DOCUMENT RESUME

ED 131 313 CE 008 966

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TITLE	The Development of Modular Instructional Materials for Physics for One-Year Vocational Students.
INSTITUTION	Forsyth Technical Inst., Winston-Salem, N.C.
SPONS AGENCY	North Carolina State Dept. of Public Instruction, Raleigh. Occupational Research Unit.
REPORT NO	VT-103-298
PUB DATE	30 Jun 76
NOTE	43p.; For related documents, see CE 008 904-907
EDRS PRICE	MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS	Audiovisual Instruction; *Curriculum Development; Curriculum Evaluation; *Individualized Curriculum; *Physics Curriculum; Pilot Projects; Program Descriptions; Program Evaluation; Reading Level; Student Attitudes; Teacher Attitudes; *Vocational Education

ABSTRACT

This report describes a project to develop and test a number of individualized vocational physics modules designed to be laboratory-oriented, written at the lowest reading level, and supplemented with audiovisual materials. The report includes descriptions of the procedures used to develop, pilot test, and disseminate the materials. Each of the five developed modules (on Jacks, Thermometers, The Alternator, The Pool Table, and The Radiator) and the 15 sound/slide programs are described. Tabulated results of the student and instructor evaluation of the materials appear in tables. Evaluation results presented include the following: (1) Interviews with students and instructors and the evaluation data indicated that the materials are a worthwhile departure from traditional physics, (2) high initial student interest supported the contention that the vocational education student prefers an application-oriented approach, and (3) on the negative side, it was found that the materials do not adapt well to traditional classroom techniques and that instructors without appropriate backgrounds have difficulty with some of the modules. Appendixes consist of student prerequisites and objectives for the five modules and the student and instructor evaluation checklists. (NJ)

THE DEVELOPMENT OF MODULAR INSTRUCTIONAL MATERIALS FOR PHYSICS FOR ONE-YEAR VOCATIONAL STUDENTS

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JUNE 30, 1976

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ACKNOWLEDGEMENTS

The author of this report wishes to acknowledge the contribution and extend thanks to the following people:

Harley P. Affeldt, President of Forsyth Technical Institute, Paul Apple, Dean of Instruction, and Grace Corey, Department Head - Related Technical Department for administrative assistance in development of the project materials.

Metta Covington at Richmond Technical Institute, Roy Barrow at Wilson County Technical Institute and Jim Summers at Haywood Technical Institute for their extensive cooperation during the pilot test of the materials.

Latha Nails and Barbara Wise for typing the materials and Harold Harrison and Frank Valdez of the Forsyth Tech Print Shop for printing the materials.

Most of all, Danny Simmons of the Occupational Research Unit for his guidance and assistance in the development and pilot testing of the materials.

I. INTRODUCTION

This project was done because of the need for good instructional materials in physics for vocational students. Existing, commercially available textbooks, workbooks, and laboratory manuals are inadequate for several reasons.

A. The reading ability required to use them is too high for most vocational students.

B. The level of mathematics is too high.

C. Most importantly, they do not deal with the real world as the vocational student sees it. They do not adequately emphasize the relationship between physics and the students vocation.

As a result of the poor instructional materials, a student oftens perceives the course as academic and completely irrelevant to him.

An earlier attempt at individualizing vocational physics at Forsyth Technical Institute failed. The materials developed then allowed for various learning rates and corrected the reading level and mathematical difficulties. It failed because it did not directly associate physics with the student's vocational interests. When the student became a more active learner by using individualized materials, he became more critical of the relevance of the subject matter.

The basic idea behind the ORU project was borrowed from the Physics of Technology Project sponsored by the American Institute of Physics. They developed some modular materials which presented physics as it pertains to certain technological devices. The materials were written for Associate Degree technical students and used some rather esoteric devices.

Using the idea of the device-centered learning module the ORU project began. The objective was to develop and test a number of vocational physics modules with the following characteristics.

1. Individualized modules which present the physics as it is found in some real device, familiar to the vocational student.
2. Written at the lowest possible reading level and including only the absolutely essential mathematics.
3. Laboratory oriented, requiring the student to learn physics by using the device.
4. Supplemented by audio-visual materials developed to accompany the modules.

II. BODY

II. A. Product Development Procedure

The procedure used to develop the materials was as follows.

1. A list of possible module titles was made and the physics that could be taught by each was outlined. A letter was sent to the vocational physics instructor at each school in the Community College system explaining the project and asking for comments and suggestions.
2. The modules to be developed during the project were chosen based on the relevance of the physics to vocational students. The sequence of development was arranged according to lead time necessary to obtain equipment and supplies.
3. A module format was designed and the first module (and subsequent modules) was developed using the following steps:
   a. Equipment and supplies were purchased and all possible vendor-supplied and otherwise available information about equipment was assembled.
   b. The content of the module was outlined and the laboratory exercises were designed.
   c. A rough draft of the module was written and copies sent to each member of a formative advisory committee. The committee members were:

      Dr. C. B. Clark, Head of Physics Department, University of North Carolina at Greensboro

