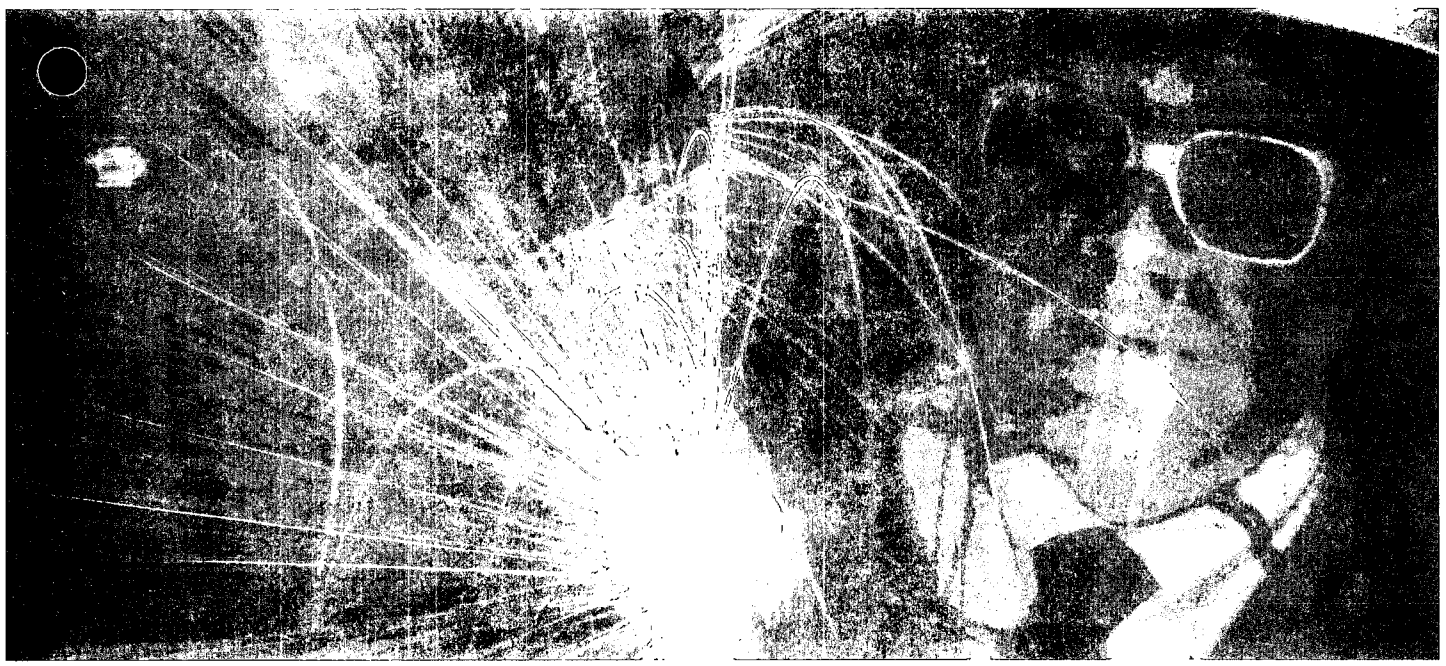
TECHNOLOGY EDUCATION
MATERIALS PROCESSING

GRADES 9-12
FOUNDATION COURSE



NEW YORK
THE STATE OF LEARNING

The University of the State of New York
The State Education Department
Bureau of Home Economics
and Technology Education Programs
Division of Occupational Education
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MATERIALS PROCESSING

OVERVIEW OF THE MODULE

Goal:

The student will understand the significance of materials used by humankind. How materials are changed and processed will be discussed and demonstrated. Laboratory activities will be provided to reinforce the concepts of materials processing.

Description:

This materials processing module is designed to offer a generic and broad view of the way humans change materials. The module differs from a traditional "unit" shop approach in a specific material as various materials use similar processing techniques. For example, separating (cutting) is a generic concept. Ceramic, polymer, wood, metal, and composite materials are all separated, often by similar techniques, such as sawing.

This module focuses on materials -- one of the seven resource inputs in the systems model. Reference to the systems model will be made within the context of this content area.

USE IN SEQUENCE: Foundation course

This course is one of the New York State approved Foundation courses in Technology Education. It is one of seven courses designed to give students a firm but broad exploration of the technical world in which they live. Students completing a sequence in Technology Education must have successfully completed any two of these seven Foundation courses.

This course may also be taken by any student as an elective. If the instructor uses this syllabus as a guide for instruction, students may be granted Regents credit for the experience.

Several courses within Technology Education offerings can be offered on a 1/2-unit or 1-unit basis. Course work earning 1/2-unit must comprise a minimum of 54 hours of instruction and course work earning 1-unit must comprise a minimum of 108 hours of instructional time.

Students with Disabilities

The Board of Regents, through the part 100 Regulations of the Commissioner, the Action Plan, and The Compact for Learning, has made a strong commitment to integrating the education of students with disabilities into the total school program. According to Section 100.2(s) of the Regulations of the Commissioner of Education, "Each student with a handicapping condition as such term is defined in Section 200.1(ii) of this Chapter, shall have access to the full range of programs and services set forth in this Part to the extent that such programs and services are appropriate to such student's special educational needs." Districts must have policies and procedures in place to make sure that students with disabilities have equal opportunities to access diploma credits, courses, and requirements.

The majority of students with disabilities have the intellectual potential to master the curricula content requirements for a high school diploma. Most students who require special education attend regular education classes in conjunction with specialized instruction and/or related services. These students must attain the same academic standards as their non-disabled peers to meet graduation requirements, and, therefore, must receive instruction in the same content areas, at all grade levels. This will ensure that they have the same informational base necessary to pass statewide testing programs and meet diploma requirements.

Teachers certified in the subject area should become aware of the needs of students with disabilities who are participating in their classes. Instructional techniques and materials must be modified to the extent appropriate to provide students with disabilities the opportunity to meet diploma requirements. Information or assistance is available through special education teachers, administrators, the Committee on Special Education (CSE) or student's Individualized Education Program (IEP).

Strategies for Modifying Instructional Techniques and Materials

1. Students with disabilities may use alternative testing techniques. The needed testing modification must be identified in the student's Individualized Education Program (IEP). Both special and regular education teachers need to work in close cooperation so that the testing modifications can be used consistently throughout the student's program.

2. Identify, define and pre-teach key vocabulary. Many terms in this syllabus are specific and some students with disabilities will need continuous reinforcement to learn them. It would be helpful to provide a list of these key words to the special education teacher in order to provide additional reinforcement in the special educational setting.

