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ABSTRACT

This guide is intended for use in teaching a course in the sequential tasks that change a designer's idea into a completed product. Emphasis is placed on the design of a product and the manufacturing system needed to produce it. 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 next sections outline the course objectives and content. A list of recommended references is also included. The remainder of the guide consists of learning modules on the following topics: manufacturing systems, designing and engineering products, selecting and sequencing operations, designing tooling, developing quality control systems, developing plant layouts, and producing products and analyzing production systems. 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. (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/leariining 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

Manufacturing enterprises face two major design tasks. They must design products to meet the needs and wants of customers, and then design manufacturing systems to produce these products efficiently and to quality standards.

Product design approaches can be divided into two major types: the production approach and the market approach. In the production approach, the company develops a product that fits its production parameters, then attempts to develop a demand for the product through highly persuasive promotional activities. The market approach identifies a specific need in the marketplace, then designs and engineers a product to meet that need.

Product design requires that (1) a need or want is identified, (2) a design direction be identified and defined, (3) product ideas be generated and refined, (4) promising ideas be selected for engineering, and (5) selected ideas be specified for production.

Once a product is developed, a manufacturing system to produce the product must be designed, installed, and operated. This activity requires that (1) manufacturing operations be selected and sequenced, (2) tooling be designed and constructed, (3) plant layouts be developed, (4) material-handling systems be designed and installed, (5) quality control systems be developed, (6) a production control system be designed, (7) a pilot run of the system be completed, and (8) the tested system be operated.

This course is designed to allow the students to study the sequential tasks that change a designer's idea into a completed product. Emphasis is placed on the study of the design of a product and the manufacturing system needed to produce it.

COURSE OUTLINE

Module Number	Title and Content	Time (Days)
1	Manufacturing Systems Systems model Functions of the system System resources Impact of manufacturing systems	5
2	Designing and Engineering Products Generating product ideas Refining product ideas Selecting product ideas for manufacture Specifying the characteristics of products	25
3	Selecting and Sequencing Operations Selecting operations Sequencing operations Documenting operations planning	5
4	Designing Tooling Determining tooling needs Designing tooling Preparing tooling drawings Building tooling Testing and installing tooling	20
5	Developing Quality Control Systems Designing the system Designing inspection gauges Preparing inspection gauge drawings Constructing inspection gauges	10
6	Developing Plant Layouts Preparing plant layout drawings Determining material-handling needs Positioning equipment	5
7	Producing Products and Analyzing the System Conducting pilot runs Analyzing the results of the pilot runs Manufacturing products Controlling quality and productivity Analyzing the results	10

COURSE OBJECTIVE AND GOALS

Upon completion of Product and Manufacturing System Design, each student should be able to:

1. Develop creative, organizational, and communication skills used for generating product ideas, establishing specifications, and identifying materials used to produce industrial and consumer products.

2. Develop problem-solving skills and positive attitudes as applied in the design and development of process, methods, tooling, and plant engineering.

3. Conduct oneself in a safe, responsible, and cooperative manner in group encounters of planning, developing, and operating production activities.

4. Analyze the task performed, the working conditions, and the education and skills needed in occupations dealing with the design, development, and engineering required in production.

5. Conserve materials and energies, consider the appropriate disposal of waste materials, establish good working conditions, and produce a safe and appropriate product.

REFERENCES

No textbook has been found that covers the content for this course. The following references are recommended for a Teacher's Reference Library which can be used to develop presentations and activities.

Amrine, Harold T., John A Ritchey, and Oliver S. Hulley, Manufacturing Organization and Management. Prentice-Hall (Latest Edition), Englewood Cliffs, NJ.

Gruenwald, George, New Product Development. Crain Books, 740 Rush Street, Chicago, IL, 1985.

Kruppa, J. Russell, and John R. Lindbeck, Basic Manufacturing. Bennett and McKnight Publishing Co., Peoria, IL, 1985.

Moore, Franklin G., and Thomas E. Hendrick, Production/Operations Management. Richard D. Irwin, Inc., Homewood, IL.

Riggs, James L., et.al., Industrial Organization and Management. McGraw-Hill, (Latest Edition), NY.

Wright, R. Thomas, Exploring Manufacturing. Goodheart-Willcox, South Holland, IL, 1986.

Wright, R. Thomas, Manufacturing. Goodheart-Willcox, South Holland, IL, 1985.

Wright, R. Thomas, Processes of Manufacturing. Goodheart-Willcox, South Holland, IL, 1987.

The following two publications contain useful forms for product design and manufacturing system design activities.

Wright, R. Thomas, Exploring Manufacturing - Activity Sheets. Goodheart-Willcox, South Holland, IL, 1986.

Wright, R. Thomas, Manufacturing - Laboratory Manual. Goodheart-Willcox, South Holland, IL, 1986.

MODULE: 1 : Manufacturing Systems

LENGTH: 5 DAYS Manufacturing CLUSTER

Manufacturing is the act of changing the shape, combination, or composition of materials to add to their worth. It is an act of form utility - adding worth by changing a materials form.

Manufacturing is completed using three major systems:

1. Custom building - a limited number of products on order and to the customers specifications.

2. Intermittent or job lot - manufacturing parts or products in groups or lots using individual machine setups for each operation. The production may be set by orders or forecasts, and be made to the customer's or the manufacturer's specifications.

3. Continuous - producing products on an uninterrupted basis to forecast the manufacturer's specifications.

The type of equipment, skill of the workers, unit production cost, quality, training requirements, and a number of other factors will be directly influenced by the manufacturing system selected.

Generally, custom manufacturing requires general purpose equipment operated by skilled workers who are responsible for their own quality inspections. The unit cost for products produced by custom techniques are high and the product uniformity difficult to maintain.

Continuous manufacturing often uses special purpose, automatic equipment operated by semiskilled workers. Generally, inspection is done by inspectors or machine sensors. Uniform quality and production rate are fairly easy to maintain and unit production costs are low.

However, continuous manufacturing systems are fairly inflexible.

New machining centers and flexible manufacturing technology is now giving custom or job lot flexibility with continuous manufacturing advantages.

OBJECTIVES

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

1. Describe differentiate between the three major types of manufac systems.
2. Describe the four major classifications of industries.
3. Describe the major types of manufactured goods.
4. Compare and contrast custom and continuous manufacturing systems.

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CALENDAR

DAY	ACTIVITY
1	Make introductions: self, students, the course, and safe conduct in the laboratory.
	Complete the required administrative details and define commonly used terms.
	Conduct laboratory tour with demonstrations of product operations.
	Explain system of evaluating student achievement.
2	Present classification used for industries manufacturing, products, and occupations.
	Describe functions to be performed in manufacturing a product.
	Illustrate the system's model used to analyze how things are accomplished.
	Introduce custom vs. continuous manufacturing activity.
3	Demonstrate custom and continuous manufacturing.
4	Students should complete custom vs. continuous manufacturing activity.
5	Present an approach used to analyze the impact on persons, society, and the environment, as a result of the production of things.
	Have students analyze the impact of selected products.