Dr. Ernest Lee, Professor of Education,
University of North Carolina
at Greensboro

Grace B. Corey, Head of Department of Related
Technical Instruction, Forsyth
Technical Institute

George Kahl, Diesel Instructor, Forsyth
Technical Institute

Leroy Foster, Electronics Instructor, Forsyth
Technical Institute

Audrey Kirby, English Instructor, Forsyth
Technical Institute

d. Suggestions made by the formative advisory committee were incorporated into the module and a final copy was written and illustrated. (The use of the formative advisory committee was abandoned after the third module due to the unacceptable time delay involved.)

e. Sound/slide programs were developed to accompany each module and audio-visual catalogs were researched to identify other potentially useful materials. Those identified were previewed and listed in the module if found suitable.

f. The modules were printed in quantity and the audio cassettes were recorded and duplicated and the slides were duplicated and collated.

4. An instructor's manual was written which itemized all the equipment and supplies needed for each module. Drawings were provided for the equipment to be fabricated. Vendor names and addresses were listed for equipment not found in the usual physics laboratory and for all commercial audio-visual materials.

II. B. Description of Product

Five modules were developed. Each module consisted of a list of pre-requisites, the objectives of the module, and the subject content divided into two to five sections. One version of a post-test was written, keyed to the objectives. The pre-requisites and objectives of each module are listed in Appendix I.

Fifteen sound/slide programs were made. Except for the first module, each sound/slide program was keyed to a specific section of a module. The sound cassette included an audible signal for changing slides. Again with the exception of the first module, each sound/slide program included student interactive material in the form of questions to be answered at two or three points in the program.

The five modules and fifteen sound/slide programs are described below.

1. JACKS - A STUDY OF SIMPLE MACHINES

   (47 pages, 5 laboratory exercises, 20 hours)

   Three common types of jacks are used to illustrate simple machines and combinations of simple machines. The most important concepts developed are work, energy, efficiency, mechanical advantage, and stress. The section on load limitations adds reality by discussing types of stresses that develop in materials under load and how the material reacts.

"Simple Machines and the Concept of Work"

51 slides, time 12:05

"Using Jacks"

55 slides, time 14:10

"Load Limitations"

31 slides, time 8:20

2. THERMOMETERS

(39 pages, 8 laboratory exercises, 20 hours)

After distinguishing between temperature and heat, the operation of different types of thermometers is described. The most important concepts developed are temperature, heat, thermal expansion, gas laws, and thermal-electrical interactions. The work with thermocouples and thermistors brings the student up to date on techniques used to measure temperature. This module requires no mathematical calculations.

"Temperature and Heat"

36 slides, time variable

"Expansion Thermometers"

46 slides, time variable

"Electrical Thermometers"

42 slides, time variable

3. THE ALTERNATOR

(69 pages, 13 laboratory exercises, 30 hours)

Without presuming any prior knowledge of electricity, the student is guided through the operation of an automotive alternator. The most important concepts developed are electric charge, current, electric potential, resistance, Ohm's Law, electro-magnetic interactions, series and parallel circuits, energy, power, and efficiency. Skills are developed in the use of voltmeters, ammeters, ohmmeters and the oscilloscope.

"Current Electricity"

55 slides, time variable

"Magnets From Electricity"

37 slides, time variable

"Electricity From Magnets"

38 slides, time variable

"Energy Conversion"

59 slides, time variable

4. THE POOL TABLE

(29 pages, 5 laboratory exercises, 15 hours)

Basic mechanics and interactions between moving bodies is studied using a pool table. The most important concepts developed are speed, velocity, acceleration, force, mass, momentum, and kinetic energy. Stroboscopic photographs taken with a Polaroid camera of balls in motion are used to calculate velocity, acceleration, momentum and energy. The non-destructive collisions allow for confirmation of the conservation laws.

"Velocity and Acceleration"

27 slides, time variable

"Force and Mass"

24 slides, time variable

"Momentum and Energy"

31 slides, time variable

5. THE RADIATOR

(19 pages, 4 laboratory exercises, 10 hours)

A small automotive radiator is used to determine the factors that affect heat transfer. The most important concepts developed are temperature, heat, conduction, radiation, convection, and specific heat. This module requires no mathematical calculations.

"Conduction and Radiation"

42 slides, time variable

"Conduction and Convection"

34 slides, time variable

5. THE RADIATOR

(19 pages, 4 laboratory exercises, 10 hours)

A small automotive radiator is used to determine the factors that affect heat transfer. The most important concepts developed are temperature, heat, conduction, radiation, convection, and specific heat. This module requires no mathematical calculations.

"Conduction and Radiation"

42 slides, time variable

"Conduction and Convection"

34 slides, time variable

II. C. PILOT TEST PROCEDURE

The North Carolina Department of Community Colleges nominated twel[illegible]o participate in the pilot test of the materials. [illegible]osen were evenly divided [illegible]en the western, piedmont an[illegible]n sections of North Carolina [illegible] they were evenly divided between primary urban and primarily rural locations. The presidents of the schools selected were notified by letter on June 18, 1975, and asked to identify a contact person for the pilot test. The contact persons named by the various presidents were contacted by letter on July 7 - 8, 1975. They were sent a description of the project, a list of equipment and materials that they would have to provide, and invited to a workshop.