3. Assign a partner for the duration of a unit to a student as an additional resource to facilitate clarification of daily assignments, timelines for assignments, and access to daily class notes.

4. When assigning long-term projects or reports, provide a timeline with benchmarks as indicators for completion of major sections. Students who have difficulty with organizational skills and time sequence may need to see completion of sections to maintain the organization of a lengthy project or report.

Infusing Awareness of Persons with Disabilities Through Curriculum

In keeping with the concept of integration, the following subgoal of the Action plan was established.

<u>In all subject areas, revisions in the syllabi will include materials and activities related to</u> generic subgoals such as problem solving, reasoning skills, speaking, capacity to search for information, the use of libraries and increasing student awareness of and <u>information about the disabled.</u>

The purpose of this subgoal is to ensure that appropriate activities and materials are available to increase student awareness of disabilities.

This curriculum, by design, includes information, activities, and materials regarding persons with disabilities. Teachers are encouraged to include other examples as may be appropriate to their classroom or the situation at hand.

STUDENT LEADERSHIP SKILLS

Development of leadership skills is an integral Part of occupational education in New York State. The New York State Education Department states that, "Each education agency should provide to every student the opportunity to participate in student leadership development activities. All occupational education students should be provided the opportunity to participate in the educational activities of the student organization(s) which most directly relate(s) to their chosen educational program."

Leadership skills should be incorporated in the New York State occupational education curricula to assist students to become better citizens with positive qualities and attitudes. Each individual should develop skills in communications, decision making/problem solving, human relations, management, and motivational techniques.

Leadership skills may be incorporated into the curricula as competencies (Performance Objectives) to be developed by every student or included within the Suggested Instructional Strategies. Teachers providing instruction through occupational educational curricula should familiarize themselves with the competencies. Assistance may be requested from the State advisor of the occupational student organization related to the program area.

Students who elect to become active members of one of the student leadership organizations chartered by the New York State Education Department have the advantage of the practical forum to practice leadership skills in an action oriented format and have the potential for recognition of their achievements at the local, State, and national level.

Skills, knowledges, behaviors to be developed:

The student will develop the ability to:

1. Identify the universal systems model as it relates to material processing technologies.
2. Differentiate the methods used by humans to procure raw materials from the earth to be later made into production materials.
3. Analyze the various materials used in production and identify the differences and similarities of each.
4. Explain the different properties that materials may exhibit and the importance of such differences.
5. Utilize the various material processing techniques commonly used in production.
6. Demonstrate the application of scientific principles used in materials processing.
7. Synthesize the many positive and negative impacts that materials have made on the quality of life after they have been altered by humans from a raw or natural state.
8. Use safe laboratory techniques while being involved with experience-based activities.

CONTENT OUTLINE

MATERIALS PROCESSING

		Estimated Learning Time
MODULE:	**RESOURCES FOR MATERIALS PROCESSING**	**27 hours**

I. Raw Material Procurement — 6 hours

- A. Harvesting/refining
  1. Plants
  2. Animals
- B. Extracting/refining
  1. Land
  2. Air
  3. Water

II. Production Materials — 21 hours

- A. Ceramics
  1. Historical development
  2. Sources of raw materials
  3. Material classifications
     - a. Clay
     - b. Glass
     - c. Hydrosetting
     - d. Refractories
     - e. Abrasives
  4. Applications
     - a. Traditional
     - b. Innovative
  5. Comparative characteristics
     - a. Physical
     - b. Mechanical
     - c. Chemical
     - d. Thermal
     - e. Electrical
     - f. Acoustical
     - g. Optics
     - h. Environmental

B. Polymers
   1. Historical development
   2. Sources of raw materials
   3. Material classifications
      a. Thermoplastics
      b. Thermosets

   4. Applications
      a. Traditional
      b. Innovative

   5. Comparative characteristics
      a. Physical
      b. Mechanical
      c. Chemical
      d. Thermal
      e. Electrical
      f. Acoustical
      g. Optics
      h. Environmental

C. Forest products
   1. Historical development
   2. Sources of raw materials
   3. Material classifications
      a. Solid wood products
      b. Wood composition
      c. Chemically derived
      d. Tree extractive products

   4. Applications
      a. Traditional
      b. Innovative

   5. Comparative characteristics
      a. Physical
      b. Mechanical
      c. Chemical
      d. Thermal
      e. Electrical
      f. Acoustical
      g. Optics
      h. Environmental

D. Metals

1. Historical development
2. Sources of raw materials
3. Material classifications
    a. Ferrous
    b. Nonferrous
4. Applications
    a. Traditional
    b. Innovative
5. Comparative characteristics
    a. Physical
    b. Mechanical
    c. Chemical
    d. Thermal
    e. Electrical
    f. Acoustical
    g. Optics
    h. Environmental

E. Composite materials

1. Historical development
2. Sources of raw materials
3. Material classification of components
    a. Resin matrix
    b. Fiber Reinforcements
4. Applications
    a. Traditional
    b. Innovative
5. Comparative characteristics
    a. Physical
    b. Mechanical
    c. Chemical
    d. Thermal
    e. Electrical
    f. Acoustical
    g. Optics
    h. Environmental

F. Other production materials
   1. Plant and animal derivatives
   2. Industrial chemicals
   3. Pharmaceuticals
   4. Electronic related
   5. Textiles

MODULE: **PROCESSING MATERIALS** **21 hours**

I. Manufacturing processes
   A. Separating
      1. Shearing
         a. Applications/examples
         b. Techniques
         c. Comparative effectiveness

      2. Chip removal
         a. Applications/examples
         b. Techniques
         c. Comparative effectiveness

      3. Non-traditional
         a. Applications/examples
         b. Techniques
         c. Comparative effectiveness

   B. Combining
      1. Mechanical fastening
         a. Applications/examples
         b. Techniques
         c. Comparative effectiveness

      2. Bonding
         a. Applications/examples
         b. Techniques
         c. Comparative effectiveness

      3. Mixing
         a. Applications/examples
         b. Techniques
         c. Comparative effectiveness

4. Coating
    a. Applications/examples
    b. Techniques
    c. Comparative effectiveness

C. Forming
1. Casting/molding
    a. Applications/examples
    b. Techniques
    c. Comparative effectiveness

2. Compressing/stretching
    a. Applications/examples
    b. Techniques
    c. Comparative effectiveness

3. Conditioning
    a. Applications/examples
    b. Techniques
    c. Comparative effectiveness

MODULE: **IMPACTS OF MATERIAL PROCESSING** **6 hours**

I. Personal
A. Lifestyle change
B. Health and safety
C. Career implications
D. Technological dependency

II. Economic
A. Individual profit/loss
B. Organizational profit/loss

III. Societal
A. Global interdependence
B. Resource management
C. Standard of living

IV. Environmental
A. Value judgments
B. Techniques of reclaiming/disposing

GENERAL INSTRUCTIONAL STRATEGIES

It is highly suggested that the reader carefully review these General Instructional Strategies to obtain the scope and limits for the delivery of instruction. Specific instructional strategies are described in the section that follows, but they may appear somewhat fragmented without a description of the overall strategy for the module. This section on General Instructional Strategies, therefore, is included to communicate the nature of the module in a more cohesive form, and is the primary reference for the instructor to synthesize the objectives for the course and to cover many objectives without a separate and different strategy for each.