DAY	ACTIVITY

0 Well before introducing this module, complete the following tasks:

1. Completely read and study the course guide.
2. Select some design and drafting books for a classroom library.
3. Select a simple product to produce using custom and line production techniques.

   Specific ideas may be found in the following publications:

   Wright, R. Thomas, Manufacturing (Instructor's Guide). Goodheart-Willcox, South Holland, IL, pp. 42-46, 1984.

   Technology Education Activity # MF-G-001. Available through a subscription service from the Center for Implementing Technology Education, Department of Industry and Technology, Ball State University, Muncie, IN 47306.

4. Prepare plans, flow process charts, and tooling for selected product.

1 Make a self-introduction and call the roll to learn the students' names. Provide an introductory preview of the course. Distribute a copy, and review the "conduct of working in the laboratory."

Define terms which are commonly used but often misunderstood: technology, industry, manufacturing, society, and environment.

Establish safety considerations to be taken into account around tools and machinery.

Conduct a laboratory tour. Demonstrate some of the unique processes and operations used to produce a simple product. Then relate that much is involved in getting a product ready to run. Operating the production itself is routine performance—the part being taken over by computer operated machinery. Show examples of the planning, organizing, tooling, instrumentation, etc. that makes the production possible. Point out that all parts of the operations can be improved and it's the problem-solving, trial and error (within safety precautions), and organizational arrangements that are important as a study of manufacturing.

Explain that evaluation of student work in the class is not based on the quality of product produced, but is assessed on the active, cooperative participation, and the learning about the various aspects of planning, problem-solving, and arranging for production by the individual within a group effort.

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DAY	ACTIVITY

2 Present the classifications used in analyzing industry and manufacturing; use examples to help clarify the differences between classifications.

A. Industries
   1. Construction
   2. Manufacturing
   3. Communications
   4. Transportation
   5. Agriculture
   6. Extractive, etc.

B. Manufacturing
   1. Primary
   2. Secondary

C. Manufacturing Approaches
   1. Custom/mass production
   2. Continuous line
   3. Intermittent
   4. Batch
   5. Job lot

D. Manufactured Goods
   1. Industrial
   2. Military
   3. Consumer
   4. Durable/Nondurable

E. Production Occupations
   1. Unskilled
   2. Semiskilled
   3. Skilled
      a. Managerial
      b. Professional
      c. Clerical

(People who work with data, people, or things.)

Describe the functions which need to be performed in order to produce manufactured goods:

1. Management
2. Research
3. Development
4. Engineering
5. Production
6. Marketing

Many of the activities within the course will provide experiences within these functions.

DAY ACTIVITY

Illustrate the system's model used to analyze how things are accomplished. The "input" takes into account all those ideas, influences, and things affecting the system. The "processes" are involved with making the things of the organized system work, function, or otherwise proceed. The "output" is the resultant product of the system; it may be ideas, data, illustrations, procedures, or things.

NOTE: Use approximately 25-30 minutes for the above discussion.

Introduce the custom vs. continuous activity. Explain that the class will be divided into two groups:

Group A will custom manufacture the selected product using the skill of a craftsperson.

Group B will use a manufacturing system to continuously manufacture the product.

At the end of the product production phase, the output will be measured on productivity (quantity produced divided by total manufacturing time, and quality).

3 Divide the class into two groups. The groups do not have to be equal in size. Assign only as many students to Group B as needed to efficiently operate the manufacturing system.

Demonstrate the continuous and custom manufacture of the product.

4 Give the groups 30-40 minutes to manufacture products.

Analyze products produced.

5 Present the three aspects to be considered in analyzing the impacts of production. Cross-analyze the three aspects with:

1. Materials and energies consumed
2. Approaches used to produce the product
3. The products themselves
4. The wastes resulting from the production.

Point out that there are both beneficial and detrimental outcomes of most economic activity.

DAY | ACTIVITY

Hand out an "Impact Analysis Chart" for students to plot impact statements regarding:

1. Impact on the person (self)
2. Impact on society as a whole
3. Impact on the environment.

Students are to consider both the good and bad influences. The teacher should have some products as samples but could enlist the students' ideas as well. The products should balance out a variety of outcomes.

Emphasize the importance of being an enlightened consumer, voter, and citizen. Encourage students to be conscious of safety in their own actions, consideration of others, thoughtful in the consumption of things, and the disposal of waste materials.

BIBLIOGRAPHY

Amrine, Harold T., John A. Ritchey, and Oliver S. Hulley, Manufacturing Organization and Management. Prentice-Hall, Englewood Cliffs, NJ, Chapter 6.

Kruppa, J. Russell and John R. Lindbeck, Basic Manufacturing. Bennett and McKnight Publishing Co., Peoria, IL, pp. 18-21, 1985.

Moore, Franklin G., and Thomas E. Hendrick, Production/Operations Management. Richard D. Irwin, Inc., (Latest Edition), Homewood, IL.

Riggs, James L., et.al., Industrial Organization and Management. Goodheart-Willcox, South Holland, IL, 1987.

Wright, R. Thomas, Manufacturing. Goodheart-Willcox, South Holland, IL, pp. 139-1^0, 1985.

Wright, R. Thomas, Processes of Manufacturing. Goodheart-Willcox, South Holland, IL, pp. 17-20, 1987.

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PRODUCT AND MANUFACTURING SYSTEM DESIGN

MODULE: 2 : Designing and Engineering Products

LENGTH: 26 DAYS Manufacturing CLUSTER

Manufactured products are generally designed to meet customer needs or wants. However, two basic approaches are used in designing these products:

1. Production Approach: The product is designed and engineered by the company then an intensive marketing program is used to gain customer acceptance or generate consumer demand.

2. Market Approach: The market (customers) is carefully studied to determine consumer needs/wants, then, the product is designed and engineered to meet these needs.

In both approaches, the product is generally developed following several identifiable steps including:

1. Identifying the need/want (defining the problem).

2. Gathering data to provide a foundation for the product development activity.

3. Developing alternate solutions to the product need using sketches, models, and brainstorming techniques.

4. Evaluating the possible solutions against manufacturing, financial, marketing, and technical criteria.

5. Communicating selected solutions through drawings, bill of materials, specification sheets, and written or oral reports.

All product designs must meet the final test of good designs. They must be safe, functional, appropriate, and economical. Also, they must be designed with manufacture, sale, and operation in mind.