A workshop was held at Forsyth Technical Institute on August 4, 1975. The purpose of the workshop was to introduce the instructors participating in the pilot test with the materials involved and to distribute the modules, tests, sound/slide programs and Instructor's Manuals. Seven schools sent instructors to the workshop.

The pilot test was scheduled to begin during the fall quarter of 1975. Very little testing was done until the winter quarter, however, due to delays in acquiring equipment and supplies. Since several of the most important pieces of equipment were not traditional physics apparatus, they did not appear on the North Carolina Department of Community Colleges' equipment list. All the items except one were added to the equipment list on December 4, 1975. Visits were made to all but one of the pilot sites during the early phase of the test. The purpose of the visits was to verify the validity of the test with respect to the adequacy of facilities and course management and also to obtain immediate feedback from instructors and students involved. Visits are listed below.

October 9, 1975 - Fayetteville Technical Institute
October [illegible] 1975 - Richmond Technical Institute
October 27, 1975 - Beaufort Technical Institute
October 27, 1975 - Wilson County Technical Institute
November 18, 1975 - Richmond Technical Institute

The visits were made by the project director and ORU personnel and, on the November 18, 1975 trip, accompanied by the director of the North Carolina Department of Community Colleges Curriculum Laboratory.

The instructors participating in the pilot test were given a recommended test procedure but were invited to modify it to suit their own style of teaching. The only required data was a student evaluation and instructor evaluation of each module (see Appendix II) and the completed post-tests.

The scope of the pilot test was limited by several factors. In some cases acquisition of equipment was delayed until the vocational physics classes had been completed for the year. In other cases, the individualized nature of the materials were not compatable with the teaching styles of the instructors involved or the level of technological content of the materials was outside the experience of the instructors. The materials were tested on 20 students at Forsyth Technical Institute but the results are not tabulated in the following section. The classes at Forsyth Technical Institute were conducted by the project director. If this data had been tabulated the bias involved may have reduced the validity of the pilot test results.

II. D. RESULTS OF PILOT TEST

The results of the student evaluation of the materials are tabulated in Tables I through VI. The results of the instructor evaluation are tabulated in Tables VII through XII.

Table I

Summary of Student Evaluation - JACKS

N = 33

	Yes	Mostly Yes	Mostly No	No
1. Did you understand the objectives of the module?	12	5	9	7
2. Do you think the objectives are worthwhile?	9	6	7	11
3. Was the module eas o read?	14	6	6	7
4. Was the reading interesting?	12	4	5	12
5. Were the lab exercises worthwhile?	15	8	3	6
6. Was the lab equipment appropriate?	26	3	0	4
7. Did the equipment work well?	20	5	2	5
8. Were you able to do the calculations involved?		8	5	10
9. Were you able to use modul w hout lot f help from yo eacher		9	9	12
10. id th audio-visual rials hel you to un rstand the concep			3	10
11. Di the test it the ives?			3	5
12. Will the knowledge that you gained from this module help you in your vocation?			5	13

SUMMARY OF COMMENTS

uld be implifie)

owledge f TMA a d AMA is not seful. (1)

uipment id not k r ght. .)

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Table II

Summary of Student Evaluation - THERMOMETERS

N = 45

	Yes	Mostly Yes	Mostly No	No
1. Did you understand the objectives of the module?	26	13	1	4
2. Do you think the objectives are worthwhile?	26	10	3	6
3. Was the module easy to read?	25	14	4	2
Was the reading interesting?	12	15	10	8
5. Were the lab exercises worthwhile?	20	17	2	4
6. Was the lab equipment appropriate?	30	10	2	3
Did the equipment work well?	21	20	1	3
Were [illegible] able to do the calculations invo[illegible]ed?	1[illegible]	18	5	7
Were you able to use this module wi[illegible]out a lot of help from [illegible]our teacher?	[illegible]	14	8	10
Did the audio-visual materials help [illegible]ou to understand the concepts?	[illegible]	18	2	5
Did the test fit the objectives?	[illegible]	15	3	2
Wil[illegible] the knowledge that you gained from this module help you in your vocation?	[illegible]	11	7	13

[illegible]UMMARY [illegible] COMMENTS

Needs more au[illegible] [illegible]isuals. (2)

Not enough wri[illegible] information. [illegible]

Should be simpl[illegible]ed. (1)

Use oral tests. [illegible]1)

Should not be ch[illegible]nged. (1)

[illegible] longer lab [illegible]me. (2)

