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ABSTRACT

This guide is intended for use in teaching a capstone course in technology education at the 12th-grade level. The course is designed to lead students through a formal hands-on study of the research process as it is applied to development operations in an industrial setting. The first two sections discuss the guide's development within the framework of North Carolina's efforts to improve technological literacy and the guide's place as part of an instructional system. The purpose and rationale of the course, its basic structure, and main objectives are explained. Recommended print and film resource materials are listed. The remainder of the guide consists of learning modules on the following topics: exploring the nature of research and development, planning and designing a research project, conducting and interpreting industrial research, translating and communicating research findings, and conducting an individual in-depth research and development project. Each module includes information about the length of time needed to complete the module, an introduction to the instructional content to be covered in class, performance objectives, a day-by-day outline of student learning activities, and lists of suggested textbooks and references. Related charts and sample materials are appended to some of the modules. (MN)

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## ACKNOWLEDGEMENTS

The North Carolina Technology Education Curriculum is the product of a curriculum redirection process begun in the early seventies. As in any change process, many individuals have contributed their time and energies to provide North Carolina students with a curriculum designed to meet their needs to be technologically literate adult citizens. The following are recognized for their vision and leadership in setting the direction for Technology Education in North Carolina schools.

Members of the N.C. Curriculum Study Taskforce who charted the course for technology education in North Carolina schools. Their study report and recommendations provided the direction for a change in the identity of the discipline and a total redirection of the curriculum.

Members of the N.C. Curriculum Committee who validated the Technology Education Curriculum Guide as appropriate study for assisting students in understanding technological systems impacting on their lives. Further, industry representatives of the committee verified the appropriateness of suggested activities reflective of practices in construction, communications, manufacturing, and transportation.

N.C. Technology Education Association who provided a forum for redirection of the discipline. It was the association that led the profession in changing identity to technology education. The association also provided opportunities for professionals to develop competence in the classroom delivery of technology education through the sponsorship of in-service programs.

Individual technology education professionals who gave leadership to other professionals in the curriculum change process. These professional leaders piloted many technology education activities in their classrooms and served as role models for other professionals.

Members of the N.C. Council of Technology Teacher Educators who provided insite and support throughout the curriculum redirection process.

Indiana curriculum developers who provided curriculum materials adopted and adapted for North Carolina Technology Education programs.

## INTRODUCTION

The North Carolina Technology Education Curriculum is a program to meet every citizen's need to be technologically literate. Some basic assumptions underlie the program, and these can be divided into content assumptions, and learner assumptions.

The curriculum was developed using the belief that the appropriate content for the field is technology, and its impact on individuals and society. It was further assumed that the content is best organized around human productive systems that have been used, are now being used, and will, most likely, continue to be used. These universal systems are communication, construction, manufacturing, and transportation. Finally, it was assumed that this content can best be addressed from a systems approach with its inputs, processes, outputs, feedback, and goals/restraints.

The curriculum was further based on the assumption that education should meet the needs of individuals and the human requirements of society. It was assumed that each person living in a technological society should have a basic understanding of and the ability to assimilate the knowledge about technology. People it was assumed, should be able to interact with the technological nature of society and help impact the type of future new technologies can provide. Additionally people should be able to be contributors to a society in their several roles, including citizen, voter, investor, consumer, worker, and leader.

These assumptions caused the curriculum to be developed in such a way as to:

1. Provide an overview of technology first, allow for more indepth study in specific technological areas, and culminate with synthesis activities.

2. Be more teacher-directed, content-centered in early courses, and highly, student-directed, process centered in advanced courses.

3. Involve problem-solving and group activities of all courses.

4. Stress the how and why of technology and its relationship to our quality of life.

5. Be activity-centered learning, with the content being used to determine the appropriateness of each activity selected.

6. Be equally important to young women and young men, both of which must function in a technological society.

Finally, the curriculum was developed to be descriptive rather than prescriptive. The materials describe what to teach and suggest ways of teaching the content. At no time are daily activities prescribed in such a way to preclude individualizing the presentations to meet local conditions.

## THE CURRICULUM GUIDE IN AN INSTRUCTIONAL SYSTEM

Each course in the North Carolina Technology Education Curriculum is seen as a dynamic activity involving a complete instruction system. This system generally includes seven components: the teacher, the students, a texbook when available, the curriculum guide, laboratory sheets, apparatus, and a reference library.

### THE TEACHER

The teacher plays the primary role in the system. This role entails being a curriculum developer. The teacher chooses the points to emphasize and to evaluate. Care should be taken to insure that the coverage of the subject is comprehensive. You should resist "picking and choosing" only modules and activities that are the most interesting, most familiar, or the easiest to implement. All modules and activities should be included. However, you are encouraged to redesign or replace activities with your own activities that contain equivalent content.

As a technical expert, the teacher gives presentations, demonstrations, and asks questions about the subject matter. Safety information, and the demonstration of teaching/learining activities, are the responsibility of the teacher.

The teacher is an instruction manager. Managers plan, schedule, direct, and control activities. The teacher, perhaps in cooperation with students, plan the instruction by identifying the instructional goals. The activities to reach these goals are scheduled. Through presentations and application activities students are directed through the construction activities. Finally, the student's work and the teacher's management is controlled through various forms of evaluation. Since evaluation instruments should be designed to measure success in reaching the goals, these instruments should be prepared by the teacher.

The teacher is the creator of the teaching/learning environment. It is highly recommended that you create a "role playing" environment. In addition to having students do tasks that simulate construction, have them play the role of workers, managers, and owners. For example, refer to a group of students as a "work crew" or "survey party" with job titles, rather than as students who carry out assigned tasks. Help them visualize themselves in their roles. The teacher can become a job superintendent, owner, or government officer, who approves the "work crew's" job.

### THE STUDENT

The target population is made up of middle-junior high or high school students. The students will often work in groups of from three to five. Their responsibilities include reading the textbook assignments, doing the worksheets as homework, and completing the activities.

## THE TEXBOOK

A textbook should be selected for the course and each student should have one. A textbook contains the body of knowledge about industrial technology. It should be selected to meet the appropriate reading level, and be written in an interesting way with numerous illustrations.

## THE CURRICULUM GUIDE

The curriculum guide is to be used to help plan your instruction. The introduction consists of a structure for the content and a description of an instructional system with suggestions on how to use it.