This learning module will allow students to take a design problem and move it from idea to specified product. It will present researching, ideation (developing ideas), imagineering (letting the imagination soar then engineer ideas back to reality), developing (sketching and modeling), and engineering (drawing, bill of materials). Throughout the module, developing, communicating, and evaluating ideas is the focus.

OBJECTIVES

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

1. List and describe the steps in the product design cycle.
2. Differentiate between production and market product design orientations.
3. Describe and participate in brainstorming sessions.
4. Generate, develop, and refine product ideas.
5. Prepare a product design statement.
6. Develop a data base for product design activities.
7. Differentiate between mockups and prototypes.
8. Construct a mockup of a product.
9. Describe detail, assembly, and system drawings.
10. Prepare engineering drawings.
11. Describe and prepare a bill of materials.

DAY	ACTIVITY
1	Introduce the functions of research, development, engineering, and their interrelationships, and discuss the factors involved in identifying and defining a design problem. Provide an overview of the procedure used to handle the design problem. Outline the techniques to be used and the design considerations to be taken into account.
2-4	Introduce the process of gathering data and defining problems. Introduce design problem. Have the students gather data and refine design problem.
5	Introduce and have students develop design direction statements.
6	Present an overview of the techniques used to generate and communicate product ideas, roughs, refined sketches, and detailed sketches.
7-8	Students should generate a set of rough, refined sketches for their assigned problem.
9-10	Introduce brainstorming, brainstorm product ideas, and select best ideas for development.
11	Students should incorporate results of brainstorming session into product designs.
12-13	Introduce dimensioning and have students dimension revised, refined sketches.
14-16	Introduce models, demonstrate mockup construction and have the students prepare a mockup.
17	Introduce product engineering and engineering drawings.
18-21	Have students prepare detail drawings
22	Introduce pictorials.
23-24	Have students prepare pictorial assembly drawings.
25	Introduce and have students prepare bill of materials.
26	Summarize module.

DAY	ACTIVITY

0 Well before introducing this module, the following tasks should be completed:

1. Prepare daily lesson plan and teaching materials for each lecture/discussion and demonstration.
2. Prepare 4-6 different product design assignments or briefs (see Appendix).
3. Obtain pictures or slides of well designed products.
4. Develop a sample market survey which will solicit opinions about product features customers want in a specific product.

1 Present a concise definition of each functional division of activity: research, development, and engineering. Provide examples to help clarify the type of activity (problems tackled, procedures used, and outcomes) within each function. Show some sample technical reports; products and processes that have been explored; and drawings, method sheets, and products engineered. Identify and differentiate between the subdivisions by the type of worked conducted.

1. Research: pure and applied

2. Development: product and process

3. Engineering: product, process, and plant.

Explain that titles refer to functions to be performed and one does not always find clear-cut divisions nor titles to persons conducting the activity - an "engineer" may work any or all of these and additional functions.

Present an overview of the differences designers and well designed products make upon the choices, uses, and effects of our lives. Point out that certain products have more appeal, work better, are constructed better out of better materials, and give us better conditions than do others; there are choices to be made.

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DAY	ACTIVITY

Motives for developing new products come from consumer needs, designer's creations, or process-related outgrowths. Discuss how some designers and inventors derive ideas and develop them into products—some fail, some succeed; some contemporary, some fads; some time-honored, some consumable; some renewable and recyclable; others obsolete.

Match designers with their products and analyze the design qualities within the products. Review the effect that time has on design-timing of advertising and supplying as in fads; length of time a design of a product remains in demand; and how quickly some are made obsolete overnight.

Public choice as a consumer is important. If the public would quit buying a product yielding ill effects, the producer would quit supplying it —lead-painted toys, tobacco, high sulfur coal, airplanes making too much noise, etc.

Show examples of goods designed products (use photos, slides or actual products).

Present the design procedure (see Introduction).

1. Identify problem
2. Gather data
3. Develop possible solutions
4. Evaluate solutions
5. Communicate solutions

2-4 Discuss the factors involved in identifying and defining a design problem. In keeping with the systems model, identify all the "input" one can find — consumer needs, wants, characteristics; producing capabilities; financial aspects, etc. Remark that company needs to work within certain restrictions on products they wish to produce.

Divide the class in groups of 3-5 students.

Provide a design problem to each group (see Appendix for examples).

Have each group:

1. Design a market survey which will determine what the customer wants to see in a new product (toy, etc.) - remember this class is using the consumer orientation to product development determine the desires of the customer, the design, and engineer a product to meet the needs. (Do in class.)

DAY	ACTIVITY

2. Conduct the survey with at least ten potential customers. (Do outside class.)

3. Survey the competition - find and analyze competing products by (a) describing the product with words and sketches, (b) listing product's strong features, and (c) listing product's weak features. (Do outside class.)

4. Gather data on designs and construction using school and community libraries. (Take class to school library.)

5 Introduce "Design Direction Statements" as the guide which directs all succeeding design activities. It gives focus and direction to all design work.

Using data gathered, have the class develop their first design direction statement (See Appendix). This statement may be revised a number of times as new insight is gained. A typical statement is:

"This is a market for a set of four wood trucks which can be used both indoors and outdoors by boys and girls ages 4-7. These trucks should be approximately 6" long and be seen as a set. The common design theme can be accomplished by using a standard cab. The market suggests that the types of trucks should be (1) log, (2) van, (3) gasoline tanker, and (4) flatbed. Interest can be developed by using woods of varying colors for the various truck beds."

6 Differentiate between "techniques" used in designing compared to design "considerations."

Present the design considerations in outline format and provide examples through photos, illustrations, and actual objects to depict good and poor aspects.

1. Design Factors: function, materials, appearance, construction, approaches, and effects.

(The last one on personal, societal, and environmental "effects" is not listed in references on design.)

DAY	ACTIVITY

2. Design Elements: line, shape, mass.

3. Design Principles: balance, proportion, harmony, emphasis, rhythm.

Present a preview of the techniques used to generate and record ideas for products, sketching with rough; refined, detailed, refined or presentation illustration; models and mockups; and presenting ideas to others for selection. Make note that these compose the "process" portion of the systems' model.

Present the types of sketches used:

1. Rough sketch is not a crude sketch but a quickly developed sketch. It captures original thoughts and forms a library of ideas. The larger the library the better the chance of it containing a good idea.
2. Refined sketch is a more complete sketch which integrates and enhances ideas caught by the rough sketches.
3. Detailed (dimensioned) sketch sizes the refined sketches.

Describe and demonstrate techniques used in making pictorial types of sketches — isometric, oblique, and perspective. Show how to develop thumbnail and refined sketches.

7-8 Have each student in each design group develop 3-5 rough sketches for each product as a whole; major feature of the product (i.e. for a toy train ideas for wheels, connectors between cars, methods of attaching wheel/axle assembly to chassis, etc.) must be explored.