Table III

Summary of Student Evaluation - THE ALTERNATOR

N = 17

	Yes	Mostly Yes	Mostly No	No
1. Did you understand the objectives of the modules?	10	6	0	1
2. Do you think the objectives are worthwhile?	13	3	0	1
3. Was the module easy to read?	6	10	0	1
4. Was the reading interesting?	7	7	2	1
5. Were the lab exercises worthwhile?	11	5	0	0
6. Was the lab equipment appropriate?	4	6	0	5
7. D[illegible] the equipment work well?	6	5	5	1
8. [illegible]re you able to do the calculations involved?	8	7	0	2
9. Were you able to use this module without a lot of help from your teacher?	5	[illegible]	1	1
10. Did the audio-visual materials help you to understand the concepts?	4	7	0	6
11. Did the test fit the objectives?	7	9	0	
12. Will the knowledge that you gaine[illegible] this module help you in your voca[illegible]	10	6	0	1

SUMMARY OF COMMENTS

Need more time for module. (5)

Table IV

Summary of Student Evaluation - THE POOL TABLE

N = 40

	Yes	Mostly Yes	Mostly No	No
1. Did you understand the objectives of the module?	15	21	3	1
2. Do you think the objectives are worthwhile?	16	17	6	1
3. Was the module easy to read?		18	1	2
4. Was the reading interesting?	10	18	10	2
5. Were the lab exercises worthwhile	19	17	4	0
6 Was the lab equipment appropriate	29	10	1	0
7. Did the equipment work well?	[illegible]	20	1	0
8. Were you able to do the calculations involved?	12	23	4	1
9. Were you able to use this module without lot of help from your teacher?	9	18	10	3
10. Did the audio-visual materials help you to understand the concepts?	22	15	[illegible]	0
11. Did the test fit the objectives?	24	15		0
12. Will the knowledge that you gained from this module help you in your vocation?	10	14	11	5

SUMMARY OF COMMENTS

- Needs more explanation. (4)
- Need m... work on formulas. (2)
- Enjoyable. (4)
- Needs an orientation to module. (1)
- Good A-V materials.)

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Table V.

Summary of Student Evaluation - THE RADIATOR

N = 10

	Yes	Mostly Yes	Mostly No	No
1. Did you understand the objectives of the module?	5	3	[illegible]	[illegible]
2. Do you think the objectives are worthwhile?	5	3	1	1
3. Was the module easy to read?	2	4	1	2
4. Was the reading interesting?	3	1	4	2
5. Were the lab exercises worthwhile?	4	3	[illegible]	0
6. Was the lab equipment appropriate?	6	4	0	0
7. Did the equipment work well?	5	4	0	0
8. Were you able to do the calculations involved?	4	4	1	1
9. Were you able to use this module without a lot of help from your teacher?	0	6	3	1
10. Did the audio-visual materials help you to understand the concepts?	3	6	0	1
11. Did the test fit the objectives?	4	5	1	0
12. Will the knowledge that you gained from this module help you in your vocation?	3	3	2	2

SUMMARY OF COMMENTS

Should be simplified. (1)

Table VI

Summary of Student Evaluations - ALL MODULES

N = 145

	Yes	Mostly Yes	Mostly No	No
1. Did you understand the objectives of the module?	68	-8	14	14
2. Do you think the objectives are worthwhile?	69	39	17	20
3. Was the module easy to read?	66	52	12	14
4. Was the reading interesting?	44	-5	31	26
5. Were the lab exercises worthwhile?	69	1	11	10
6. Was the lab equipment appropriate?	105	3	3	12
7. Did the equipment work well?	71	54	9	9
8. Were you able to do the calculations involved?	47	60	15	21
9. Were you able to use this module without a lot of help from your teacher?	30	56	31	27
10. Did the audio-visual materials help you to understand the concepts?	57	57	8	22
11. Did the test fit the objectives?	75	53	7	8
12. Will the knowledge that you gained from this module help you in your vocation?	46	39	25	34

Table VII

Summary of Instructor Evaluation - JACKS

N = 3

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Average Response
1. The module objectives are adequately stated.	5	4	3	2	1	4
2. The written materials are sufficient for students to meet the objectives.	5	4	3	2	1	2.7
3. The learning activities are appropriate to facilitate learning.	5	4	3	2	1	3.7
4. The audio-visual materials are appropriate to facilitate learning.	5	4	3	2	1	4
5. The test questions are appropriate measures of the objectives.	5	4	3	2	1	3.3
6. The format of the module made it easy to use.	5	4	3	2	1	3
7. The level of reading difficulty and mathematics required are appropriate for the students involved.	5	4	3	2	1	3.7
8. Overall, this module is very good for use in teaching vocational physics.	5	4	3	2	1	3.3

SUMMARY OF COMMENTS

Experiments need improving so as to get consistently good results.

More working examples and problems are needed.

Can be made into excellent module.

Math requirements were too extensive.

Table VIII

Summary of Instructor Evaluation - THERMOMETERS

N = 3

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Average Response
1. The module objectives are adequately stated.	5	4	3	2	1	4
2. The written materials are sufficient for students to meet the objectives.	5	4	3	2	1	2.3
3. The learning activities are appropriate to facilitate learning.	5	4	3	2	1	3.7
4. The audio-visual materials are appropriate to facilitate learning.	5	4	3	2	1	4.3
5. The test questions are appropriate measures of the objectives.	5	4	3	2	1	3.3
6. The format of the module made it easy to use.	5	4	3	2	1	3
7. The level of reading difficulty and mathematics required are appropriate for the students involved.	5	4	3	2	1	4
8. Overall, this module is very good for use in teaching vocational physics.	5	4	3	2	1	3

SUMMARY OF COMMENTS

Module should be divided to two parts.