The remainder of the curriculum guide briefly describes the modules. Each module consists of an introduction, objective(s), and a description of the activities. The description of the activities includes a schedule, presentation titles, application activities, and presentation titles, references, and safety guidelines. Suggestions for getting prepared and carrying out the activity are found in the teacher activity sections.

Suggestions for a variety of optional activities may also be found throughout the curriculum guide.

## THE APPARATUS

Often the course guide contains plans for specialized apparatus useful in teaching the course. Drawings will be placed with the activity in which they are used. You can use the drawings to construct the apparatus.

## THE REFERENCE LIBRARY

Some courses require student reference books. The titles of these are included in the reference library and copies should be purchased for laboratory use.

## DAILY LESSON PLANS AND EVALUATION

The planning of daily activities and an on going evaluation system are th teacher's responsibility and rightfully so. Each student should adapt activities and presentations to insure they help students develop the identified concepts within local conditions. The curriculum guide was designed to help you, the local professional, present a relevant, exciting course. Good luck!

## INTRODUCTION

### PURPOSE & RATIONALE

This course in Technology Research and Development is intended as a capstone for studies in Technology Education at the 12th grade level. It is recommended that students enrolling in the course should have above grades in math, science, english, and previous Technology courses. The course is designed to lead students through a formal hands-on study of the research process as it is applied to developmental operations in the industrial setting.

Specific objectives are cited within each module of study. However, it must be said here that this course should be organized and taught with the goal firmly in mind of developing technological literacy, and the skills, knowledge, attitudes, and habits useful in everyday life, and be essential to effective citizenship in today's world.

Industry, as an economic institution, generates, adapts, and applies technology to the production of goods and delivery of services. The continual improvement of this function results in new products and services, improved products and services, and increased availability of products and services to people to meet the needs of individuals and society. The function of industry permeates our entire society and impacts heavily on most societal institutions and the basic needs of people. The nature of a society's industry has considerable influences on the nature and availability of food, clothing, and shelter; it influences not only how we earn a living but how we live - the nature of our way of life.

At the very heart of improving the functioning of industry, is Research and Development, thus the reason for this course.

Teacher Role

The role of the teacher in this program is to guide students to resources, to supervise experimentation, and to provide suggestions for improvements or revisions. Naturally, the teacher will not forsee the answers to many problems which arise, but the solution of these is the whole purpose for research and development. The experience is rewarding to both the students and the teacher.

Course Organization and Teaching Strategies.
The course is comprised of five modules. Each module has a specific role to play in achieving the purpose or goals of the course. The following is a sequential listing of the modules and an explanation of the nature and role of each one.

Module I
Exploring the nature of R & D comprises the content for the first five days of the semester. The activities are strictly TEACHER-CENTERED, intended to quickly orient the student to the elements and terminology of R & D. The instructor will actually carry out a pre-planned research project as a demonstration to the class on how to do research. The teacher involves the students in the decision-making process as he moves from one step to another. Although the teacher knows the result or decision ahead of time, the students are led with logic and interpretation to make the appropriate decision.

Explanations and discussions/interactions with the class will be carried out on each part of the project.

Modules II, III, & IV
Once the students have been led through the preplanned research experience and introduced to the sequence of events, major elements, and basic terminology of R & D, the next phase is to lead them through the process again as teams; the teams making the decisions with the help from the teacher in a TEACHER-CONTROLLED situation. This phase is accomplished in Modules II, III, and IV in a five-week period.

Module V
The final 12-week phase of the course is devoted to individual, indepth R & D projects. This phase is STUDENT-CENTERED, the teacher serving as a guide and resource person. While this phase is intended as an opportunity for individuals to pursue their own interests, design, and carry out their own project, and participate in leadership and reporting activities, teachers may, in some cases, find that a given student's needs may be better satisfied by teaming that student with another student with similar interests.

## OBJECTIVES

This course provides students with knowledge and skills relating to the principles and practices of industrial research and development. Through the methodology and strategies employed, and the industrial and technological problems studied, the students are expected to:

1. Understand the role of R & D in industry and its importance to the industrial enterprise and society at large.

2. Understand and apply basic R & D principles to common industrial problems.

3. Exhibit inventiveness and innovativeness in designing and creating new products and mechanisms.

4. Exhibit confidence in their ability to attack a problem.

5. Apply logical reasoning to common day-to-day problems

6. Exhibit an increase in communication skills.

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FILMS

Berfunkle
Perennial Education, Inc.

Change Training Teachers for Innovations
I/D/E/A.

Developing More and Better Ideas
Industrial Education Film, Inc.

Discovery and Experience
E. Malony Time-Life Films, Inc.

Effective Listening
Industrial Education Films, Inc.

Koestler on Creativity
Time-Life Films, Inc.

Maslow and Self-Actualization
Psychological Films.

Problem-Solvers
Churchhill Films.

Technology and Society Audio-Visual Resources Digest
The National Science Foundation.

The Cosmic Zoom
Contemporary/McGraw-Hill Film.

The Creative Attitude
General Motors.

The Dot and the Line
Films, Inc.

The Teacher and Technology
Ohio State University, Motion Picture Division.

## MAILING ADDRESSES FOR FILMS

BNA COMMUNICATIONS, INC.
194 Decoverly Hall Road
Rockville, MD 20850

CHURCHILL FILMS
662 North Robertson Boulevard
Los Angeles, CA 90028

CONTEMPORARY/MCGRAW-HILL FILMS
Film Rental Libraries
Princeton Road
Hightstown, NJ 08520

CREATIVE EDUCATION FOUNDATION
State University College at Buffalo

FILM, INC.
1144 Wilmette Avenue
Wilmette, IL 60091

FORD FILM LIBRARY
North American Automotive Operation
Ford Motor Company
The American Road
Dearborn, MI 48121

GENERAL MOTORS CORPORATION
Public Relations Staff - Film Library
General Motors Building
Detroit, MI 48202

I/D/E/A
P. O. Box 446
Melbourne, FL 32901

INDUSTRIAL EDUCATION FILMS
P. O. Box 398
Harurch Port, MA 02646

MODERN TALKING PICTURE
1212 Avenue of the Americas
New York, NY 10036

OHIO STATE UNIVERSITY
Motion Picture Division
156 West 19th Avenue
Columbus, OH 4 3210

PERENNIAL EDUCATION, INC.
1825 Willow Road
Northfield, IL 60093

PSYCHOLOGICAL FILMS
Administration Office
205 West 20th Street
Santa Ana, CA 92707