Have each student in each design group develop a refined sketch for each product as a whole and each major feature.

NOTE: Students should be learning how to communicate using sketching techniques NOT drafting skills or numerous specific terms.

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DAY	ACTIVITY
9-10	Introduce brainstorming as a "gathering of two or more people to explore creative ideas on a subject where the ideas presented by one person stimulates other people to develop additional ideas."

Present the tenet of brainstorming:

1. Think first - judge later.
2. The wilder the idea, the better.
3. Avoid criticism.
4. Expand, combine, integrate ideas.
5. Quantity is the goal.
6. Record all ideas.

Have the students in each group present their sketches and brainstorm improvements. The presenter should record all recommended improvements.

Based on the brainstorming session, the students in each group should select the designs they will further develop and file the remaining ideas for reference. They should have an approved idea for each product, and an approved idea for each major product feature.

11 The students should prepare a set of refined sketches which incorporate the suggestions from the brainstorming session. (This activity should start as soon as brainstorming is over on Day 10.)

12-13 Introduce dimensioning. Present the idea that dimensioning provides geometric information (shape), size information, and location information.

Make the presentation informative but brief. The goal is to show students how to communicate information NOT become drafters.

The students should dimension the revised, refined sketches. This includes both total product sketches and product feature sketches.

14-16 Describe the different types of models and their uses — mockup (appearance), and prototype (working model). Describe the types of materials used to make mockup. Demonstrate the use of the tools, procedures and processes of making a mockup — a heavy paper dust pan, a cardboard toolbox, a styrofoam casting, a modeling clay sculpture, a balsa wood piece of furniture, etc.

DAY	ACTIVITY
	Point out that one of the purposes of making a mockup is to evaluate size, shape, and appearance of an object. Modification of design is made much more efficiently in the development phase rather than in later phases of engineering and production.
	Have each student group prepare one or more mockups of their products.
	NOTE: Introduce material selection and testing at this point and again on Day 25.
17	Describe the functions to be performed by product engineering: working drawings, a material list, and written specifications.
	Explain the necessity of accuracy and detail in the working drawings.
	Demonstrate techniques for composing multi-view, orthographic projection drawings. 1. Position of views 2. Projection of views 3. Weight of lines 4. Dimensioning of parts.
	Differentiate between detail (part) drawing which are usually orthographic projections, assembly drawings which are often exploded pictorials, and system (schematic) drawings.
	Have each group determine the drawings needed to communicate their designs.
18-21	Demonstrate producing detail drawings (dimensioned drawings with parts). Introduce tolerances.
	Have the student groups prepare the detail drawings for their product.
22	Introduce pictorials and demonstrate their production.

DAY	ACTIVITY
23-24	Have each student group prepare assembly drawing using dimensioned pictorials.
25	Introduce "selecting materials to meet design parameters." Present and have students prepare a bill of materials for each product.
26	Review product design and development. (Include in the review product testing.) NOTE: If a CAD system is available the days in the course beyond to 80 scheduled in this guide may be used to enlarge the drawing component to include CAD.

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DESIGN DIRECTION STATEMENT

GROUP #: ______________________ CLASS: ______________________

FIRST DRAFT: DATE: ______________________

SECOND DRAFT: DATE: ______________________

31

COMPETITION ANALYSIS SHEET

NAME: ______________________________ DATE: ______________

Name of the Product: ______________________________

Manufacturer: ______________________________

Retailer: ______________________________ Selling Price: __________

SKETCH OF THE PRODUCT

Product Description:

Strong Features:

Features Needing Improving:

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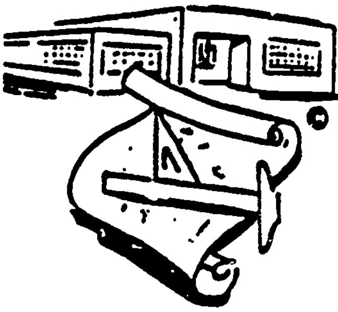


CREATIVE EDUCATIONAL PRODUCTS

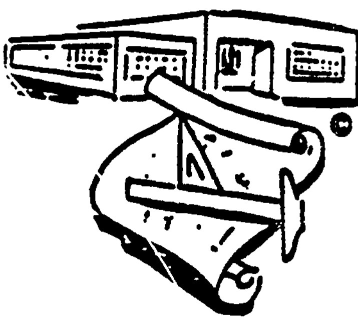
MOTOR CAR TOYS

You have been recently employed as a designer for the MOTOR-CAR TOY DIVISION of the CREATIVE EDUCATIONAL PRODUCTS COMPANY. This division of the company specializes in designing and manufacturing toy cars for children.

MOTOR-CAR, like, all companies, needs a constant flow of new product ideas to maintain its share of the highly competitive toy market. Your first major design assignment with the company is to develop a completely new line of toy cars which has high market appeal.

The chief designer has met with the company's marketing director and the following design criteria were developed for the project:

1. The line should have a minimum of four different models.
2. Each toy should be seen by the customer as an individual product, but the toys should also be seen as an integrated line of toys.
3. The primary material to be used in constructing the toys should be wood.
4. Each toy should not exceed four inches in length.
5. The products should all fit in the same standard sized package.
6. The products should be childproof and safe.
7. The products should be easily and efficiently manufactured on typical, general purpose woodworking machines.



CREATIVE EDUCATIONAL PRODUCTS

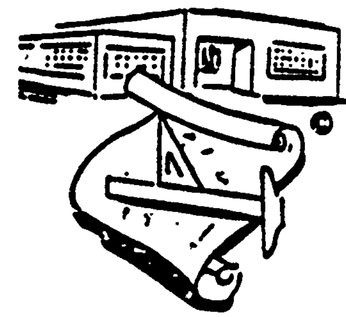
ROAD BED TOYS

You have been recently employed as a designer for the ROAD-BED TOY DIVISION of the CREATIVE EDUCATIONAL PRODUCTS COMPANY. This division of the company specializes in designing and manufacturing toy trains for children.

ROAD-BED, like all companies, needs a constant flow of new product ideas to maintain its share of the highly competitive toy market. Your first major design assignment with the company is to develop a completely new line of toy trains which has high market appeal.

The chief designer has met with the company's marketing director and the following design criteria were developed for the project.

1. The line should have a minimum of four different cars plus an engine.
2. Each toy should be seen by the customer as an individual product, but the toys should also be seen as an integrated line of toys.
3. The primary material to be used in constructing the toys should be wood.
4. Each toy should not exceed five inches in length.
5. The products should all fit, in the same standard sized package.
6. The products should be childproof and safe.
7. The products should be easily and efficiently manufactured on typical, general purpose woodworking machines.