Needs working examples of converting temperature scales.

Lacks continuity.

Needs some problems for students to work.

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Table IX

Summary of Instructor Evaluation - THE ALTERNATOR

N = 2

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Average Response
1. The module objectives are adequately stated.	5	4	3	2	1	4
2. The written materials are sufficient for students to meet the objectives.	5	4	3	2	1	3
3. The learning activities are appropriate to facilitate learning.	5	4	3	2	1	4
4. The aduio-visual materials are appropriate to facilitate learning.	5	4	3	2	1	4
5. The test questions are appropriate measures of the objectives.	5	4	3	2	1	4.5
6. The format of the module made it easy to use.	5	4	3	2	1	4
7. The level of reading difficulty and mathematics required are appropriate for the students involved.	5	4	3	2	1	4.5
8. Overall, this module is very good for use in teaching vocational physics.	5	4	3	2	1	3.5

SUMMARY OF COMMENTS

Needs more instructions on use of meters.

Add some homework exercises.

Table X

Summary of Instructor Evaluation - THE POOL TABLE

N = 2

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Average Response
1. The module objectives are adequately stated.	5	4	3	2	1	4.5
2. The written materials are sufficient for students to meet the objectives.	5	4	3	2	1	3.5
3. The learning activities are appropriate to facilitate learning.	5	4	3	2	1	4.5
4. The aduio-visual materials are appropriate to facilitate learning.	5	4	3	2	1	4
5. The test questions are appropriate measures of the objectives.	5	4	3	2	1	4
6. The format of the module made it easy to use.	5	4	3	2	1	4
7. The level of reading difficulty and mathematics required are appropriate for the students involved.	5	4	3	2	1	4.5
8. Overall, this module is very good for use in teaching vocational physics.	5	4	3	2	1	4

SUMMARY OF COMMENTS

Excellent module.

Explain some terms more clearly.

Use more examples and practice problems.

Table XI

Summary of Instructor Evaluation - THE RADIATOR

N = 1

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Average Response
1. The module objectives are adequately stated.	5	4	3	2	1	4
2. The written materials are sufficient for students to meet the objectives.	5	4	3	2	1	2
3. The learning activities are appropriate to facilitate learning.	5	4	3	2	1	4
4. The audio-visual materials are appropriate to facilitate learning.	5	4	3	2	1	4
5. The test questions are appropriate measures of the objectives.	5	4	3	2	1	4
6. The format of the module made it easy to use.	5	4	3	2	1	3
7. The level of reading difficulty and mathematics required are appropriate for the students involved.	5	4	3	2	1	4
8. Overall, this module is very good for use in teaching vocational physics.	5	4	3	2	1	2

SUMMARY OF COMMENTS

Needs additional problems.

Needs more illustrations.

Table XI

Summary of Instructor Evaluation - THE RADIATOR

N = 1

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. The module objectives are adequately stated.	5	4	3	2	1
2. The written materials are sufficient for students to meet the objectives.	5	4	3	2	1
3. The learning activities are appropriate to facilitate learning.	5	4	3	2	1
4. The audio-visual materials are appropriate to facilitate learning.	5	4	3	2	1
5. The test questions are appropriate measures of the objectives.	5	4	3	2	1
6. The format of the module made it easy to use.	5	4	3	2	1
7. The level of reading difficulty and mathematics required are appropriate for the students involved.	5	4	3	2	1
8. Overall, this module is very good for use in teaching vocational physics.	5	4	3	2	1

SUMMARY OF COMMENTS

Needs additional problems.

Needs more illustrations.

Table XII

Summary of Instructor Evaluation - ALL MODULES

N = 11

		Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Average Response
1.	The module objectives are adequately stated.	5	4	3	2	1	4.1
2.	The written materials are sufficient for students to meet the objectives.	5	4	3	2	1	2.7
3.	The learning activities are appropriate to facilitate learning.	5	4	3	2	1	3.9
4.	The audio-visual materials are appropriate to facilitate learning.	5	4	3	2	1	4.1
5.	The test questions are appropriate measures of the objectives.	5	4	3	2	1	3.7
6.	The format of the module made it easy to use.	5	4	3	2	1	3.4
7.	The level of reading difficulty and mathematics required are approriate for the students involved.	5	4	3	2	1	4.1
8.	Overall, this module is very good for use in teaching vocational physics.	5	4	3	2	1	3.3

III. SUMMARY

III. A. DISSEMINATION EFFORTS

Since the beginning of the project, efforts have been made to make the objectives of the project known to vocational physics instructors and educational administrators. Part of the efforts were in the form of correspondence to those persons at both the post-secondary and secondary level. The efforts other than private correspondence are listed below.