PYRAMID FILMS
Box 1048
Santa Monica, CA 90406

TIME-LIFE FILMS, INC.
Distribution Center, Multi-media
100 Eisenhower Drive
Paramus, NJ 07652

COURSE OUTLINE

| Module Number | Title and Content | Time (Days) |
|---|---|---|
| 1 | Exploring the Nature of Research and Development<br>5 Nature and function of research and development<br>The team concept<br>The research process<br>Reporting research data | |
| 2 | Planning and Designing the Research Project<br>Identifying problems<br>Variables and controls<br>Planning research and development approaches<br>Recording and interpreting data<br>Writing the proposal | 10 |
| 3 | Conducting and Interpreting Industrial Research<br>Research<br>Preparing for the experiment<br>Conducting experiments and recording data<br>Drawing conclusions | 10 |
| 4 | Translating and Communicating Research Findings<br>Findings<br>Format for written and oral reports<br>Tables, charts, and graphs<br>Preparing conclusions and recommendations | 5 |
| 5 | Conducting an Individual Research and Development Project<br>Delimiting the problem<br>Scheduling the project<br>Developing a research procedure<br>Reporting progress<br>Conducting the research<br>Interpreting findings<br>Communication results<br>Exhibiting research findings<br>Research and development in industry<br>Employee ethics and security<br>Patents and copyrights | 50 |

MODULE: 1 : Exploring the Nature of R & D

LENGTH: 5 DAYS Field Integration CLUSTER

The function of this module is threefold:

1. To introduce the student to the basic concepts in R & D.
2. To orient the student to the sequence of activities for the semester.
3. To lead the student through the sequential steps in the research process.

This module is organized as a teacher-centered activity, wherein the teacher leads the students through a predetermined research process on a similar problem which results in each student submitting a research report on the results.

The activities in this module are expected to provide the knowledge base essential for individual participation in subsequent class activities.

Because of the short duration of this module, extreme care in selecting the problem to be researched, is critical. The problem must provide the opportunity to introduce the major research concepts and procedural steps, yet be easily understood by students and lend itself to student-derived solutions. Problems should be selected which have potential for high student interest. It is also vital to the success of this module that the teacher have preplanned and prepared, the step-by-step instructional procedure to be employed with all necessary resources, equipment, and materials for demonstrations and student activities, ready and organized for maximum utilization of time.

## OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Differentiate between research and development in terms of common industrial applications.

2. Explain the interrelationship between research activities and development activities in industry.

3. Characterize basic and applied research in the industrial setting.

4. Explain the concepts variables and controls as factors in industrial research.

5. Characterize and sequence the basic steps to be taken in attempting to solve a given, simple industrial problem.

6. Explain and justify the research design and outcomes for a specific research and development project which he/she has completed.

## CALENDAR

| DAY | ACTIVITY |
|---|---|
| 1 | Complete administrative details required by school officials.<br><br>Orient class to R & D concepts and semesters activities.<br><br>Students will participate in class and team activities. |
| 2 | Monitor team meetings and help students develop research, plan activities, and reports. |
| 3 | Guide research activity and explain reporting procedures as students conduct research and record data. |
| 4 | Guide reporting activities as students and team leaders prepare written and oral reports. |
| 5 | Lead the class in discussion of the weeks activity. Administer a quiz, then orient class to next activity. |

## PRESENTING THE MODULE

| DAY | ACTIVITY |
|---|---|
| 0 | Take roll and other administrative duties. |
| 1 | Discuss nature and function of R & D in industrial setting and illustrate its importance to efficiency and service.<br><br>Explain course structure, activities, and expected outcomes.<br><br>Introduce the predetermined research problem and discuss its role in its related developmental process. See Appendix B.<br><br>Discuss team concept as applied in industry and explain how the class will be divided to serve as research teams; each team researching the same problem. Students will participate in discussion and have questions answered.<br><br>Appoint team leaders and hand out an assignment sheet outlining responsibilities. Provide 5-10 minutes for team meeting.<br><br>Students meet in small groups (teams) to discuss responsibilities and identify specific assignments. |
| 2 | Provide 5 minutes for team meeting and arrange for team leader reports.<br><br>Lead discussion of approaches reported and direct ideas toward predetermined approach.<br><br>Demonstrate/explain approach (research design) and emphasize variables, controls, test procedures, and interpretation principles/ features. |
| 3 | The teacher will guide the teams as they conduct their research activity. Emphasis on recording accurate data must be stressed. |
| 4 | A seminar will be conducted with team leaders reporting on findings, interpretation, and conclusions. From this report and discussion individual team reports will be written. |
| 5 | Lead recap discussion on conclusions, how arrived at, recommendations for change in procedure and implementation of results from team reports.<br><br>Identify and discuss advantages and disadvantages.<br><br>Administer quiz or short test - introduce Modules II, III, & IV.<br><br>Instruct class on selection of next R & D activity. |

## BIBLIOGRAPHY

The suggested textbooks for this course are listed below along with chapters/pages containing information related to this module. For teacher's use only!

DeVore, Technology and Science - A Perspective for Technical Research. Chapter 1 & 2, pp. 1-45.

Emory, C. William, Business Research Methods.(Revised Edition). Richard D. Irwin, Inc., Illinois, Chapter 2, pp. 20-45; Chapter 3, pp. 51-81, 1980.

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**APPENDIX - A**

# S I M P L I F I E D  M E T H O D

STATEMENT OF THE PROBLEM

ANALYSIS AND RESEARCH

POSSIBLE SOLUTIONS

EXPERIMENTATION

FINAL SOLUTION

APPENDIX - B

# DESIGN PROBLEM SOLUTION METHOD

STATEMENT OF THE PROBLEM

LISTING THE DESIGN CRITERIA

RESEARCH AND ANALYSIS

SUGGESTING POSSIBLE SOLUTIONS IN LIGHT OF THE RESEARCH CONDUCTED

SKETCHING POSSIBLE SOLUTIONS TO PROBLEMS

EVALUATION OF POSSIBLE SOLUTIONS IN TERMS OF THE DESIGN CRITERIA

SELECTION OF THE BEST SOLUTION TO THE DESIGN PROBLEM

CONSTRUCTION OF A SCALE MODEL OF THE FINAL SOLUTION

REVISION OF SKETCHES AND MODEL FOLLOWING EVALUATION

PREPARATION OF WORKING DRAWINGS OF THE FINAL SOLUTION

APPENDIX - C

GROUP ASSIGNMENT

Introduction

In this lab, you are to boil water in a test tube, then insert it and a thermometer into insulating materials of your group's choice. You then are to read the thermometer every minute for 20 minutes to discover how well your chosen insulating materials hold the heat.