1. **Student projects.**

   The instructor can enjoy tremendous latitude in the selection of learning activities (projects) for this module. Individually different projects can be accomplished by the student. Like-projects can also be employed. Group projects may be used as well. The instructor should strive to incorporate as many different materials as possible within each activity. This should not be done at the expense of good design, however. The instructor should consult with the student during the planning stages and motivate that student to consider a variety of different materials. In fact, this can become one evaluation criterion. Appropriate design and utilization of materials should be separate criteria, however.

2. **Facilities.**

   This module should be taught in a multi-material (general type) laboratory. This requirement is based on the need to have a variety of material processing equipment available. Each student must have the opportunity to utilize the appropriate material and process based on a product's design and function. A general laboratory is most conducive to using a variety of materials. The new State Education Department facility plan recommends that the Material Processing Course be taught in the proposed Production System Laboratory. This facility is designed to have a variety of processing equipment in order to also support the teaching of such courses as Production R&D, Creativity and Innovation, Computer Aided Manufacturing and Residential Structures.

3. **Major project/minor projects.**

   A general strategy is to have the student involved in a major project that can incorporate as many objectives as possible. There might be objectives that cannot be covered within the context of this major project, however. It is recommended that a small number of short projects be required that would include competencies specified by other objectives. Also, a small number of experiments should be included for the same reason. For example, students might select a rather large scale project that involves shearing, chip removal, non-traditional separating, mechanical fastening, bonding, mixing, coating, compressing/stretching, and conditioning processes. It might be difficult to include a casting/molding experience within this project. The instructor could then have the student injection-mold a small product as a minor project, to gain exposure in this area that was not included in the major project. Several of these minor projects could be developed and used as necessary.

   In addition, several experiments should be included in the requirements to cover objectives that deal in testing and advanced technology applications. For instance, if a small, educational laser-cutting device becomes available for school applications, the instructor could write a student experiment involving this device. Also, a few experiments dealing with testing comparative characteristics (tensile, impact, thermal, etc.) should be developed as necessary to cover the stated objectives.

4. **Combine objectives for one activity.**

   The module outline displays the different materials separately. Also, individual strategies are offered (in the following section) for each subheading of the content outline. The instructor would probably find it easier to combine some of the objectives from each separate material into one activity. For example, historical development of the materials is included under each. Rather than cover history with several different activities, one for each material, it would be wiser to combine them. Perhaps the specific instructional strategy of stretching a time-line (clothesline) across the laboratory for each material, and having a group of students attach milestone events with objects and 5x8 cards, would be a more efficient approach.

   Another example might be a unified approach to involving the students in determining traditional and innovative applications of the materials. The instructor could assign one application to each student, and have that student bring a representative example from home. The collection from the class could then be displayed.

The main point, therefore, is that the instructor should find ways to combine some of the like objectives for better utilization of time.

5. **Concluding activity.**

   It is highly recommended that the instructor have some kind of concluding activity or event that forces the student to critically analyze the product(s) and experiments that were developed and be able to explain where examples of shearing, chip removal, non-traditional separating, mixing, casting, etc. were used, or not used. Some students might be able to develop a summary report. Another strategy might be a fill-in-the-blank exercise. Verbal presentations might be used, if time allows. Still another strategy might be to give the students a plan sheet, procedure sheet, and bill of materials for a project and have them explain all the inputs, processes, and impacts for this representative example.

6. **Comparative characteristics.**

   The instructor should not attempt to get too heavily involved in testing and measurement of materials. This general education module could not do justice to such an expansive and accurate aspect of materials processing. Instead, the focus should be on comparative characteristics, using simple tests. In other words, do not try to replicate tests found in the ASTM handbook, but rather devise simple experiments that will be of value in a general education sense.

7. **Field trips.**

   Field trips to advanced technology applications of materials processing are encouraged when the laboratory cannot demonstrate such technologies.

8. **Films.**

   Films should be judiciously used to represent advanced technology that cannot be emulated in the laboratory.

9. **Guest speakers.**

   This general strategy is another recommended technique to gain expertise that might not be available from the instructor.

MODULE: Resources for Materials Processing
TOPIC: Raw Material Procurement

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to summarize how raw materials are procured from the environment and eventually processed for utilization by humankind, after instruction. To accomplish this performance objective, the student will:

   a. Appraise how raw materials are harvested and/or refined from plant and animal life.
   b. Compare the different methods of how materials are extracted from land, air, or water.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. The students could take a field trip to a local lumber mill or other processing plant that initially processes raw materials from plant or animal life.
   b. The students could harvest raw materials that are found locally and proceed to turn them into usable manufacturing materials. For example, a tree could be harvested, debarked, cut, dried, and used for a simple product.
   c. The student will draw a flow chart describing how various forms of plant and/or animal life are harvested and processed.
   d. Do a native clay project. Dig clay in area of school. Dry, crush, sift, slurry, purify, dry and condition, then use to produce a product to be fired and glazed.
   e. Write a research report on a topic to be presented to the class; such as -- "Mining of..."; "The refining of..."; "The harvesting of...".
   f. Have the students visit a local farm where produce is picked and packaged.

2. a. Have the students select a product and report where its major material has come from.
   b. Make a wall chart of methods used to obtain materials from the air, earth and water. Add to chart as class analyzes materials they are currently working with.
   c. Have the students develop a list of methods that are used to extract materials from land, air, and water, and then used by humans.