1. Talk entitled "Physics for the Vocational Student" at the annual Christmas Conference on Recent Advances in Physics, Chapel Hill, N.C., December, 1974. Audience of approximately 50 persons, mostly secondary and college physics teachers.
2. The first three modules were exhibited at the National Science Teachers Association convention in Los Angeles, California in March, 1975.
3. Session entitled "Modular Instructional Materials in Physics for the Vocational Student" at the ORU Conference on April 24 - 25, 1975. Audience of 30 public school and community college administrators.
4. Talk entitled "Modular Materials" at the North Carolina Department of Community Colleges spring conference in May, 1975. Audience of approximately 15 community college instructors.
5. Article entitled "Physics and Metaphysics" in the June, 1975 issue of the Community College Review.
6. Exhibit with description of project in Washington, D.C. at U.S. Office of Education during week of September

21, 1975.

7. Talk entitled "Physics for the Vocational Student" at the North Carolina Science Teachers Association conference in Charlotte, N.C. on November [illegible] 1975. Audience of approximately 15 secondary science teachers.

8. Session entitled "Modular Instructional Mat[illegible]ls [illegible] Physics for the Vocational Student" at the ORI Conference on April 15 - 16, 1976. Audience of [illegible] public school and community college administrators. Approximately 20 sets of the modules were distributed at this conference.

III. B. CONCLUSIONS

Interviews with students and instructors using the materials and the evaluation data summarized in Tables I through XII revealed some faults that should be corrected.

1. Some concepts introduced such as theoretical and actual mechanical advantage are not obviously useful to the student and should be omitted.
2. The reading ability required of the students is too high. The style of writing should be changed to shorter sentences and more reiteration.
3. They are too mathematical. Some unnecessary math needs to be eliminated and more practical problems should be added where the math is essential. It should be noted, that two of the modules, THERMOMETERS and RADIATORS, are complete non-mathematical.
4. Some of the modules cover too much material. They should be divided into two or three shorter modules.
5. There is insufficient feedback to the student. More self-correcting review questions need to be included.
6. The instruction for the laboratory exercises are not well written. Too much instructor assistance was needed.

The pilot test also showed that in spite of its shortcomings, the materials are a worthwhile departure from traditional physics. High initial student interest supported the contention that the vocational student prefers an application oriented approach. The data of Table VI indicate that the unconventional laboratory exercise worked very well. The lack of precise control of all variables did not seriously affect the validity of the experimental results. Student and instructor response to the sound/slide programs was positive.

Two unanticipated problems arose that severely limited the amount of pilot test data collected.

1. The materials do not adapt well to traditional classroom teaching techniques. They are individualized materials and must be used with appropriate facilities and management techniques.
2. The materials are technologically oriented. They are, in many cases, as new to the instructor as they are to the student. Instructors without appropriate backgrounds will have difficulty with some of the modules.

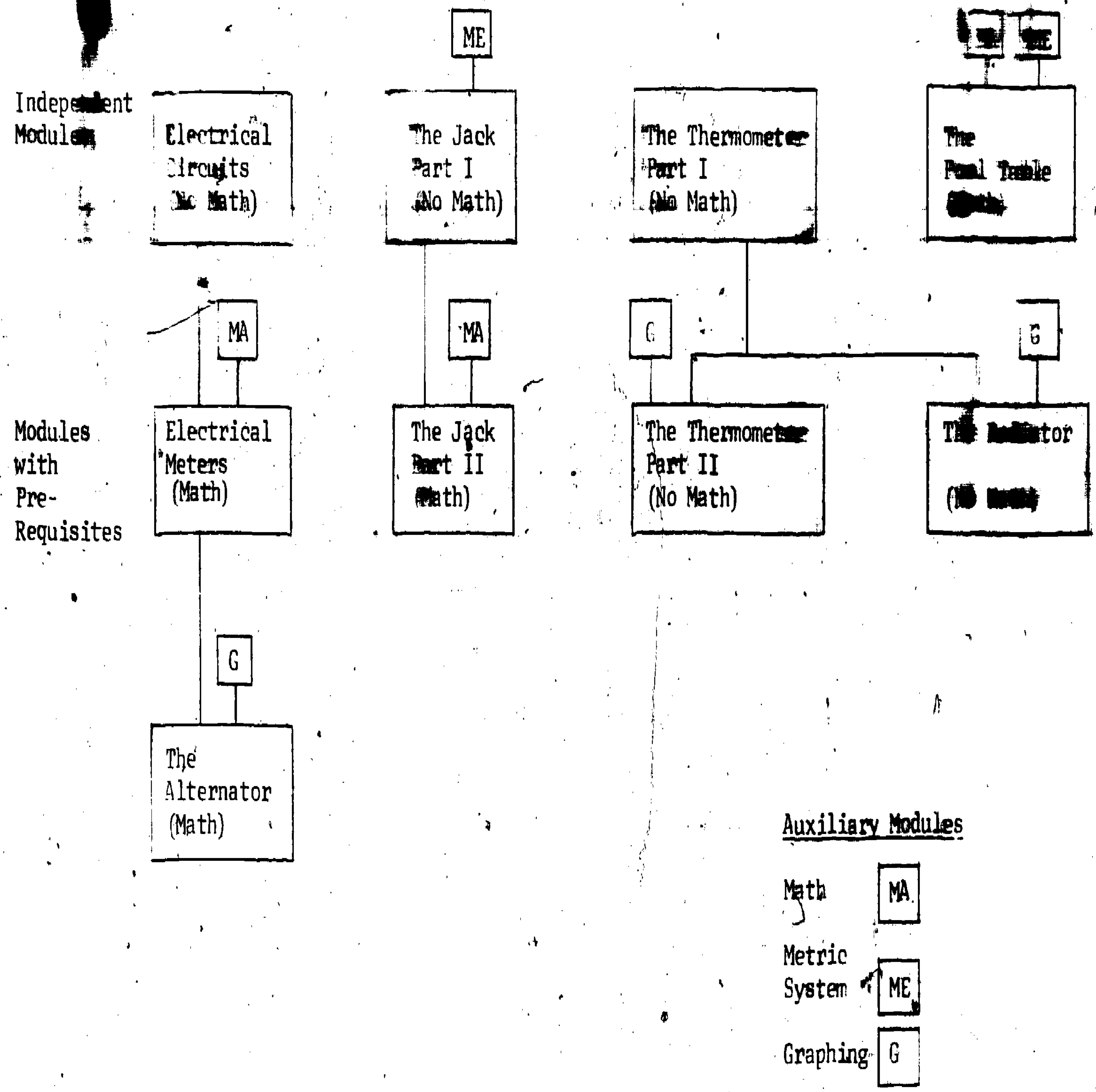
These problems seem to suggest that the pilot test instructors should not have been chosen at random and/or they should have been given more extensive preparation during the workshop.

