math labs. (#30)
2. Used 30+ minutes or more. (#38)

Do you have any suggested modifications or general comments?

no comments

Fluid—Lab 10*3

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. Could not conduct the lab because of equipment shortage. (#78)
2. No equipment. (#38)
3. No equipment. (#30)

Do you have any suggested modifications or general comments?

no comments

Fluid—Lab 10*4

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. Poor lab results because of equipment limitations. (#78)
2. No equipment. (#30)
3. No equipment. (#38)

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Electrical—Mathematics Lab

Did you discover any errors or inaccuracies?

1. Check for typos, etc. (#37)

Did you have any management problems?

1. Used 30+ minutes or more. (#38)

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. No equipment. (#38)
2. Steam engine not big enough. (#78)
3. No equipment. (#30)

Do you have any suggested modifications or general comments?

no comments

Electrical—Lab 10°6

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. No equipment. (#30)
2. No equipment. (#38)
3. Could not do; no equipment. (#78)

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

1. Steam engine segment too long and talky. (#30)

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments

Thermal—Mathematics Lab

Did you discover any errors or inaccuracies?

1. Check for fine tuning. (#37)

Did you have any management problems?

1. Extra time used for math lab. (#30)
2. Used 30+ minutes or more. (#38)

Do you have any suggested modifications or general comments?

no comments

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. No equipment. (#78)
2. No equipment. (#30)
3. No equipment. (#38)

Do you have any suggested modifications or general comments?

no comments

Thermal—Lab 10*8

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

1. No equipment. (#78)
2. No equipment. (#38)
3. No equipment. (#30)

Do you have any suggested modifications or general comments?

1. The lab report, as on page 19 is a worthwhile and necessary activity, especially for second year students. (#35)

Summary—Video

Did you discover any errors or inaccuracies?

no comments

Did you have any management problems?

no comments

Do you have any suggested modifications or general comments?

no comments