Every group is to plan TWO SETS of insulating materials and MAKE TWO TESTS.

With Your Group

1. Decide what two sets of materials you want to test.
2. Draw diagrams.
3. Decide who is to bring what materials. (You may bring them from home.)
4. Decide how to divide the work of testing and recording.
5. Be ready to run your tests the next day.

Recording Data

Prepare two data tables such as the one below.

MATERIALS TESTED

| Time (Min.) | Temperature (o C) |
|---|---|
| 1. | |
| 2. | |
| 3. | |
| 4. | |
| 5. | |

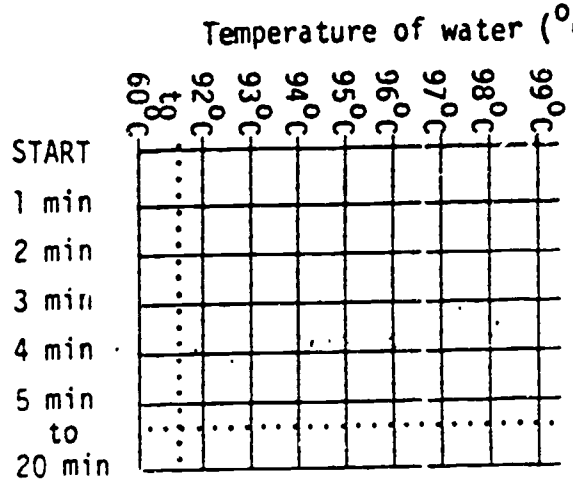
(Continue Chart to 20.)

Procedure

Test your two sets of insulating materials using instructions below:

1. Fill both test tubes with 15 ml. of water.
2. Put the chips, thermometer and cork into each test tube. Make sure you are using split corks and that you can read thermometers from 60o to 95 oC.
3. Light the alcohol burners and hold the test tubes over the flames.
4. Bring the water to a boil.
5. Quickly remove the test tubes from the flames and insert them with the corks and thermometers still in place into your insulating materials and containers.

6. Read and record on your data charts the temperature of the water when you first place the test tubes in the containers.
7. Read and record the temperature of both test tubes every minute for 20 minutes.
8. Clean up the area by removing the test tubes and putting the materials away.
9. On graph paper, make graphs of your two group data charts. See sample below.




As a group, write out the answers to these questions. Present your group answer sheets, your data charts, and your graphs to your teacher when finished.

1. Why did you pick the materials you used?
2. Which of the two sets of materials retained heat the longest?
3. Did your materials beat the control—the test tube without the insulating material?
4. What would be the advantages and disadvantages of using the materials you tested for insulation in a home or school building?
5. Did the amount of insulation material affect how well it worked?

Class Comparison

Compare your data with the data obtained by other groups.

Identify the materials tested which have the highest insulating value.

Discuss this questions: What do insulating materials have to do with conservation?

MODULE: 2 :Planning and Designing the Research Project

LENGTH: DAYS CLUSTER

Research is an integral and vital part of industrial development. The scope of what is called research in industry runs the gamut from simple trial-and-error approaches often employed to solve problems to the highly complex and sophisticated laboratory studies often associated with the chemical and pharmaceutical industries.

The most visible and perhaps most commonly recognized applications of R & D are those relating to the design and production of products, the design and implementation of industrial processes, and the process of materials testing. Two other important applications of research in industry, which should not be ignored, are in the areas of market research and the study of organizational effectiveness.

In any case, research is the keystone to building a body of reliable information from which judgments can be formed to make wise decisions in solving industrial problems. Proper design of the research is the foundation for a successful project. A poor design cannot produce good results.

This module is designed to lead the student through the research design process by involving the student in the step-by-step planning of a project. The activity is teacher-controlled. Emphasis should be given to understanding the necessity and process of delineating the problem to be solved (or dealt with), and the vital role that controls and proper tests play in providing dependable information.

It is important that the student be led to discover the desired design rather than the design being presented in completed form.

## OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Discuss the necessity and importance of delimiting a problem for study.
2. Relate the steps or phases of the process of designing a study and discuss the nature of each.
3. Identify variables and essential constants in a problem and discuss their ramifications in relation to researching the problem.
4. Outline a proposed plan of attack to researching a simple one or two variable problem.
5. Discuss the application of the design process to common, simple Industrial Research and Development problems.

## CALENDAR

| DAY | ACTIVITY |
|---|---|
| 1 | Organize class into research teams and present research problems. The team should discuss potential interest. |
| 2 | Teams should review information from day one, and with assistance from the instructor, identify and delimit the problem. |
| 3 | Assist teams in identifying possible treatments or variables. Reduce experimental factors to no more than two and establish controls. |
| 4 | Aid students in selecting treatments and controls, being sure to stress pros and cons. |
| 5 | Guide class in discussion of obstacles and alternatives as they collect, organize, and identify resources. |
| 6-7 | Lead discussion of proposed structures and contents, nature of data recording. Then have students outline their research proposal and structure the procedure for recording data. |
| 8-10 | Provide assistance to the teams as they develop their proposal. |

| DAY | ACTIVITY |
|---|---|
| 1 | Divide class into research teams. Hand out instructional materials, including a list of prescreened "industrial research problems," from which each team will select one as the team project. See Appendix for ideas.<br><br>The students will read, listen, and consider personal interests in various problems. Look for variables.<br><br>The teacher should discuss scope and nature of each problem, the need to delimit the problem, and guide class in identifying variables and possible controls.<br><br>The students will participate in class discussion of problems citing variables identified. They will also participate in class deliberations of potential treatment and control.<br><br>Remind teams to be ready to select a problem on Day 2. |
| 2 | Guide teams in reviewing information from Day 1. Encourage team discussion of information gathered.<br><br>Guide teams in selecting a problem to research.<br><br>Have students express preference for a project, explain ideas for approach, and cooperate with team to select a team project.<br><br>Review the need to delimit and state problem precisely, and guide teams in doing so.<br><br>Have students discuss and assist in delimiting problem — making it more precise.<br><br>Review significance and process of designing appropriate treatment and controlling selected variables.<br><br>Students should begin identifying ways of "solving" problem — treatments and controls.<br><br>Assign team responsibility to be ready in identifying variables, potential treatments, and controls on Day 3. |

