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ABSTRACT

This guide is intended for use in teaching a course in human and product transportation systems. The purpose of the course is twofold. First, students are introduced to the design process and the steps used to analyze various solutions to basic problems. Second, the course focuses on the application of the design and evaluation process to review a given problem in the transportation industry. 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. An outline of the major topics addressed during the course is presented. The remainder of the guide consists of learning modules on the following topics: analyzing transportation systems, using the design and evaluation process, identifying transportation problems, defining transportation problems, developing possible solutions, selecting an appropriate solution, testing possible solutions, evaluating solutions, implementing solutions on both a small and large scale, and presenting solutions. 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, related diagrams and drawings, 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 assured, should be able to interact with the technological nature of society and help impact the type of future new technologies can provide. Additionally people should be able to be contributors to a society in their several roles, including citizen, voter, investor, consumer, worker, and leader.

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

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

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

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

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

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

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

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

THE CURRICULUM GUIDE IN AN INSTRUCTIONAL SYSTEM

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

THE TEACHER

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

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

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

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

THE STUDENT

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

THE TEXBOOK

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

THE CURRICULUM GUIDE

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

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

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

THE APPARATUS

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

THE REFERENCE LIBRARY

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

DAILY LESSON PLANS AND EVALUATION

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

DESIGN AND EVALUATION OF TRANSPORTATION SYSTEMS

The design and evaluation process is the method by which industry identifies and develops solutions to given problems. This creative activity may involve anything from altering a simple, technical device, to changing the operation of a complex system. While there are numerous technical design and evaluation procedures in use today, all employ basically the same sequence of steps in attempting to improve a system or process.

The purpose of this course is two-fold. First, students should learn about the design process and develop an understanding of the steps used to analyze various solutions to basic problems. It is not necessary that students memorize the actual steps; rather, it is important they comprehend the fundamental process of evaluating the technological systems which are designed to improve our lives. Second, this course will focus on the application of the design and evaluation process to review a given problem in the transportation industry. At this point, students become "experts" and apply not only their knowledge of the design process, but also utilize their experiences, creativity, and resourcefulness to solve a problem.

Work done in this course reflects a combination of individual effort and group dynamics. Since industry uses both methods, it is important to allow for both in the secondary classroom. This also helps develop the concept of teamwork which is widely used in the world of technical design.

Course Objectives

The study of designing and evaluating transportation systems will enable a student to:

1. Understand the logical sequence of events in modern design and evaluation processes.
2. Develop or adapt a design procedure to evaluate transportation problems.
3. Identify relevant problems in transportation systems and technology.
4. Develop alternative solutions to transportation problems.
5. Implement and evaluate solutions to simple transportation problems.
6. Communicate technical information related to a formal research activity.
7. Apply basic problem-solving and analytical abilities to a formalized technical problem.

COURSE OUTLINE

Module Number	Title and Content	Time (Days)
1.	Analyzing Transportation Systems Transportation system components Transportation environments	5
2.	The Design and Evaluation Process Designer traits The design process Solving transportation problems Identifying the problem Defining the problem Developing possible solutions Selecting an appropriate solution Implementing the solution Evaluating the solution	18
3.	Solving a Transportation Problem Identifying a Transportation Problem Technical Managerial Environmental Interrelated/System Defining the Problem Gathering data Preparing a definition Developing Possible Solutions Past applications and systems Present applications and systems Future applications and systems Selecting an Appropriate Solution Technically feasible Economically feasible Socially acceptable Testing possible solutions Developing prototypes Testings systems Refining and implementing solutions Evaluating Solutions Cost vs. benefit Efficiency Environmental impact Long-range feasibility	50
4.	Presenting Solutions Written reports Oral reports Models	7

DESIGN & EVALUATION OF TRANSPORTATION SYSTEMS

I. Analyzing Transportation Systems

   A. Historical Development
      1. Evolution
      2. Social aspects
      3. Environmental aspects

   B. Transportation Concepts
      1. Technical concepts
      2. Managerial concepts
      3. Environmental concepts
      4. System operation

   C. Transportation Mediums
      1. Land
      2. Water
      3. Atmospheric
      4. Space

II. The Design & Evaluation Process

   A. Purpose of Design/Evaluation

   B. Designer Traits
      1. Creativity
      2. Analytical skills
      3. Problem-solving abilities
      4. Research talents
      5. Technical understanding
      6. Communication skills
      7. Team/goal-oriented