MODULE: Resources for Materials Processing
SUBMODULE: Production Materials
TOPIC: Ceramics

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. Given instruction, students will be able to assess how ceramic materials have contributed to the technological development of humankind. To accomplish this performance objective, the student will:

   a. Summarize the historical development of ceramic materials.

   b. Classify sources of raw materials used to produce ceramic products.

   c. Identify ceramic materials, according to classification.

   d. Examine traditional and innovative uses of ceramic materials.

   e. Compare and contrast the various characteristics and properties of ceramic materials with each other and other materials.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have the students write a report from the encyclopedia concerning the history of ceramics.
   b. Make a bulletin board of photos or drawings showing the use of ceramics through the ages.
   c. Stretch a piece of clothesline across the laboratory, near the ceiling. Make a large sign that says "Technology Time Line". Have the students each research a major development in the history of ceramics, and print it on a 5 x 8 card. Use a clip to attach the card to the time line. Add markers indicating the centuries. Other materials could also be included on this time line.

2. a. Make a map to show the location of ceramic raw materials that are commercially mined in that area. Use a state map or a national map.

3. a. Use annual reports or photos gathered from industries, to develop a bulletin board display of examples of the many ceramic applications and classify them in groups. Student groups could be assigned to research/write the various classifications.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

b. Students will bring to class various samples of ceramic materials that they have in their home. In class, they will attempt to identify and place each sample into its proper ceramic classification.

4. a. Have the students research the ceramic materials used during recent space flights.
   b. Student committees could research and report back to the class their findings concerning the traditional and innovative uses of ceramic materials.

5. Perform a series of selected lab tests to compare the characteristics of ceramic samples with other materials. Simple testing apparatus can be teacher-constructed.

MODULE: Resources for Materials Processing
SUBMODULE: Production Materials
TOPIC: Polymers

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. Given instruction, students will be able to analyze how materials produced from polymers have contributed to the technological development of humankind. To accomplish this performance objective, the student will:

   a. Determine major events in the history of polymers.
   b. Identify the sources of raw materials used in polymer technology.
   c. Group polymer materials into thermoplastics or thermosets.
   d. Appraise the traditional and innovative applications of polymer materials.
   e. Examine and compare the various characteristics and properties of polymer materials with each other and other materials.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have the students examine the automobile and discuss the past changes from metal products to plastics over the years.
   b. Produce a time line to show when plastics were introduced as replacements/substitutes for a material that was traditionally used.
   c. Student committees will report on the major events that occurred in the development of polymers.
   d. Have the students draw a time line on the board. Add to the time line several selected, significant historical events important to metals, woods, ceramics, and polymers. (This strategy could cover more historical objectives than just 1221).

2. a. Have the students write a report on the making of a polymer.
   b. Diagram a particular polymer to show the flow and processing of raw materials to produce a finished production material. See "Plastics School" kits.
   c. Obtain the chemicals used to produce synthetic rubber. Demonstrate the production of synthetic rubber and relate it to the need for rubber sources during WW II. Get info from NASA Spacemobile - United University of Oak Ridge, Tennessee.
   d. Obtain the appropriate chemicals and polymerize nylon in a beaker. The nylon is removed from the surface in a fine thread. Reference texts can be consulted for the procedure, as this is an easily produced laboratory phenomenon.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

3. a. Have students group the different plastic products that are around the lab.
   b. Use "Plastics School" teaching aids to show and classify a number of samples of polymers into thermosets and thermoplastics categories.
   c. Have students do a scavenger hunt (for a homework assignment) to find samples of as many plastic types from a teacher prepared listing. Classify the products by burn testing.
   d. After learning about the differences between thermoplastics and thermosets the students will take unknown polymer samples, cut them into small pieces, and then try to burn them in order to determine which samples were thermoplastics or thermosets.
   e. The instructor could bring in 15 different polymer products, each representing a different material. Have the students identify the materials and group them into thermoplastic or thermoset categories.

4. a. Collect products that now generally use polymers in place of some material that seemed to be traditionally used for an application (eg. plastic soft drink containers instead of cans or bottles).
   b. Have students brainstorm various uses of polymers. Then have them consult plastics magazines to determine new and innovative applications of polymer materials.
   c. Have the students bring in an example of the most innovative packaging technique that they can find around their house.

5. a. Perform a series of selected lab tests to compare the characteristics of polymer samples with other materials. Simple testing apparatus can be teacher-constructed.
   b. Have the students bring to class examples of products that have broken in their homes. Analyze the material, and compare them to polymer materials used in similar applications. If the products brought in are polymer, discuss the forces that worked on the product to cause its failure.

MODULE: Resources for Materials Processing
SUBMODULE: Production Materials
TOPIC: Forest Products

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. Given instruction, students will be able to appraise the significance of forest products to humankind's existence. To accomplish this performance objective, the student will:

   a. Identify historical periods in which forest products played an important role in the progress of human endeavor through technology.
   b. Analyze the sources of raw materials used in forest product technology.
   c. Summarize the many forest product material classifications.
   d. Examine the traditional and innovative uses of forest product materials.
   e. Compare and contrast various characteristics and properties of forest product materials with one another and with other materials.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have the students select a building material such as plywood sheathing and trace how that sheathing material has changed through time.
   b. Construct a time line to show the important developments in human history where the material made a difference in life style/living conditions.
   c. Make a fire by using wood as source of fuel. Construct a bow drill or use a dowel in an electric hand drill for demonstration.
   d. Student committees could be assigned various historical periods of forest product development. After research, oral reports could be given to the class from each committee.
   e. The instructor should select a number of periods in history and have the students surmise the role of forest products in each of these periods. This would then be discussed in class.

2. a. Make a graph of major forest materials and show percentages available from U.S. sources compared with percentage of dependance on other nations for imports.
   b. On a map of the United States students will indicate the location of major forest product sources and indicate which type of forest product comes from that area.
   c. Have the students research the various sources of raw materials that are available locally, and bring an example to class of a product that could be made from those raw materials.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

3. a. Have the students identify the species of wood used for their home furniture.
   b. Make a show case with a chart of a tree as a background, with strings connected to finished products. Be sure to identify material classifications (see content outline).
   c. A flow chart could be utilized to illustrate how forest products are separated and broken down into different material classifications.
   d. Have the students bring an example to class of a product that represents a specific material classification in forest products technology. Each student would be responsible for one example, and a display case could be set up that contains these objects.

4. a. Have the student visit local lumber yards to collect literature on innovative uses of forest products.
   b. Make a laminated wood product of veneers and glue, such as a salad server, toast tongs, etc.
   c. Make a bulletin board collection of photos that show traditional and/or innovative applications of forest products.
   d. Have the students bring in a magazine article, advertisement, or encyclopedia reference on an innovative use of a forest product. The class could then vote on which student produced the most innovative example, and a small prize could be awarded.

5. a. Perform a series of selected lab tests to compare the characteristics of wood samples with other materials. Simple testing apparatus can be teacher-constructed.