| DAY | ACTIVITY |
|---|---|
| 3 | Guide teams in identifying important variables.<br><br>Guide teams in identifying viable treatments and controls.<br><br>Students will participate in team activities on identifying variables, identifying treatments, and identifying variables to be controlled.<br><br>Remind teams to be ready on Day 4 to discuss pros and cons of proposed treatments and controls, and to select the best ones for their project. |
| 4-5 | Guide class in discussion of pros and cons of each team's ideas.<br><br>Team leader presents the team's ideas from Day 3.<br><br>All participate in class discussion of each team's ideas.<br><br>After discussion, students should participate in selecting the best treatment and control ideas.<br><br>The teacher should guide teams in scheduling treatments and controls, then follow up with discussion of obstacles — (things that can go wrong in carrying out the project), and possible alternatives. |
| 6 | Hand out samples of proposal outlines.<br><br>Explain and illustrate to class the nature, content, structure, and function of each part of a proposal.<br><br>Students should listen, ask questions, take notes on proposal outline, and on how to record data.<br><br>Guide teams in drafting a proposal outline.<br><br>Provide samples and explain importance of organized recording of data.<br><br>Assign each student to bring outline on Day 7. |

| DAY | ACTIVITY |
|---|---|
| 7 | Have students participate in team deliberation on outline and identify necessary resources, then review teams list.<br><br>Students should develop team plans for recording data and have them reviewed by instructor. |
| 8-10 | The teacher should continue to guide the proposal development by the students to its completion. |

## BIBLIOGRAPHY

The suggested textbooks for this course are listed below along with chapters/ pages containing information related to this module. For Teacher's Use Only!

Emory, C. William, Business Research Methods. (Revised Edition). Richard D. Irwin, Inc., Illinois, 1980.
Chapter 3, pp. 51-81, "The Research Process"
Chapter 4, pp. 82-116, "Research Design"

Israel, Everett N., & R. Thomas Wright, Conducting Technical Research, (36th Yearbook, Council on Technology Education), Glencoe Publishing Company, 1987.
Chapter 4, pp. 58-67, Weede, "Conceptualizing the Research Topic"
Chapter 5, pp. 68-87, White, "Selecting a Technical Research Design"

Maley, Donald, Research and Experimentation in Technology Education. International Technology Association, pp. 1-20, 1986.

## APPENDIX

Sample topics taken from "Table of Contents" of Arthur W. Earl's book.

AUTO MECHANICS

Lubricating Quality of Oil
Power of Gasoline
Protection Ability of Anti-Freeze
Wearability of Pneumatic Tires

CERAMICS

Absorption of Casting Slip
Compatibility of Glaze and Clay
Strength Characteristics of Clay
Underglaze Decoration of Ceramic Ware

DRAFTING

Mark-Removing Ability of Pencil Erasers
Reproduction Quality of Translucent Drawing Paper
Surface Quality of Drawing Paper
Wearing Ability of Drafting Pencils

ELECTRICITY

Bimetallic Property of Metal
Electrical Conductivity of Wire
Fuse Load Capacity
Insulative Value of Flexible Nonconductive Material
Power of Flashlight Cells

FASTENERS

Holding Power of Nails
Holding Power of Rivets
Holding Power of Wall Fasteners
Holding Power of Wood Screws

FINISHING MATERIALS

Cutting Ability of Abrasive Papers
Durability of House Paint
Durability of Natural Finishes
Durability of Paste Wax
Permanency of Stain

LEATHER

Natural Leather Finish
Penetration of Leather Dye
Permanency of Leather Enamel
Reaction of Cleaner on Leather

METALWORK

Expansion and Contraction of Metal
Holding Power of Tapped Threads
Strength of Sheet Metal Joints
Tensile Strength of Soft Solder
Tensile Strength of Wire

PHOTOGRAPHY

Exposure of Contact Prints
Exposure of Negatives
Focus in Photography
Motion in Photography

PLASTICS

Bending Ability of Plastic
Holding Power of Plastic Adhesive
Strength of Laminated Plastics
Twisting Characteristics of Plastics

TEXTILES

Permanency of Textile Dye
Strength of Sewing Thread
Textile Fiber Characteristics

WOODWORK

Bending of Wood
Holding Power of Wood Adhesives
Moisture Absorption of Wood
Strength of Wood Joints

MISCELLANEOUS

Durability of Floor Tile
Adhesive Strength of Glue
Thermal Conductivity of Insulating Material

MODULE: 3 : Conducting and Interpreting Industrial Research

LENGTH: 10 DAYS Field Integration CLUSTER

Having just designed the research project, the student (teams) should already know how the problem will be attacked and have an idea as to how the findings might be interpreted, depending on their outcome.

The significance of this module lies in the learnings which result from the student attempting meticulously to follow the plan, implementing controls, exercising care and precision in observing and recording results, and then studying the findings for clues leading to conclusions.

It is important that the class understand the "team" concept of research, and that each student be involved as a team member. The teacher should look for opportunities for students to become role-players on a team.

Utilizing the "panel" approach to reporting findings (Days 8-10) requires every student to report on some aspect of the study. This also creates a chance for class interaction with a given student, but under control of the teacher.

Throughout this 10-day module, the instructor must continually monitor each student's progress in identifying and developing information about his individual research efforts for Module 5. If this is not done, the instructional scheme for the last 12 weeks will be hindered.

## OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Explain the essence of the team's problem and discuss the variables, treatment, and controls involved.

2. Explain the steps taken in attacking the problem undertaken by the team and the need or purpose of each step.

3. Follow a system of observing and recording data.

4. Explain relationships between conditions set forth in the design and the findings in determining interpretations of data.