III. C. RECOMMENDATIONS

In order to correct the faults found with the materials and to further develop the strong points, the following recommendations are made.

1. Shorten the modules to 10-12 student hours each. Longer modules can be rewritten as two or three shorter modules. (See Figure 1
2. Develop short 5 hour auxiliary modules on mathematics, the metric system and graphing. (See Figure 1)
3. Lower the reading level required and eliminate all math not absolutely essential.
4. Simplify the laboratory exercises and include more detailed instructions.
5. Include more self-correcting review questions.
6. Add more audio-visual materials.

Figure 1. PROPOSED LAYOUT OF REVISED MODULES



III. D. TRANSPORTABILITY PROJECTIONS

The Occupational Research Unit grant totalled $26,300. The cost of the project was primarily in salaries for the project director and a secretary and in the reproduction of printed materials and audio-visual materials for the pilot test. The cost of using the materials will be much less than the research cost. The approximate cost of equiping a laboratory to use all the modules is indicated below. The cost of supplies and equipment normally found in a physics laboratory or learning resource center is not included.

MODULE	EQUIPMENT	SOUND/SLIDE PROGRAMS
Jacks	$ 50	$ 34
Thermometers	330	31
Alternators	[illegible]	47
Pool Table	455	23
Radiator	95	20
Total	$1245	$155

The total cost, not including the module printing costs, is $1400 for equipment and sound/slide programs for a class size of students.

The level of instruction and subject matter presented make the modules appropriate for the students in a wide variety of vocational curricula in the Community College System and in the secondary schools.

APPENDICES

APPENDIX I

PRE-REQUISITES AND OBJECTIVES

APPENDIX I. A. JACKS

PRE-REQUISITES

Before beginning this module the student should be able to work the following types of mathematical problems.

1. Given several numbers, calculate the average of their values.

2. Given the diameter of a circle, calculate its area and circumference.

3. Given the diameter and height of a cylinder, calculate its lateral surface area.

4. Make conversions between the following units:

   (a) inches - feet
   (b) ounces - pounds
   (c) grams - kilograms

The student should also be able to read the scale of an English/metric rule and the scale of a spring balance.

OBJECTIVES

After completing this module, the student should be able to recognize the definitions and applications of the following terms. Testing will be by multiple choice questions.

1. Weight
2. Simple Machine
3. Lever
4. Inclined Plane
5. Hydraulic Press
6. Actual Mechanical Advantage
7. Theoretical Mechanical Advantage
8. Work
9. Pressure
10. Energy
11. Friction
12. Efficiency
13. Torque
14. Stress
15. Tensile Stress
16. Compressive Stress
17. Shear Stress
18. Ultimate Strength
19. Elasticity
20. Safety Factor

The student should also be able to solve numerical problems involving the following quantities.

1. Actual Mechanical Advantage
2. Theoretical Mechanical Advantage
3. Work
4. Pressure
5. Efficiency
6. Torque
7. Stress

The system for assigning grades to levels of performance will be determined by the instructor.

APPENDIX I. B. THERMOMETERS

PRE-REQUISITES

The students should be able to read the scales of the following instruments.

1. metric rule
2. mercury-in-glass thermometer
3. Bourdon pressure gauge
4. millivolt meter
5. ohmmeter
6. milliammeter

OBJECTIVES

After completing this module the student will be able to do the following.