MODULE: Resources for Materials Processing
SUBMODULE: Production Materials
TOPIC: Metal Products

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to analyze how materials made from metals have affected human existence, after instruction has been given. To accomplish this performance objective, the student will:

   a. Identify the major historical developments in the use of metals.
   b. Examine sources of raw materials used to produce metals.
   c. Determine the various classifications of metals.
   d. Appraise traditional and innovative uses of metals.
   e. Assess and classify the various characteristics and properties of metals with each other and with other materials.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. A time line could be drawn which illustrates the major historical developments in the use of metals.
   b. Using encyclopedias and an opaque projector, show the students examples of metal artifacts used in several periods of human history.

2. a. Have the students report on the production of a metal product from its raw material.
   b. Make a collection of raw materials to produce a kind of metal. Write for samples from producers.
   c. Draw a flow chart describing how metal is made. Attach samples of raw and finished materials as they are obtained.

3. a. Make a collection of metal samples, displayed in a manner to show various classifications. Use objects or photos cut from advertisements from various trade publications.
   b. The instructor could explain the categories into which metals are classified. Using a list of common metals the students will then properly place those metals into the correct category. They will also explain why they chose those categories.
   c. Have the students identify examples of standard metals, and then group the metals found in ferrous and nonferrous categories.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

d. Use an old grinding wheel to grind examples of ferrous and non-ferrous metals. Have the students identify the ferrous metals as those that produce sparks.

4. a. Have the students identify new uses of metal where other materials were once used.
   b. The students could brainstorm the traditional uses of metals. Using various resource materials (such as the library and technology magazines) the students could then research innovative uses of metals and report those findings to the class.

5. a. Perform a series of selected lab tests to compare the characteristics of metal samples with other materials. Simple testing apparatus can be teacher-constructed.

MODULE: Resources for Materials Processing
SUBMODULE: Production Materials
TOPIC: Composite Materials

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. Given instruction, students will be able to summarize how composite materials are used as a resource for material processing technologies. To accomplish this performance objective, the student will:

   a. Examine the historical development of composite materials from ancient Israelites use of straw and mud bricks; medieval swords of laminated metals; to today's epoxy and carbon aircraft.
   b. Identify sources of materials which are utilized for composites, with emphasis on the advanced technology of resin matrix and reinforcement.
   c. Determine the major classifications of components used in composite materials technology and use a variety of these materials in laboratory experiments and activities.
   d. Analyze traditional and innovative uses of composite materials in natural occurring states (wood, bone), common forms (plywood, concrete and wire mesh), and advanced technology (resin matrix with reinforcement).
   e. Differentiate between the various characteristics and properties of advanced composite materials such as E-glass, S-glass, Kevlar, carbon/graphite, polyester matrix, epoxy matrix, and others.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Collect examples or photos of composite applications and determine how long ago this application was developed and what material(s) it replaced.
   b. Have the students bring in one example of a product made from a composite material. They must also explain when this product was first introduced to the market place.
   c. Have students research the development of the Corvette.

2. a. Collect a variety of materials that might lend themselves to composite structures and have students explain thoughts on their choice.
   b. The students will be assigned a composite material to be investigated. After research, the student will report to the class what components are used to make the composite material, and where those materials came from.
   c. Have the students make a list of possible materials that could be used for composites, found in their home state.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

3. a. The student will be assigned a composite material to be investigated. After research, the student will determine the major classifications of materials that were used to develop that composite material.
   b. Have the students produce a composite reinforced plastic product in the laboratory (fiberglass lay up) and be able to describe the classifications of materials that went into this example. Use alternate materials, such as Kevlar, carbon/graphite, and others (available from IASCO catalog).

4. a. On a large illustration of a modern fighter aircraft, (obtained from Grumman, General Dynamics, etc.) show the area where composite technology has been used and explain/speculate reasons for its application.
   b. Studying the science section of the New York Times, students will report weekly to the class any stories that are concerned with composite materials, both traditional and innovative.
   c. Show the development of the B-2 (Flying Wing) bomber, with its fuselage of composite materials.

5. a. Compare a composite such as fiberglass reinforced resin, with wood of equal thickness/weight in a given application. Discuss the merits of a goalie mask made of fiberglass compared with other available materials.
   b. Perform a series of selected lab tests to compare the characteristics of composite samples with other materials. Simple testing apparatus can be teacher-constructed for shear, tensile, impact, etc. Circles of reinforcement material, with about 20 grams of resin matrix added to an 8-ounce paper cup, will make a nice, round test "disk" that can then be destructively tested. Also, these disks, along with disks of other materials, can be placed on a display board so students can handle them.

MODULE: Resources for Materials Processing
SUBMODULE: Production Materials
TOPIC: Other Production Materials

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to analyze examples of production materials not commonly associated with materials processing, such as plant and animal derivatives, industrial chemicals, pharmaceuticals, electronic-related, and textiles. To accomplish this performance objective, the student will compare the similarity and differences of the following, with other materials that are processed:

   a. Plant and animal derivatives
   b. Industrial chemicals
   c. Pharmaceuticals
   d. electronic related (semi-conductors, photo-diodes, liquid crystals, piezoelectric materials)
   e. textiles

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have the students brainstorm the many plant and animal derivative products found around the home.
   b. Research the industrial materials that are made from a product, like milk. Write to the Borden Co. for an annual report or product inventory.
   c. Trace the path of the leather in your shoes back to the production that made them possible.
   d. Visit a modern dairy barn operation that uses industrial methods in the production of milk.
   e. Describe James O'Neil's (NASA) view of food production with a space orientation. How will it be done?
   f. Have the students bring to class a sample of what they believe is a processed and an unprocessed plant or animal derivative product. A discussion will follow.

2. a. Have the students look in the yellow pages to make a list of all the industrial chemical companies in their area.
   b. Make a display of common chemicals that are found in use around the home.
   c. List the industrial chemicals found in the Technology Ed. Lab.

TOPIC: Other Production Materials

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

d. List on the black board names of various common industrial chemicals. Have the students try to determine which ones are not processed. If they cannot identify any particular one, have them brainstorm the names of industrial chemicals which they believe are not processed.

3. a. Have the students make a list of all the pharmaceuticals found in their homes.
   b. Research the natural pharmaceuticals that were used by native Americans (herbs, plants, roots, and weeds). How many of these can be found locally?
   c. Do a report on the history of a commonly used medicinal drug, such as aspirin, penicillin, etc.
   d. Invite a pharmacist to class. Let him/her conduct a demonstration which involves the processing of a simple pharmaceutical.