## CALENDAR

| DAY | ACTIVITY |
|---|---|
| 1-4 | Advise and assist teams as they gather resources and make preparations for experiments. Also, aid them in their choice for the Module 5 activity. |
| 3-6 | Supervise the students as they conduct experiments and record data. They should also begin collecting information regarding Module 5. |
| 6-7 | Provide forms for teams to organize and record "raw" finishings and other data in preparation for the seminar and discussion. They should continue gathering information for Module 5. |
| 8-10 | Assist teams in clarifying and interpreting data, then aid them in developing conclusions and recommendations. |
| | Continue to monitor Module 5 information-gathering and have submitted at close of class. |
| | Guide students as they report and discuss their conclusions and recommendations in the seminar. |

## PRESENTING THE MODULE

| DAY | ACTIVITY |
|---|---|
| 0 | Prior to beginning this module, the instructor should have available to students, as many of the resources as feasible to conduct the preselected projects. Information on securing other resources should be made available to the students. |
| 1 | Explain to the class that for the next two weeks they will be involved in two basic tasks:<br>1. Conducting and interpreting the research on the proposal they just completed<br>2. Selecting and collecting information on a problem they will research independently for a 12-week period.<br><br>Hand out a list of problems suitable for student research. Assign students the task of coming to class on Day 2 ready to identify their problem (one from the list, or one of their own).<br><br>Have teams begin gathering resources and making preparation for their experiments.<br><br>Monitor the team's progress and advise as needed. |
| 2 | Have teams continue preparations for their experiment.<br><br>Counsel and discuss with each student, his progress on the Module 5 problem to assure suitability, and have him begin gathering information.<br><br>Monitor experiment preparations and information-gathering, or assist teams in starting their experiments, as they are ready. |
| 3–4 | Same as Day 2, with students.<br><br>Continue experiments, gathering and recording data, and preparing for the seminar. They will also continue gathering information on Module 5. |
| 5–6 | Monitor experiments, watching for instructional opportunities, such as a team about to use improper procedures or a particularly creative approach.<br><br>As teams complete experiments, have them tentatively read their raw data, on the forms provided, and continue gathering information on their Module 5 problem, until all teams are ready for the reporting seminar.<br><br>All experiments should be completed by end of Day 6. |

| DAY | ACTIVITY |
|---|---|
| 7 | Allow teams 5-10 minutes to complete organization and recording of findings.<br><br>Student team leader should meet with his team to organize for seminar.<br><br>Lead seminar where the team's leader briefly reports the problem, the nature of the experiment, and raw findings.<br><br>Discuss how conclusions must be supported by data.<br><br>Illustrate types of errors common in interpreting data:<br>1. Making inferences beyond scope of data<br>2. Failing to consider all findings in making judgment<br>3. Failing to take into account the limitations of the study.<br><br>Students should participate in class discussion.<br><br>Hand out assignment for Days 8-10 to prepare conclusions and recommendations for reporting in seminar.<br><br>Students should record assignment for Days 8-10. |
| 8-10 | Moderate as members of each team serve as a panel to:<br>1. Present their findings<br>2. Clarify the findings for the class in terms of their meanings and implications<br>3. Present their conclusions and recommendations.<br><br>Students will be participating as panel members and in class discussion of team reports.<br><br>Serve as moderator to stimulate discussion and interaction between panel and class.<br><br>Collect Module 5 information as students submit them. |

## BIBLIOGRAPHY

Israel, Everett N., & R. Thomas Wright, Conducting Technical Research. (36th Yearbook, Council on Technology Education), Glencoe Publishing Company, 1987.
Chapter 8, pp. 122-142, Shackleford, "Conducting the Technical Research Project."
Chapter 9, pp. 143-170, Kovac, "Assessing the Results."

Maley, Donald, Research and Experimentation in Technology Education. International Technology Association, pp. 1-20, 1986.

MODULE: _ : Translating and Communicating Research Findings

LENGTH: DAYS Field Integration CLUSTER

Once the R & D's sequence is completed and the findings are known and analyzed, they must be translated into a form which can be communicated to and understood by, persons who need the information.

In this module the instructor should emphasize ANALYTICAL AND REPORTING SKILLS. For example, when two or more findings (readings, numbers, observations) present conflicting evidence, the discrepancy must be clarified; or, when two or more findings support one another as evidence toward a conclusion, that fact must be made known. The ability to translate such information into logical conclusions and recommendations is "analytical skill." and the ability to transform the analysis into a form or forms which Unable people to understand the real meaning of the findings, is "reporting skill."

The recorded results of research in R & D efforts often end up in the form of numbers (frequencies, size, speed, distance, temperature, etc.), or notations on observable effects (color, shape, structure), or some combination of forms. It is this information that must be translated into charts, tables, drawings, graphs, models, prototypes, and words, to explain the significance of the data. Throughout the module, the instructor must assist students in learning the nature and application of each of these communication forms.

## OBJECTIVES

The overall purpose of this module is twofold:

1. To develop knowledge and skills in the analysis of research data, and
2. To develop knowledge and skills in communicating the results of the analysis to others.

Thus, upon completing this learning module each student should be able to:

1. Discuss the nature of the team's raw data and interrelationships which may exist.

2. Explain how the interpretation of a given list of data from the team project may be affected by the study design or variables.

3. Put interpretations of data into appropriate forms of communication such as tables, charts, diagrams, writing, etc.

## CALENDAR

| DAY | ACTIVITY |
|---|---|
| 1 | Outline reporting procedures and have teams discuss preparation of their reports.<br><br>Return Module 5 information. |
| 2 | Assist teams in deciding on reporting format and needs, then aid them in assigning team members' responsibilities.<br><br>Remind them to upgrade their Module 5 information. |
| 3-4 | Monitor and guide student activity as team members work on assigned responsibilities and assemble reports. |
| 5 | Lead the seminar and discussion as team leaders present their final reports. |

PRESENTING THE MODULE

| DAY | ACTIVITY |
|---|---|
| 0 | Prior to beginning Module 5 the instructor should have prepared a handout on Guidelines for Writing a Research Report which specifies requirements for the written report, sample formats, samples of charts and tables, the major headings to be used, and any other special information and requirements not otherwise available. |
| 1 | Hand out "Guidelines" for writing a research report.<br><br>Explain reporting sequence and writing procedures:<br><br>1. Show sample formats.<br>2. Show how to update material developed for the proposal and put it into present tense for the written report.<br>3. Show how to use table and charts and how to interpret them for the reader.<br><br>Students should make notes on presentation and how it relates to the team project.<br><br>Explain the week's activities and assignments.<br><br>Return Module 5 papers to class with appropriate notations.<br><br>Allow a team 5-10 minutes to discuss possible formats and writing responsibilities to have ready for Day 2. |
| 2 | Ass[illegible]ms discussion and work space.<br><br>Monito[illegible]eam discussions to keep them moving in direction of finding best report in format.<br><br>Assist each team in arriving at closure on format. Students should participate in team discussion and take notes on their own responsibility on the team.<br><br>Check to be sure each member understands and has an outline.<br><br>Guide each team in assigning the writing responsibilities to its members.<br><br>Remind class to upgrade Module 5 information. |

| DAY | ACTIVITY |
|---|---|
| 3-4 | Students will be writing and making charts, drawings, prototypes, models, etc. as assigned on team. The instructor should monitor the teams in completing the writing and assembling of their report. |
| 5 | Introduce team leaders from R & D Department who will present research report.<br><br>Instructor monitors the seminars as team leaders report and helps lead the discussion on reporting techniques. (Emphasize the report, not the findings.)<br><br>Others make notes and participate in discussion on each report. |

## BIBLIOGRAPHY

The suggested textbooks for this course are listed below along with chapters/pages containing information related to this module. For teacher's use only!