CREATIVE EDUCATIONAL PRODUCTS

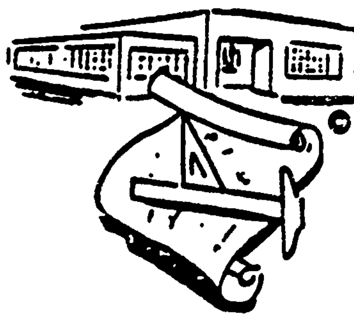
PLAY FAST TOYS

You have been recently employed as a designer for the PLAY-FAST TOY DIVISION of the CREATIVE EDUCATIONAL PRODUCTS COMPANY. This division of the company specializes in designing and manufacturing toy trucks for preschool children.

PLAY-FAST, like all companies, needs a constant flow of new product ideas to maintain its share of the highly competitive toy market. Your first major design assignment with the company is to develop a completely new line of toy trucks which has high market appeal.

The chief designer has met with the company's marketing director and the following design criteria were developed for the project.

1. The line should have a minimum of four different models.
2. Each toy should be seen by the customer as an individual product, but the toys should also be seen as an integrated line of toys.
3. The primary material to be used in constructing the toys should be wood.
4. Each toy should not exceed five inches in length.
5. The products should all fit, in the same standard sized package.
6. The products should be childproof and safe.
7. The products should be easily and efficiently manufactured on typical, general purpose woodworking machines.



CREATIVE EDUCATIONAL PRODUCTS

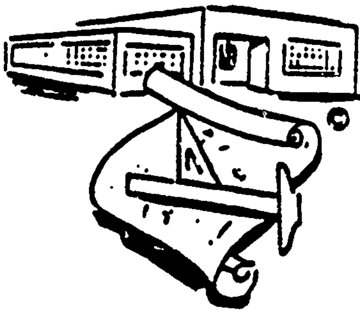
AGRA - PLAY TOYS

You have been recently employed as a designer for the AGRA-PLAY TOY DIVISION of the CREATIVE EDUCATIONAL PRODUCTS COMPANY. This division of the company specializes in designing and manufacturing farm-type toys for children.

AGRA-PLAY, like all companies, needs a constant flow of new product ideas to maintain its share of the highly competitive toy market. Your first major design assignment with the company is to develop a completely new line of farm toys which has high market appeal.

The chief designer has met with company's marketing director and the following design criteria were developed for the project.

1. The line should have a minimum of four different models.
2. Each toy should be seen by the customer as an individual product, but the toys should also be seen as an integrated line of toys.
3. The primary material to be used in constructing the toys should be wood.
4. Each toy should not exceed six inches in length.
5. The products should all fit, in the same standard sized package.
6. The products should be childproof and safe.
7. The products should be easily and efficiently manufactured on typical, general purpose woodworking machines.



CREATIVE EDUCATIONAL PRODUCTS

HI FLYING TOYS

You have been recently employed as a designer for the HI-FLYING TOY DIVISION of the CREATIVE EDUCATIONAL PRODUCTS COMPANY. This division of the company specializes in designing and manufacturing toy airplanes for children.

HI-FLYING, like all companies, needs a constant flow of new product lines to maintain its share of the highly competitive toy market. Your first major design assignment with the company is to develop a completely new line of toy airplanes which has high market appeal.

The chief designer has met with the company's marketing director and the following design criteria were developed for the project.

1. The line should have a minimum of four different models.

2. Each toy should be seen by the customer as an individual product, but the toys should also be seen as an integrated line of toys.

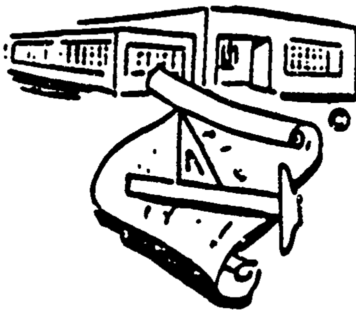
3. The primary material to be used in constructing the toys should be wood.

4. Each toy should not exceed six inches in length.

5. The products should all fit, in the same standard sized package.

6. The products should be childproof and safe.

7. The products should be easily and efficiently manufactured on typical, general purpose woodworking machines.



CREATIVE EDUCATIONAL PRODUCTS

SIREN TOYS

You have been recently employed as a designer for the SIREN TOY DIVISION of the CREATIVE EDUCATIONAL PRODUCTS COMPANY. This division of the company specializes in designing and manufacturing emergency vehicle type toys for children.

SIREN TOYS, like all companies, needs a constant flow of new product ideas to maintain its share of the highly competitive toy market. Your first major design assignment with the company is to develop a completely new line of emergency vehicle toys which has high market appeal.

The chief designer has met with the company's marketing director and the following design criteria were developed for the project.

1. The line should have a minimum of four different models.
2. Each toy should be seen by the customer as an individual product, but the toys should also be seen as an integrated line of toys.
3. The primary material to be used in constructing the toys should be wood.
4. Each toy should not exceed five inches in length.
5. The products should all fit in the same standard sized package.
6. The products should be childproof and safe.
7. The products should be easily and efficiently manufactured on typical, general purpose woodworking machines.

PRODUCT AND MANUFACTURING SYSTEM DESIGN

MODULE: 3 : Selecting and Sequencing Operations

LENGTH: 5 DAYS Manufacturing CLUSTER

Manufacturing depends on an orderly conversion of material resources into products. Product drawings (as developed in Module 2) are analyzed to determine the most efficient method of manufacture.

Operations are selected and sequenced. This activity involves using three basic tools of the manufacturing engineer:

1. Operation Sheet - lists the order of operations with their tools and machines that are needed to produce each PART.

2. Flow Process Chart - lists, in order, the operations, inspections, transportations, delays, and storage acts needed to produce each PART.

3. Operation Process Chart - a branched chart which shows the operations and inspections that are needed to produce the PRODUCT.

This learning module will allow students to first analyze the drawings then select and sequence operations needed to produce the product.

OBJECTIVES

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

1. Describe and prepare Operation Sheets, Flow Process Charts, and Operation Process Charts.

2. Analyze drawings to determine operations needed to produce a product.

3. Describe the need for proper planning in establishing manufacturing systems.

DAY	ACTIVITY
1	Introduce manufacturing engineering, and more specifically, operation selection and sequencing.
	Analyze a simple product to determine operations needed to produce it.
2	Organize manufacturing engineering teams.
	Have each team analyze drawing to determine operations required to build the product and prepare Operation Sheets.
3-4	Introduce Flow Charting.
	Have students prepare and present Flow Process Charts.
5	Prepare Operation Process Charts for the product.

PRESENTING THE MODULE

DAY	ACTIVITY

0 Before introducing the module, complete the following tasks:

1. Prepare lecture/discussion.

2. Select a simple product then develop for it:
   a. Operation Sheets
   b. Flow Process Charts
   c. Operation Process Charts.