4. a. Have the students identify as many parts as possible taken from an old television dismantled in the lab.
   b. Have students produce a crystal set using galena and locating a station with a cat's whisker and compare the reception with a fixed germanium diode in its place.
   c. Have the students etch a circuit board.
   d. Develop a bulletin board that shows a variety of materials that are processed. Include actual examples of electronic related materials, to illustrate their uniqueness.

5. a. Have the students make a list of all the different textiles they are wearing.
   b. Process some native material into a fiber used for textiles, such as the flax plant, cotton balls, raw wool, etc.
   c. Construct a simple card weaving frame and weave a belt of fibers.
   d. Make a synthetic fiber by combining chemicals to produce a nylon filament.
   e. Identify common fibers. Have the students explain how those fibers are eventually processed into fabrics for clothing.

MODULE: Processing Materials
SUBMODULE: Manufacturing Processes
TOPIC: Separating

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to summarize how the separation of materials is accomplished as a function of materials processing, after laboratory instruction has been given. To accomplish this performance objective, the student will:

   a. Identify the uniqueness of shearing as a technique for separating materials and demonstrate common examples, techniques, and the comparative effectiveness over other separating methods.
   b. Utilize the chip removal method of separating materials and identify common applications, techniques, and the comparative effectiveness over other separation methods.
   c. Examine nontraditional techniques to separate materials (such as laser and water jet cutting) and demonstrate applications, techniques, and the comparative effectiveness.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have students experience a variety of shearing techniques using sheet aluminum. Demonstrate cold chisel, metal snips, aviation snips, chassis punch, hole punch, notcher, and squaring shears.
   b. Have the students involved in a laboratory activity that includes the process of shearing several materials. The students should complete an analysis sheet at the conclusion of the activity that requires a full description of the shearing process.

2. a. Have students do a lab operation on a product that will require application of chip removal.
   b. Utilize various hand and power tools to illustrate how materials are separated by the chip removal method.
   c. A requirement in a student activity would be the inclusion of a chip-removal separation technique. Have each student analyze the specific technique after a product is produced.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

3. a. Demonstrate chemical etching as a separating technique. Students could silk screen a resist onto aluminum disks in a design that could be etched. Edges can be fluted to produce a coaster.
   b. Demonstrate the use of a cutting torch to separate heavy steel plate.
   c. Have a laboratory work station that contains a nontraditional separation technique, such as a laser or perhaps induced fracture (glass cutting). Require the students to complete an experiment with this technique.

MODULE: Processing Materials
SUBMODULE: Manufacturing Processes
TOPIC: Combining

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to analyze how materials are combined, as a function of materials processing, after laboratory instruction has been given. To accomplish this performance objective, the student will:

   a. Identify the methods of mechanical fastening as a technique in combining materials and demonstrate the common application, techniques, and the comparative effectiveness over other combining methods.
   b. Utilize the methods of bonding as a technique in combining materials and identify common applications, techniques, and the comparative effectiveness over other combining techniques.
   c. Use mixing techniques as materials are combined, and examine the common applications, techniques, and comparative effectiveness.
   d. Analyze coating as a combining technique for materials processing and demonstrate the common applications, techniques, and comparative effectiveness.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Make a display board of the mechanical fasteners in the lab, plus as many as the students can locate at home or in catalogs.
   b. Demonstrate proper nailing technique and have students try to drive nails in a scrap piece of hard wood. Bend a few nails for nailing contest. Demonstrate the use of soap as a lubricant.
   c. The students would be required to include at least one method of mechanical fastening in the product that they select for a laboratory activity.

2. a. Students could make a number of sample bonds using a variety of materials and adhesives. These could be destructively tested to compare results and these observations recorded.
   b. Samples of bonding agents could be tested for water resistance by soaking in a pail.
   c. Students will construct a product using one or more bonding techniques.

MODULE: Processing Materials
SUBMODULE: Manufacturing Processes
TOPIC: Combining

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

3. a. Students could weigh, combine and mix a batch recipe for a sample glaze and test fire several variations.
   b. Students could mix a batch of plaster for pouring into a mold. This could be compared by ratio-mix and rule-of-thumb mixing.
   c. Students could be given a sample paint color chip and asked to duplicate the color by mixing matches using tempera paints.
   d. Students could be assigned to mix and test a sample batch of water resistant or waterproof adhesive.
   e. Measure and mix ingredients for a concrete casting.
   f. The students could mix the appropriate thinner and finish material for the application to their individual project.

4. a. Demonstrate the coating of tool handles using organisols or plastisols.
   b. Bend a coat hanger wire into a recipe cardholder and coat it using fluidized bed application of plastic.
   c. Demonstrate proper use of spray can paint coating techniques.

MODULE: Processing Materials
SUBMODULE: Manufacturing Processes
TOPIC: Forming

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to analyze the methods of forming materials as a function of materials processing. To accomplish this performance objective, the student will:

   a. Utilize casting and molding as a forming process for materials, and identify common applications, techniques, and the comparative effectiveness over other forming processes.
   b. Use compressing and stretching techniques as a method for forming materials, and explain the common applications, techniques, and the comparative effectiveness over other forming techniques.
   c. Examine how materials are conditioned and demonstrate common applications, techniques, and the comparative effectiveness over other forming processes.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have the students produce a plastic mold using a vacuum forming technique, such as a school or club emblem. They could then use the mold to make a plaster casting.
   b. As part of a metal project, the students will be required to form one piece of the project by casting it in a sand mold.
   c. Have the students cast an aluminum filled epoxy mold that could be used for injection molding. Then each student could injection mold a product.

2. a. An acrylic shape could be compressed or stretched under polarized light source on the overhead projector or to show resultant stress and strain.
   b. Students could make a plastic key holder by using compression along with heat in a hot press to make a cohesive bond.
   c. Wood chips and glue can be compressed into checkers or other game piece shapes.
   d. Utilizing sheet metal machines, the students will identify where stretching and compressing of the metal occurs during the bending process.
   e. The student could laminate wood veneer into a product, such as salad serving forks, using a form made from 4 x 4 lumber. Stressed would be the manner in which each piece of veneer needs to stretch and compress in order to be bent.

MODULE: Processing Materials
SUBMODULE: Manufacturing Processes
TOPIC: Forming

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

3. a. Dig native clay and process it through conditioning to a usable ceramic material or recondition some lab clay that has dried out.
   b. The student will heat treat a piece of metal to the proper hardness as part of the conditioning process.
   c. Operate an oven to dry wood to the appropriate moisture content. Stress the fact that this is a conditioning process.