Emory, C. William, Business Research Methods. (Revised Edition). Richard D. Irwin, Inc., Illinois, 1980.
Chapter 14, pp. 459-488, "Research Communication.

Israel, Everett N., & R. Thomas Wright, Conducting Technical Research. (36th Yearbook, Council on Technology Education), Glencoe Publishing Co., 1987.
Chapter 10, pp. 171-184, Andrews, "Reporting the Results."

Maley, Donald, Research and Experimentation in Technology Education. International Technology Association, pp. 1-20, 1986.

# FORMAT FOR RESEARCH PAPER

TITLE PAGE

INTRODUCTION

TABLE OF CONTENTS

IDENTIFICATION OF PROBLEM

HYPOTHESIS

ASSUMPTIONS

LIMITATIONS

EXPERIMENTAL PROCEDURE

GRAPHIC ILLUSTRATION OF RESULTS

CONCLUSIONS

RECOMMENDATIONS

BIBLIOGRAPHY

MODULE: 5 : Conducting Individual Indepth R & D Project

LENGTH: DAYS Field Integration CLUSTER

In this student-centered module, the student will select and study indepth an actual industrial problem using the research and development process. The student should be encouraged to use resourcefulness in selecting a problem, however, it will be necessary for the teacher to be prepared to help provide ideas. Also, it may be possible to adopt activities from the four cluster integration courses.

In addition to the facilities and equipment in the Industrial Technology area, the student may find it necessary to use other school or community resources. During this entire module, the student will be communicating with industry for assistance and using the total school faculty as a resource. Most problems selected by the student will require the design and construction of special testing apparatus and/or the construction of a model to be tested. Again, resources outside the department may be necessary.

The role of the teacher in this module is to guide students to resources, to supervise experimentation, and to provide suggestions for improvement or revisions. The teacher is in the role of facilitator. The student may select a problem that is beyond the technical background of the teacher. This is a good situation as it may actually refine the role of the teacher in the program.

Through weekly student-conducted seminars, the students will communicate their progress to date and will seek ideas and assistance from other students. The seminars will also be used for the study of the total role of R & D in industry and the discussion-related information.

The module will conclude with a student exhibit to include guests representing local industry. This culminating activity may also require the student to make a formal presentation.

## OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Discuss common industrial problems requiring research and typical applications of research in industry.

2. Delineate the major elements of an industrial problem and design an appropriate research project.

3. Select and obtain the necessary information and resources to complete an R & D project.

4. Actively participate and contribute in a seminar setting.

5. Select, design, or construct the needed equipment and models to conduct the laboratory research.

6. Follow, establish, research, design, and conduct research for an R & D project.

7. Interpret research data and make judgments concerning appropriate solution(s) to an industrial problem.

8. Communicate interpretations and recommendations from the research findings through such methods as:
   1. technical reports
   2. models
   3. charts, tables, and specifications
   4. drawings
   5. prototypes.

9. Discuss the role and structure of R & D in industry.

## CALENDAR

| DAY | ACTIVITY |
|---|---|
| 1-4 | Guide and assist students as they study their problems and identify available sources of information. Help them establish limits of their research. |
| 5 | Lead the students as they participate in the seminar activity. |
| 6-8 | Guide students as they set final project parameters and finish their information-gathering process. |
| | Lead students in discussion of Employee Ethics. |
| 9 | Monitor the conduct and participation of the student seminar. |
| 10-13 | Guide students work in organizing, assisting, and planning their research activity. |
| | Lead discussion with students on Security. |
| 14 | Monitor the conduct and participation of the student seminar. |
| 15-17 | Assist students as they plan the research activity and identify needed equipment, materials, models, etc. |
| 18 | Monitor the conduct and participation of the student seminar. |
| 19-22 | Guide and assist students as they determine their test designs, controls, and experimental factors. |
| | Help students plan and build needed testing equipment or models. |
| | Lead discussion on role of R & D. |
| 23 | Monitor the conduct and participation of the student seminar. |
| 24-26 | Continue to supervise and assist students as they accumulate and/or build needed test equipment or models. |
| 27 | Monitor the conduct and participation of the student seminar. |

| DAY | ACTIVITY |
|---|---|
| 28-29 | Same as Days 24-26.<br><br>Lead discussion on organization of R & D within a company. |
| 30 | Monitor the conduct and participation of the student seminar. |
| 31-33 | Guide and supervise students as they conduct experiments and record data. |
| 34 | Monitor the conduct and participation of the student seminar. |
| 35-37 | Same as Days 31-33.<br><br>Lead discussion on role of engineering and its relationship to R & D. |
| 38-40 | Guide and assist students as they analyze data, draw conclusions, and revalidate data as necessary. Identify the best solution to the problem. |
| 41 | Monitor the conduct and participation of the student seminar. |
| 42-43 | Supervise students as they prepare their final report. |
| 44 | Monitor the conduct and participation of the student seminar. |
| 45-47 | Same as Day 42-43. |
| 48 | Monitor the conduct and participation of the student seminar. |
| 49 | Assist students with their report to the community. |
| 50 | Supervise students as they wrap up and clean up. |