   (Use the charts as backup in the Day 1 discussion. DO NOT distribute them.)

3. Select one of the products or product sets developed in Module 2 to be used for the remainder of the class.

   NOTE: This can be a class activity for Day 2 of this module.

4. Obtain a copy of the filmstrip with audio tape Developing Production Methods from:

   Manufacturing Forum
   Department of Industry and Technology
   Ball State University
   Muncie, IN 47306

1 Describe manufacturing engineering as the acts of:

1. Developing methods for manufacturing product
2. Tool design and engineering
3. Plant layout
4. Material-handling engineering
5. Time study.

Describe methods study:

Whereas, product engineers deliver the specifications for the product, methods engineers are to develop procedures and techniques whereby the product can be produced in an efficient manner.

Planning procedures, techniques, tool adaption, and arrangement for the production of the product, is the task of process engineering.

DAY	ACTIVITY
	Describe the first stage of design of process as the analyzing of the product (as specified by product engineering) into its component parts, sub-assemblies, and assemblies; this is called exploding the product.
	Then standardization of parts is considered - can some parts be used across product lines? New parts and special setups can be eliminated by using parts which are available or used in other products.
	Present a definition of an operation: it's all the "operation" things done with a component, sub-assembly, or assembly at one work station. Discuss the importance of identifying all of the operations as well as the sequential order in which they should be performed. Analysis of the details of the cutting, bending, heat processing, sanding, etc. will help in placing them in order. Some sequences may be altered after experimenting or even after producing a quantity of products.
	Take a simple product (bookend, etc.) and analyze it by: 1. Listing parts 2. Operations needed to make each part 3. Order for assembling the parts into a product.
	NOTE: Use class interaction to develop these items.
2	Organize the class into manufacturing engineering teams of 3-4 students each.
	Give each group one or more part drawings to analyze.
	All drawings for the parts (detail drawings) should be distributed.
	Have each group analyze each drawing and develop an Operation Sheet for the part or parts.

DAY	ACTIVITY
3-4	Introduce Flow Charting by illustrating and describing the use of Flow Process Charts; they are used to plot the activities needed to produce the components, sub-assemblies, and assemblies. They are developed for new products which have not been produced and are used to evaluate and improve existing operations. Illustrate and explain the standard flow process symbols; differentiate between the activities of each category. Use a sample product to illustrate the task of filling out a Flow Process Chart. Use examples to clarify differences between categories. Inform students that their charts will be a preliminary copy and that changes will be made as more details are developed. Show filmstrip, Developing Production Systems. Have the students prepare and present a Flow Process Chart for each part their group has assigned to them. A form for Flow Process Charts can be found on Page 46 of Wright, Manufacturing Laboratory Manual, or Activity 21A in Wright, Exploring Manufacturing - Activity Sheets.
5	With class discussion, prepare an Operation Process Chart on a large piece of Kraft paper. See Wright, R. Thomas, Manufacturing. pp. 145, for an example.

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MODULE: 4 : Designing Tooling

LENGTH: 20 DAYS Manufacturing CLUSTER

Mass production requires that interchangeable parts be produced by the manufacturing system. This requires machining and assembly equipment to perform their tasks reliably over repeated use. Often, special devices to insure consistent production are used. These devices, often called tooling, includes jigs, fixtures, patterns, templates, and molds.

A well designed tooling device will increase the speed, accuracy, and safety of an operation. It will eliminate the need for human judgement (cutting on a line) or manual holding parts near a cutter. Good tooling will cause the operation to operate at a more predictable speed. Loading parts, actuating the operation, and unloading the finished workpiece, will be made uniform.

Tooling may be seen as a product. It is designed (need determined, solutions developed, best solution selected, and drawings produced), fabricated (materials selected, parts produced, and final item assembled), and tested.

This module will allow students to determine tooling needs, propose possible solutions, select a promising solution, then fabricate, test, and adjust the device.

OBJECTIVES

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

1. Define and describe tooling.
2. Define and describe the types of tooling.
3. List the reasons for using tooling.
4. Determine the tooling needs for a simple product.
5. Sketch possible solutions for a tooling problem.
6. Prepare a tooling drawing.
7. Fabricate and test a simple tooling device.

DAY	ACTIVITY

0 Before introducing this module, complete the following tasks:

1. Fabricate some simple drilling, cutting, and assembly tooling which can be used for Day 1 demonstrations.
2. Obtain the filmstrip with audio tape, Tooling Design, from:
   Manufacturing Forum
   Department of Industry and Technology
   Ball State University
   Muncie, IN, 47306
   Cost: $10.00
3. Prepare an assortment of materials for tooling fabrication:
   a. Bases (5/8 particle board underlayment)
      Typical sizes: 8 x 12, 10 x 12, 10 x 14, 10 x 16
   b. Stops and fences
      (3/4 x 1, 3/4 x 1 1/2, 1 1/2 x 1 1/2 construction lumber)
   c. Hinges, springs, band iron, sheet metal, clear acrylic sheet, etc.

1 Introduce tooling by:

1. Explaining that tool engineering is responsible for preparing all equipment for efficient production of the product and for writing out the specifications for each workstation. It includes:
   a. Selection of type of machines and accessories used at each workstation
   b. Determination of adaptations and adjustments of equipment
   c. Design and development of unique tools and accessories
      (1) Jigs and fixtures
      (2) Patterns and templates
      (3) Molds, dies, and forms
      (4) Unique material-handling devices
   d. Retooling any equipment as needed
   e. Specifications for the installation of the setup.

2. Defining and showing examples of patterns, templates, molds, and forms. Examples include:
   a. Two-dimensional patterns: Full-size and accurate shape outline of two-dimensional layout, usually made of paper patterns for irregular flat products.
   b. Three-dimensional patterns: In-the-round object made for tracing with a stylus or forming a cavity as in a mold.
   c. Template: Full-size and accurate shape outline of a two-dimensional layout made out of some durable material for repeated tracing or stylus following - as at a tracer or duplicator lathe and of repeated layout of irregular lines.

DAY | ACTIVITY

d. Mold: A container-like unit with internal cavity of a conformity in the form of a reverse three-dimensional pattern - sand mold for casting; injection mold for plastic; slip cast mold for ceramics.
e. Die: Tooling containing either (1) internal contoured hole through which a material is pushed or pulled, or (2) external contour which passes through or around a workpiece (as in an extrusion die and a punch press).
f. Form: An open, shaped, structure to which a material is either held or forced against or into for the purpose of gaining new geometry of sheet materials - wood lamination form and plastic blowforming form.