MODULE: Impacts of Materials Processing
TOPIC: Personal

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to assess the past, present, and future impacts on individuals from materials processing technology, after instruction. To accomplish this performance objective, the student will:

   a. Examine how lifestyles may change, due to materials processing technology.
   b. Determine the effects of materials processing on the health and safety of the individual and society.
   c. Identify the career opportunities in materials processing technology.
   d. Analyze how people can become dependent on technology by the processing of materials.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have the students bring a product to class that they feel has made a lifestyle change in their family.
   b. Have students compare the materials used in older housing with today's housing, and then project ideas of what materials may be used in the future. This might be a class/group project to make a display cut-a-way of a model home.
   c. The students will interview a senior citizen, parent, or grandparent to determine the life styles that person had as a youth and compare that to the lifestyle the student is experiencing.
   d. Have the students bring in examples of common toys that their parents might have had when they were teenagers, and compare to present day toys. These could also be used in display case with a title of "Materials Processing - Then and Now".

2. a. Have the students discuss why life is safer with the development of new materials and products.
   b. Examine the lifespans of people in the United States 100 years ago as compared to today and relate how materials processing has increased the health, safety, and lifespans of people today.
   c. Develop a display case that shows the uses of polymer materials in a typical hospital or health-care facility. Stress how the changes have helped prevent the spread of infection, by disposable products.

MODULE: Impacts of Materials Processing
TOPIC: Personal

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

3. a. Have the students bring in a page from the classified section of the newspaper. Discuss the occupations that deal with materials processing.
   b. Consult the Occupational Outlook Handbook for career opportunities in the area of materials processing.

4. a. Have the students keep a log for a day. In it record all the plastic materials contacted during that day. Then list what/and if these objects might have been made from 125 years ago.
   b. Show Burke's "Connections" film number one, which illustrates how people became dependent on technology which has been made possible by the processing of materials (Title, "Trigger Effect"; get from BOCES).
   c. Ask the students to go for one entire day without touching (handling) anything made from plastic. Discuss the problems involved during the next class. Stress how we are currently dependent on these materials that were virtually nonexistent 50 years ago.

MODULE: Impacts of Materials Processing
TOPIC: Economic

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to summarize the economic impacts of materials processing, after instruction. To accomplish this performance objective the student will:

   a. Analyze the factors that determine individual profit or loss.
   b. Summarize the factors that influence organizational profit or loss.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have the students find out the salaries of many occupations by looking in the Career Outlook Handbook.
   b. Make an organizational chart of a typical materials processing industry and show the wage scale that can be expected at various technical levels.
   c. Compare the wages of United States and Japanese automotive workers and relate how the reduced wages of foreign workers effects the American economic well-being.
   d. Analyze how robotics can lead to more efficient materials processing and effect the individual's profit or loss.

2. a. Develop a bill of materials for a given lab product and determine the number of units needed to be made to reach the break even point.
   b. Discuss the factors that lead to the decline of the steel industry in this country. How might the problems be resolved to make it a viable industry again?
   c. Have the students determine the cost of producing the product that was developed during the semester. Have them figure the retail price that would have to be charged to make a profit.

MODULE: Impacts of Materials Processing
TOPIC: Societal

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. The student will be able to analyze the impact that materials processing technology has on society, after instruction. To accomplish this performance objective, the student will:

   a. Explain how humans are becoming more globally interdependent for the acquisition of raw materials and the disposition of goods.
   b. Assess how material processing can impact on resource management.
   c. Judge the impact on the societal standard of living due to the processing of materials.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have the students discuss what happened during the energy crisis in the 1970s, regarding international implications of energy availability.
   b. Chart on a world map where the materials used in a modern automobile originate (see poster by GM). Make a list of those materials which are not found in sufficient quantities in the United States.
   c. Look up the Department of Defense listing of strategic materials. Make a graph to show percentage of needs as compared to native production. -- How much is imported and from which countries?
   d. Research the import and export of raw materials to and from the United States. Explain how those imports or exports lead to global inter-dependence.
   e. Do a class survey of automobiles, stereos, radios, and cameras, and determine the country where each was made.

2. a. Manage a local wood lot on or near school property with the help of the local agricultural agency. Process logs to lumber, condition, and produce products.
   b. Make a chart which illustrates how shrinking supplies of high quality iron ore required better resource management by the production of taconite.
   c. Have the students brainstorm several specific cases of resource management for each of the materials used in their activity. This could be part of the final analysis after their product is completed.

MODULE: Impacts of Materials Processing
TOPIC: Societal

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES, continued

3. a. Have the students compare our standard of living to a third world country.
   b. Make a bulletin board display showing the material wealth of three income levels in the U.S. - use poverty level, middle income, and wealthy. Use photos from magazines to show housing, transportation, clothing and recreation.
   c. Compare a Sears catalogue from the early 1900s to one of today.

MODULE: Impacts of Materials Processing
TOPIC: Environmental

PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES*

1. Given appropriate instruction, students will be able to evaluate the environmental impacts brought about by the methods and techniques used to process materials. To accomplish this performance objective, the student will:

   a. Discuss the decision-making process and value judgments that must be made, when materials are processed.
   b. Analyze the techniques of reclaiming or disposing materials.

SUGGESTED SPECIFIC INSTRUCTIONAL STRATEGIES

1. a. Have a debate on the environmental impacts of a waste dump for nuclear by-products in your community or the transportation of hazardous chemicals/gases through the community.
   b. Role play executives in a corporate board room who are discussing whether to produce automobiles with a cast iron, aluminum or a ceramic engine.
   c. Have the students complete a final analysis report that describes the environmental impact and value judgments that would need to be made if their individual product was mass-produced.

2. a. Have the students explain why the new bottle law went into effect in New York State.
   b. Have the students recycle a plastic gallon jug such as a bleach bottle, or a two liter beverage bottle.
   c. Combine saw dust and wood shavings into compression molded checkers.
   d. Have students build a compost pile at their homes to dispose of organic materials like grass clippings, food peelings, etc.
   e. Have the students keep an inventory of the items that are disposed of from their house. Have them determine which items could be reclaimed and which should be disposed of. Give reasons for each.
   f. Each student should report on how the various waste materials used in the lab are finally reclaimed or disposed.

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Resources

Films

Box Business - 26 minutes [#19894]

This video essay tells the story of the people and careers in the largest segment of the packaging industry, the corrugated box business, and we see who they are and what they do. The program tours the world of corrugated packaging through the eyes of the people who design, manufacture and sell this indispensable but little noticed product.