## PRESENTING THE MODULE

| DAY | ACTIVITY |
|---|---|
| 0 | Before the introduction of this module the following will have been completed,<br><br>By the Instructor:<br>1. Assisted the students in the selection of their R & D projects<br>2. Assisted and directed the students in collecting preliminary information for conducting their research activity<br>3. Arranged for any speakers, field trips, and/or AV material needed during this module<br>4. Set up outline and schedule for seminars to be conducted during this module.<br><br>By the Student:<br>1. Selected the project<br>2. Started gathering preliminary information for conducting research. |
| 1–4 | The assigned written work for the week includes an outline of the project and its limits; why or how the project relates to an actual industrial problem; and an outline of data collected or requested (or assist with research).<br><br>Assist, motivate, and challenge the students in finalizing their research project, and guide the progress of the project.<br><br>To be turned in on Day 5 by the students:<br>1. An outline of the project and its limits<br>2. Determine why or how the results of this project relate to an actual industrial problem<br>3. An outline of data collected or requested that will contribute to the research.<br><br>Plan work to be done during Days 6-8. |
| 5 | Lead the seminar activity and set the format for all regular seminars that follow:<br>1. Seminar leaders<br>2. Topics to be discussed at each seminar and by whom<br>3. Responsibilities of each seminar participant.<br><br>Collect the week's assignment, and record evaluation of students' progress. |
| 5 | The students will participate in seminar, receive seminar responsibilities for this module, and submit assignments for the week. |

| DAY | ACTIVITY |
|---|---|
| 6-8 | Instructor will lead discussion with students on Employee Ethics.<br><br>Have students prepare in writing the final project parameters and list the information collected for conducting research.<br><br>Supervise students collection of data and encourage them to be creative in approach to R & D project.<br><br>Remind students of assignments that are due on Day 9 and help them get prepared for seminar responsibilities.<br><br>Plan with teacher the work to be done during Days 10-13. |
| 9 | Monitor seminar activities to be conducted by students.<br><br>Evaluate student presentations.<br><br>Have students submit assignments for week and report to group.<br><br>Record student progress. |
| 10-13 | Emphasize creativity and lead discussion on Security of information, design, and product.<br><br>Guide student planning of research activity.<br><br>Students prepare in writing the plan for the research activity and an outline of available information.<br><br>Guide student work on organization of collected information.<br><br>Remind students of assignments (research activity plan), and help them prepare for seminar responsibilities.<br><br>The students should plan with the teacher the work to be done during Days 15-17. |
| 14 | See Day 9. |
| 15-17 | Emphasize creativity and guide students in planning research activity, including needed equipment, materials, models, etc.<br><br>Have students prepare in writing the outlines of the research activities including needed equipment, materials, models, etc. Also, remind students of assignments and seminar responsibilities. Students should plan with the teacher the work to be done during Days 19-22. |

| DAY | ACTIVITY |
|---|---|
| 18 | See Day 9. |
| 19-22 | Build student self-esteem.<br><br>Lead discussion on role of R & D, the importance of R & D, and how research and development function together.<br><br>Help students identify the types of equipment and resources that are available and how they might build or obtain the rest.<br><br>Suggest alternative test procedures as needed.<br><br>Have students prepare in writing the final test design with the control and experimental factors identified. Also, include the plan for obtaining necessary equipment.<br><br>Remind students of assignments that are due on Day 23 (outline of test including control and experimental factors, and the drawing and explanation of the experiment).<br><br>Have students do final planning for research experiment including set-up and accumulation of equipment. Also, prepare for seminar activity.<br><br>Plan with the teacher the work to be done during Days 24-26. |
| 23 | See Day 9. |
| 24-26 | Build student self-esteem.<br><br>Guide students construction and set-up of experiments.<br><br>Have students prepare in writing a status report on set-up for research experiments - progress to date.<br><br>Remind students of the assignment due on Day 27 (report of progress to date).<br><br>Help students plan work to be done during Days 28-29 and prepare for seminar activity. |
| 27 | See Day 9. |

| DAY | ACTIVITY |
|---|---|
| 28-29 | Build student self-confidence.<br><br>Lead discussion on organization of R & D within the company such as research teams, and the relationship of R & D with other departments.<br><br>Have students finalize work of Days 24-26 then prepare in writing a final report on set-up for research equipment.<br><br>Plan with the teacher the work to be done during Days 31-33.<br><br>Prepare for seminar. |
| 30 | See Day 9. |
| 31-33 | Develop students attitudes toward the importance of the experiment as students start conducting tests. Guide and supervise student experimentation and data collection.<br><br>Have students prepare in writing, the test data collected from research experiment.<br><br>Remind students of the assignment due on Day 34 (data gathered to date and information obtained from experiment).<br><br>Have students plan the finalization of experiment to be done on Days 35-37.<br><br>Prepare for seminar activity. |
| 3 | See Day 9. |
| 35-37 | Lead discussion on role of engineering and its relationship with R & D.<br><br>Same as Day 31-33.<br><br>Students complete experimental activity and finalize in writing the data collected and information gained from experiment.<br><br>Plan with the teacher the work to be done during Days 38-40. |

| DAY | ACTIVITY |
|---|---|
| 38-40 | Build the students' communication skills.<br><br>Guide students in the analysis of data, draw conclusions, and suggest the revalidation of any data that might include errors.<br><br>Guide students' selection of best solution to industrial problem.<br><br>Remind students of the assignments due on Day 41 (report of final data and planned solution of industrial problem).<br><br>Help students plan the writing of final report to be done during Days 42-43. Have themm prepare in writing the preliminary research report; prepare for seminar activity. |
| 41 | See Day 9. |
| 42-43 | Build students' communication skills.<br><br>Lead discussion on protecting information, patents, trade secrets, copyrights.<br><br>Guide students in the preparation of their final reports and displays for seminar.<br><br>Plan students' day for reporting to the community. (This activity is to be set up as an exhibit where the students will be prepared to talk with interested individuals. Also, the students may make a formal presentation.)<br><br>Remind students of the assignment due on Day 44 (preliminary research report). |
| 44 | See Day 9. |
| 45-47 | Same as Days 42-43.<br><br>Students should finalize the final report to be turned in on Day 48. |
| 48 | See Day 9.<br><br>Collect final report. |
| 49 | Help coordinate students exhibits and reports to the community.<br><br>Evaluate student reports. |
| 50 | Wrap up and assist with clean-up. |

## BIBLIOGRAPHY

The suggested textbooks for this course are listed below along with chapters/pages containing information related to this module. For teacher's use only!

Emory, C. William, Business Research Methods (Revised Edition). Richard D. Irwin, Inc., Illinois, 1980.

Israel, Everett N., & R. Thomas Wright, Conducting Technical Research. (36th Yearbook, Council on Technology Education), Glencoe Publishing Company, 1987.

Maley, Donald, Research and Experimentation in Technology Education. International Technology Association, pp. 1-20, 1986.

Use other specific resources as needed from Module 1 Resource and Library List.