3. Presenting types of tools, machines, and accessories to aid in considering a broad array of possible equipment. Many of the pieces of equipment will need to be adapted/fitted with tools and adjusted. Examples include:
   a. Tools and machinery items
   b. Cutting tools and dies
   c. Gauges, stops, clearance block, spacing pieces
   d. Safety aids
   e. Programming CNC machines.

   Show the use of accessories available within the laboratory (select those which might be used for the products being developed). Explain some of the characteristics of the accessories which industries may have.

4. Presenting the use of jigs and fixtures to produce manufactured products in quantity and quality. Some may be commercially available (dovetail jigs) while many are custom-made for unique applications. Some provide for flexible use (dovetails can be made of various styles and sizes) while others are used for a specific product only. Show use of auxilliary guides, work-holding devices, and workpiece and tool guidance systems in actual setups. Display special hardware which will aid in developing jigs and fixtures. Point out safety elements in the production of jigs and fixtures.

5. Showing the filmstrip, Tooling Design.

2 Using the Operation Process Chart and through class discussion, determine and list all tooling needs.

Divide the class into groups of 2-3 students and assign each group one or more tooling problems which will require fabrication of a jig, fixture, etc.

DAY	ACTIVITY
3-4	Have each group prepare rough and refined sketches of at least two (2) different ways to tool-up to meet the tooling problem. They should then select their best idea in consultation with the instructor.
5-8	Have each student group prepare a set of drawings for the tooling. These drawings may be: 1. A dimensioned drawing with a. Tooling in black b. Part in red c. Cutting tool (if used) in blue. OR 2. A dimensioned drawing of the tooling with a. Part overlay b. Cutting tool overlay. Check and approve all tooling drawings.
9	Demonstrate basic machines which will be used to fabricate tooling. Stress safe and proper use. Learning nomenclature is not important.
10-19	Supervise and provide individual demonstrations as students build tooling according to their approved plans. Tooling should be built with accuracy and ease of operation in mind. Corners should be rounded, edges softened, etc. Tooling operation should be tested at critical stages of fabrication. The test should consider accuracy of operation, ease of use, safety, speed (efficiency) of loading, using, and unloading. Tooling designs and the tooling itself should be refined and adjusted in terms of the tests. A good part should be produced from completed tooling before the device is "signed-off" by the instructor. NOTE: If a group or individual finishes his/her tooling before the end of the module, assign them as "helpers" where tooling development activities are slow.
20	Review module.

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MODULE: 5 : Developing Quality Control Systems

LENGTH: 10 DAYS Manufacturing CLUSTER

Products must function well, look attractive, and be consistent in their operation. In other words, the product must have quality - it must have a degree of fineness built into it.

Each product has its own quality standards. A fine piece of furniture should be flat and smooth. However, a very smooth nail would have low holding power. We generally expect higher quality from expensive or long-lived products. China cups are expected to be uniform in size and decoration. On the other hand, vending machine cups must simply hold the liquid for a few minutes or hours to meet our expectations. The appearance is secondary.

Quality is designed and built into a product. Manufacturing systems must be designed to produce a quality product. Proper materials must be selected (Module 2); operations must be wisely selected and sequenced (Module 3), and tooling must be designed and fabricated to produce uniform products (Module 4).

In addition to these tasks, workers must be encouraged to work with quality in mind and the product must be inspected to insure that they meet stated standards. This learning module will allow students to explore the last two elements: motivational and inspection programs.

OBJECTIVES

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

1. Define and describe quality in terms of product function and use.
2. Describe the motivational and inspection aspects of a total quality control program.
3. Determine quality control checkpoints (inspections) for a product.
4. Design and fabricate a simple inspection gauge.
5. Design and produce quality control motivational program materials.

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CALENDAR

DAY	ACTIVITY
1	Discuss/present quality control.
2-3	Identify inspection needs.
	Divide class into groups and assign each group inspection gauge design problems.
	Develop rough and refined sketches for inspection gauges.
4-5	Prepare engineering drawings for inspection gauge.
6-8	Construct and test inspection gauge.
9	Introduce quality control motivational programs.
	Have students develop motivational materials.
10	Review module.

DAY	ACTIVITY

0 Before introducing this module, the following tasks should be completed:

1. Prepare lecture/discussion plans and materials.
2. Construct or obtain sample inspection gauges.
3. Obtain sample quality control posters and materials.
4. Obtain the filmstrip with audio tape Quality Control from:
   Manufacturing Forum
   Department of Industry and Technology
   Ball State University
   Muncie, IN 47306
   Cost: $10.00

1 Introduce quality control by:

1. Presenting an overview of quality in terms of:
   a. Quality of design
   b. Quality relative to compliance to specifications and to expected use
   c. Quality of performance.

   Quality of a product is a responsibility of many groups within a manufacturing firm. The designer and product development personnel match quality to type of sales; market engineers provide input regarding possible sales and then promote the product of set quality; product engineers write specifications relative to intended product use, and process engineers maximize processes relative to product standards.

2. Explaining that quality control or quality assurance refers to maintaining the quality of components and products up to the standards as established. Inspection is the act of checking specific aspects of a component or product in compliance with specifications. Inspection is to be conducted in three stages:
   a. In preparation for production - upon delivery of materials
   b. During the production - in process
   c. After product has been produced.

3. Describing informal inspection as being accomplished by the operator of the workstation in the conduct of the job. Formal inspection is conducted by an independent inspector and is accomplished either on-the-line at location or in a centralized inspection room.

DAY	ACTIVITY

4. Expressing the need to identify how to go about the inspection tasks.
   a. What needs to be inspected? Incoming materials; components, sub-assemblies, and assemblies; completed products, and inspection devices.
   b. How many should be inspected? Depends on product - 100% of critical airplane parts; sampling of others. Sampling accomplished by checking every-so-many or every-so-many minutes.
   c. How inspect? Visually, mechanically, physically, or other. Describe the need to write out the technique and criteria for inspection at each formal inspection station and make a note on each informal step on the Operation Sheets.
   d. What criteria? Some parts will need to be checked for dimensions; measuring or gauging instruments will be needed.
   e. Describing the difference between a measurement device (or indicating gauge) and an attribute (or fixed) gauge. Assist students.

2-3 Through discussion and using the operation process chart from Module 3, determine the needs for inspection.

Divide the class into groups of 2-3 students.

Assign each group one or more inspection tasks.

Have each group develop rough and refined sketches for gauges or other devices to inspect the assigned product feature (length of part, location of a hole, etc.).

NOTE: Be sure the gauge measures both too small - too big (size), too close - too far (hold location, etc.).

4-5 Have the groups prepare drawings for their inspection device which either:

1. Shows the gauge in black; part with correct features in red and with incorrect features in green

   OR

2. Shows the gauge in black with overlays to show correct size part and reject parts.

DAY	ACTIVITY
6-8	Have the student groups construct and test their inspection gauges.
9	Introduce the concept of "motivating workers to build products with quality in mind." Discuss quality circles and use of motivational materials. Have each student develop a quality slogan and poster design (finish as homework).
10	Review module.