A. Use molecular theory to describe the differences between
   1. heat and temperature, and
   2. solids, liquids, and gases.

Testing will be by multiple choice questions.

B. Describe the construction and operation of
   1. a bimetallic thermometer,
   2. a liquid-in-glass thermometer,
   3. a constant volume gas thermometer
   4. a constant pressure gas thermometer
   5. a thermocouple thermometer, and
   6. a thermistor thermometer.

Testing will be by discussion questions.

The system for assigning grades to levels of performance will be determined by the instructor.

APPENDIX I. C. THE ALTERNATOR

PRE-REQUISITES

Before beginning the module, the student should be able to work the following types of mathematical problems.

1. Given two whole numbers, calculate their product.
2. Given two whole numbers, one a dividend and one a divisor, calculate the quotient.
3. Given two decimal fractions, calculate their sum.
4. Given two decimal fractions, calculate their differences.

The student should also be able to read a mercury-in-glass thermometer.

OBJECTIVES

A. After completing the module, the student will be able to recognize the definitions and applications of the following terms. Testing will be by multiple choice questions.

1. electric potential
2. electric current
3. resistance
4. volt
5. ampere
6. ohm
7. voltmeter
8. ammeter
9. ohmmeter
10. magnet
11. generator
12. alternator
13. diode
14. alternating current
15. direct current
16. oscilloscope
17. energy
18. power
19. joule
20. watt
21. series circuit
22. parallel circuit
23. torque
24. efficiency

B. The student will be able to name the factors that

1. determine the resistance of a material,
2. determine the strength of an electromagnet, and
3. determine the size of an induced voltage.

Testing will be fill-in-the-blank questions.

C. The student will also be able to solve numerical problems involving the following quantities.

1. electric current
2. voltage
3. resistance
4. energy
5. power

The system for assigning grades to levels of performance will be determined by the instructor.

APPENDIX I. D. THE POOL TABLE

PRE-REQUISITES

Before beginning this module, the student should be able to work the following types of mathematical problems.

1. Given two decimal numbers, calculate their sum, their difference, and their product.
2. Given a measurement in millimeters, convert it to meters.

The student should also be able to read the scale of a metric rule.

OBJECTIVES

A. After completing this module, the student will be able to recognize the definitions and applications of the following quantities and the factors that determine their magnitude. Testing will be by multiple choice questions.

1. velocity
2. acceleration
3. force
4. mass
5. momentum
6. kinetic energy

B. The student will also be able to explain the results of certain collisions in terms of the concepts of:

1. conservation of momentum, and
2. conservation of energy.

Testing will be by discussion questions.

APPENDIX I. E. THE RADIATOR

PRE-REQUISITES

Before beginning the module the student should be able to read the Celsius scale of a mercury-in-glass thermometer.

OBJECTIVES

A. After completing the module the student will be able to recognize the definitions and applications of the following terms. Testing will be by multiple choice questions.

1. radiator
2. heat exchanger
3. thermal energy (heat)
4. temperature
5. conduction
6. radiation
7. thermal conductivity
8. convection
9. specific heat

B. The student will also be able to name the factors that affect heat transfer by

1. conduction
2. radiation
3. convection

Testing will be by fill-in-the-blank questions.

INSTRUCTOR CHECKLIST FOR INDIVIDUAL MODULES

Instructor's Name ______________________________ Module ____________________

		Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1.	The module objectives are adequately stated.	5	4	3	2	1
2.	The written materials are sufficient for students to meet the objectives.	5	4	3	2	1
3.	The learning activities are appropriate to facilitate learning.	5	4	3	2	1
4.	The audio-visual materials are appropriate to facilitate learning.	5	4	3	2	1
5.	The test questions are appropriate measures of the objectives.	5	4	3	2	1
6.	The format of the module made it easy to use.	5	4	3	2	1
7.	The level of reading difficulty and mathematics required are appropriate for the students involved.	5	4	3	2	1
8.	Overall, this module is very good for use in teaching vocational physics.	5	4	3	2	1

9. My suggestions for improving this module and the audio-visual materials are:

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APPENDIX II. B.

STUDENT CHECKLIST MODULE ________________

Select the response that matches the way you feel the question should be answered. Do not put your name on this paper.

	Yes	Mostly Yes	Mostly No	No
1. Did you understand the objectives of the module?				
2. Do you think the objectives are worthwhile?				
3. Was the module easy to read?				
4. Was the reading interesting?				
5. Were the lab exercises worthwhile?				
6. Was the lab equipment appropriate?				
7. Did the equipment work well?				
8. Were you able to do the calculations involved?				
9. Were you able to use this module without a lot of help from your teacher?				
10. Did the audio-visual materials help you to understand the concepts?				
11. Did the test fit the objectives?				
12. Will the knowledge that you gained from this module help you in your vocation?				

Can you suggest any way in which the module can be changed to make it better? Comment on the reading material, lab exercises, lab equipment, A-V materials, and test. (Use back of sheet if more space is needed.)