Available from: Modern Talking Picture Service
3520 Progress Drive - Suite C
Cornwells Heights, Pennsylvania 19020

Copper, The Oldest Metal - 28 minutes [#256]

This film depicts the latest technology in mining, processing, and fabricating copper and shows the many uses of the metal in the world today.

Available from: Audiovisual Library
Bureau of Mines
Cochrans Mill Road
P.O. Box 18070
Pittsburgh, Pennsylvania 15236

Lead in Motion - 20 minutes [#277]

This film illustrates how lead is extracted from the earth, and in successive steps is prepared for smelting and refining. It also illustrates how lead's commercial uses span a spectrum encompassing radiation absorption in nuclear applications, the sparkling gleam of lead-crystal goblets, and scores of other everyday applications.

Resources, continued

Films, continued

Available from: Audiovisual Library
Bureau of Mines
Cochrans Mill Road
P.O. Box 18070
Pittsburgh, Pennsylvania 15236

Industrial Technology in Japan Today - 27 minutes
This film shows that architecture, steel production, shipbuilding and other vital industries in Japan have been greatly altered by the use of computers, automated systems, and other technological innovation.
Available from: Consulate General of Japan
280 Park Avenue
New York, New York 10017

Making Paper - 23 minutes
This film presents a nontechnical description of the paper and paperboard making process from forests to consumer products. It includes pulping, paper making, and converting to boxes and bags.
Available from: Longview Fibre Company
P. O. Box 639
Longview, Washington 98632

Plastics, The World of Imagination - 27 minutes [#16132]
Emphasized is the important role of plastics in today's world. On location sequences blend into a fascinating review of the specific, and often amazing, uses of plastics. These include flight, architecture, textiles, packaging, transportation, energy conservation and medicine.
Available from: Modern Talking Picture Service
3520 Progress Drive - Suite C
Cornwells Heights, Pennsylvania 19020

Progress in Metal Joining - 13 minutes
This film tells how a "welding systems" approach provides the most efficient and economical way to join metal.
Available from: Hobart Brothers Company
600 West Main Street
Troy, Ohio 45373

Resources, continued

Films, continued

Show Me - 25 minutes
This film illustrates the story of modern steel production as it takes place at the Timken Company in Ohio.
Available from: The Timken Company
Advertising Department
1835 Dueber Avenue, Southwest
Canton, Ohio 44706

Steel From Inland - 28 minutes [#13878]
Filmed at the nation's largest steel plant, the Inland Steel Company's Indiana Harbor Works in East Chicago, Indiana, this feature shows viewers how iron ore, coal and limestone become steel. It offers a close look at some of the new production and environmental technology that has changed the complexion of steel making and steel industry jobs in recent years.
Available from: Modern Talking Picture Service
3520 Progress Drive - Suite C
Cornwells Heights, Pennsylvania 19020

The Trigger Effect - Connection Series Program 1
This film illustrates how we have become dependent on technology. Examining the 1965 New York City blackout, James Burke raises questions about modern society's reliance on complex, interdependent technological systems.
Available from: Time-Life Multimedia
Room 32 - 48
Time & Life Building
New York, New York 10020

Filmstrips

Filmstrips with Audio Cassettes:

What is Manufacturing - #674010-9
Overview of materials, processes, tools and production methods. $46.47

The Materials of Manufacturing - #674020-6
Raw materials, and how standard stocks are produced from them. $46.47

Resources, continued

Filmstrips, continued

The Tools and Processes of Manufacturing - #674030-3
Tools and processes, from hand tools to giant industrial machines. $46.47

Forming Processes in Manufacturing - #674040-0
Covers casting, compressing and stretching, conditioning, and shows several examples of each type. $46.47

Separating Processes in Manufacturing - #674050-8
Covers shearing, punching, sawing, milling, drilling, cutting on lathes, etching, and induced fracturing of glass, among others. $46.47

The Combining Processes in Manufacturing - #674060-5
Shows several examples of mixing, coating, bonding, mechanical fastening; includes glass making, paper making, oil refining, electroplating, welding and riveting. $46.47

Research and Development in Manufacturing - #674070-2
Depicts the different tasks of research and development and traces these in a single product - a fiberglass boat. $46.47

Types of Production in Manufacturing - #674080-X
Explains and shows differences among the three major types: custom; job-lot; and line. $46.47

The Final Manufactured Product - #674090-7
Shows how various completed products are inspected, tested, packaged, stored, shipped, and marketed. $46.47

Energy Sources for Manufacturing - #674100-8
Looks at the major industrial source - oil, and alternative sources - including solar, geothermal, and nuclear. $46.47

Complete set of 10 - $393.99

All the above filmstrips are available from:

Glencoe Publishing Company
809 W. Detweiller Drive
Peoria, IL 61615

Resources, continued

Video Tapes

Manufacturing Processes Video Programs

Video Program Price List

Metal Processing Series - #0696

Title	Price	Order Code
Forging	$250.00	VT 150
Casting	300.00	VT 151
Rolling	200.00	VT 152
Powder Metallurgy	200.00	VT 153

Non-Conventional Metal Removal Series - #0696

Title	Price	Order Code
Electric Discharge Machining	$250.00	VT 126
Laser Drilling	200.00	VT 127
Chemical Milling	200.00	VT 128
Abrasive Flow Machining	200.00	VT 129
Electrochemical Machining	200.00	VT 130
Electrochemical Grinding	200.00	VT 131

Resources, continued

Video Tapes, continued

The above titles are available from:

Society of Manufacturing Engineers
1 SME Drive
P.O. Box 930
Dearborn, MI 48121

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890 — Manufacturing Systems Explained
Series of 4 VHS cassettes

3 of 4 — Processes of Manufacturing
Introduces forming, separating, combining, conditioning. Details the operational procedures of each process.

Set of 4 - $215.00

Available from: Bergwall Production, Inc.
P.O. Box 238
Garden City, New York 11530

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Understanding Plastics VHS - 30 minutes
Includes environmental history, extrusion, injection molding, blow molding, compression molding, transfer molding, rotational molding and thermoforming.

Available from: Stout University Foundation
320 South Broadway
Menomonie, WI 54751 $75.00

Resources, continued

Transparencies

Manufacturing Materials - #MGM000
Complete series of 38 multicolored transparencies, instructor's guide and library case. $132.50

Manufacturing Processes - #MGP000
Complete series of 31 multicolored transparencies, instructor's guide and library case. $110.00

Available from: DCA Educational Products, Inc.
Kellers Church Road
P.O. Box 338
Bedminster, Pennsylvania 18910