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MODULE: 6 : Developing Plant Layouts

LENGTH: 5 DAYS Manufacturing CLUSTER

Each manufacturing plant has an arrangement of equipment to insure efficient flow of people, materials, and products through the factory. The equipment is arranged in two basic ways. Plants which specialize in custom and intermittent production often arrange the equipment according to the process it is used with. The result is process departments - machining, assembly, finishing, etc.

Continuous manufacturing factories use the sequence of operations to be performed as the data base. The product dictates the arrangement and sections of the production line and takes on product names - chassis assembly, dash assembly, etc.

An integral part of each plant layout is material-handling which can be either:

1. Fixed Path - conveyors, pipes, chutes, etc. (used in continuous manufacturing).
2. Variable Path - forklifts, two motors, wheelbarrows, etc. (used in intermittent manufacturing and to supply continuous manufacturing lines).

This learning module will allow the students to prepare plant layouts and flow diagrams for the manufacturing system.

OBJECTIVES

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

1. Describe plant layout in terms of the manufacturing system used.
2. Differentiate between product and process layout.
3. Differentiate between and describe the uses for fixed path and variable path material-handling equipment.
4. Prepare a simple plant layout drawing.
5. Prepare a flow diagram.

DAY	ACTIVITY
1	Present/discuss plant layout and material-handling.
2	Divide class into manufacturing engineering groups. Assign each group a plant layout task. Have each group prepare plant layout sketches.
3	Have each group design material-handling system.
4-5	Have each group prepare plant layout drawings, flow diagrams, and material-handling plans.

DAY	ACTIVITY

0 Before introducing this module, complete the following tasks:

1. Prepare lecture/discussion plans and materials.
2. Construct or obtain two or three-dimensional models of laboratory equipment.
3. Prepare a laboratory floor plan without equipment located.
4. Build or obtain belt, roller, and/or air cushion conveyors.

1 Introduce the plant layout and material-handling functions of manufacturing engineering by:

1. Presenting overview on planning and installing the physical facilities in preparation for producing identified products. Manufacturing engineering is responsible for the layout of the workstations and the flow of the materials throughout the production floor; they are also responsible for the type and arrangement of the material-handling devices; they also arrange for storage, providing transportation of goods, and maintenance of both the setups and the facilities.

2. Reviewing requirements for storage. Consider storage and security of materials, components, and assembled products regarding:
   a. Incoming materials: Quantity and quality
   b. Goods in process: Remain on the line for continuous line production
   c. Goods in process with delay: Allow for secure drying time for glued or finished articles
   d. Batch-produced components: To storage awaiting authorization to be moved
   e. Finished products: Stores for controlled distribution.

3. Describing some of the computerized storage and retrieval systems used in industrial firms.

4. Presenting the way material-handling devices are accommodated for the production of the products. Standard items such as conveyors, boxes, pallets, and mobile carts and supplies are set in place by plant engineers. Unique handling devices needed specifically for handling the materials within or between workstations for the specific product need to be planned and fabricated by tool engineering.

DAY **ACTIVITY**

5. Describing alternative techniques and apparatus for handling materials. Containers assist in moving parts as well as providing storage, security, and accountability. Many types of commercial containers are produced; they often are made to stack with considerable weight, yet, nest when empty. Systems used to move items may include conveyors, mobile carts, dollies, or a hand truck. Often a tool stand, small table, or even a stool can be used beside a workstation to facilitate handling of materials.

6. Reviewing safety in relation to the physical facilities and all workstation's setups. Identify the standard color code system used to mark potential hazards and point out their use in the laboratory. Point out the use of standardized sign systems (and their colors) used throughout industrial and commercial buildings.

2 Divide the class into groups of 3-5 students.

Assign each group a part manufacture or assembly task and a portion of the laboratory to arrange.

Have the groups sketch or use models to develop a plant layout for their assigned task. They should use the Flow Process Charts from Module 3 for a data base.

NOTE: Caution groups to coincide safety and the flow of people and goods.

3 Have each group select a material-handling system for their assigned task.

Discuss and integrate the several plant layout sketches.

Have the groups modify their sketches so that their part fits into a "whole."

4-5 Have the groups:

1. Prepare a plant layout drawing for their section of the plant.
2. Prepare a flow diagram for their tasks.
3. Prepare drawings or sketches for their material-handling devices.

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MODULE: 7 : Producing Products and Analyzing the System

LENGTH: 10 DAYS Manufacturing CLUSTER

All the activities of the course have been leading to a major event - installing and operating a system to efficiently produce products to stated quality standards.

Four major phases are involved in this task:

1. Installing the production system
2. Pilot-testing the system
3. Running the system
4. Monitoring output.

This learning module will allow students to put their product and manufacturing system designs to the ultimate test - they will operate the system to produce a LIMITED number of products which meet design specifications.

OBJECTIVES

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

1. Design a simple workstation.
2. Install a simple production system.
3. Participate in the testing and operation of a simple production system.
4. Analyze the effectiveness of a simple production system.
5. Discuss the impacts of production systems on people and society.

CALENDAR

DAY	ACTIVITY
1-2	Discuss/present work station design and specifications.
	Develop work and inspection station designs.
3	Install and test production system.
4-5	Train worker and pilot-test production system.
6-8	Run production system.
9	Analyze effectiveness and output of production system.
10	Discuss impacts of production systems on people and society.
	NOTE: Additional days in the course may be used for this discussion.

PRESENTING THE MODULE

DAY	ACTIVITY
1-2	Discuss workstation design specifications - the How to do the Job.
	Assign each student a work or inspection station and have him/her develop a layout and written directions for its operation.
3	Using the specifications and plant layout drawings, install and test the production system.
4-5	Conduct a training session and a pilot run.
	Assign a student to each workstation.
	Show each student how to perform the job properly and efficiently. Do not provide other information, i.e. blade types, abrasive types, etc. This is on-the-job training.
	Have each student complete one cycle of his/her operation as soon as he/she receives the demonstration.
	After all demonstrations are complete, build 2-3 products, carefully watching each student.
	Analyze the pilot run.
	Make adjustments.
6-8	Review production tasks - stress safety.
	Run production line to build 20-30 products.
	Have inspectors inspect each product and maintain quality control record and have the supervisors maintain production records.
	NOTE: Production and inspection reports form may be found on Page 57 and 58 of Wright, Manufacturing Laboratory Manual or Activity 24C and 24D in Wright, Exploring Manufacturing - Activity Sheets.
9	Analyze production activity - quality, productivity, needed improvements, etc.
	Distribute products.
10	Summarize course.

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