   C. The Design\Evaluation Process
      1. Identifying problems
      2. Defining the problem
      3. Developing possible solutions
      4. Selecting an appropriate solution
      5. Testing/refining solutions
      6. Implementing the solution
      7. Evaluating final solutions
      8. Communicating results

III. Identifying Transportation Problems

A. Technical
1. Propulsion
2. Suspension
3. Control
4. Guidance
5. Structural
6. Support

B. Managerial
1. Planning
2. Organizing
3. Directing
4. Controlling

C. Environmental
1. Functional
2. Economical
3. Social
4. Human

D. Interrelated/System

IV. Defining Transportation Problems

A. Technical

B. Managerial

C. Environmental

D. Interrelated/System

V. Developing Possible Solutions

A. Past Application/Solutions
1. Renovated
2. Adapted
3. Replaced
4. Eliminated

B. Present Applications/Solutions
1. Update
2. Improve
3. Replace

C. Future Applications/Systems
1. Develop new
2. Develop alternatives

VI. Selecting an Appropriate Solution

A. Technical Feasibility
   1. Most probable to succeed
   2. Most closely related to problem
   3. Available technology

B. Economical Feasibility
   1. Most probable to succeed
   2. Within budgetary guidelines

C. Social Feasibility
   1. Human
   2. Service
   3. Aesthetics

D. Other

VII. Testing Possible Solutions

A. Developing Materials
   1. Prototypes/models
   2. Charts/graphs/plans, etc.
   3. Physical devices
   4. Energy/power
   5. Schedules/timetables
   6. Other

B. Testing Solutions/Systems
   1. Experimentation
   2. Pilot-testing
   3. Comparative studies
   4. Other

C. Refinement
   1. Start over
   2. Revise key elements
   3. Terminate the project

VIII. Evaluating Solutions

A. Cost Benefit
   1. [illegible] costs
   2. Related costs
   3. Actual benefits

B. Efficiency
   1. Productivity
   2. Interfacing with related systems

C Environmental Impacts
   1. Land/water/air
   2. Pollutants
   3. Aesthetics
   4. Conservation
   5. Other

D. Long-range Feasibility
   1. Adaptable to future needs
   2. Flexibility
   3. Timetable

IX. Implementation

A. Small-scale

B. Full-scale

X. Presenting Solutions

A. Written Documentation
   1. Reports
   2. Journals
   3. Graphs/charts
   4. Other

B. Oral Presentations
   1. Individual reports
   2. Group presentations

C. Related Materials
   1. Visual media
   2. Model/prototypes
   3. Vehicles
   4. Displays
   5. Other

MODULE: 1 : Analyzing Transportation Systems

LENGTH: 5 DAYS Transportation CLUSTER

The practice of transporting people and cargo is a fundamental activity in all societies. As more and better technologies have emerged, the means of transport have improved dramatically. This is true in all areas of transport—land, water, air, and space. The advances in transportation technology have also provided new possibilities for moving from location to location. We now have choices as to which device or system will be the best for certain applications.

The procedures used to identify and review a particular problem is not limited to fields of modern technology. However, the ability to take a given situation and compare possible solutions or alternatives is common to designing technical systems. In the area of transportation, this should be quite evident. Examples of the "resulting" efforts of transportation designers include our national highway systems, varying types of recreational vehicles, commercial airline operations, high-speed rail networks, and the latest designs in spacecraft. Each item started as a design challenge and resulted in a commercially viable product, or service,to fill a societal need.

Analyzing various problems is the first step in the design and evaluation process. It is during this step in which the technical and system information is gathered on a specific topic. This information should include both background circumstances as well as present situations. There is absolutely **NO** attempt made at problem identification or solution development; to do so would lead to poor conclusions and inappropriate solutions. There **MUST** be a **THOROUGH** understanding of the area before any further steps can be taken.

This module deals with analyzing transportation systems with the topics being presented in three groups:

1. Historical Development
2. Concepts of Transportation
3. Transportation Mediums

The content of this module is directed towards developing an understanding of transportation systems with activities that will allow the students to follow individual areas of interests in the field. A broad knowledge base must be developed at the outset in order to apply various concepts later in the course.

OBJECTIVES

At the end of this learning module, students should be able to:

1. Discuss the link between transportation and cultural evolution.
2. Give examples of how society has affected the development of transportation systems.
3. Discuss the environmental concerns involved with transportation systems.
4. Explain what is meant by transportation **system**.
5. List and explain the basics of transportation system operations.
6. Describe the managerial function of transportation systems and industries.
7. List and explain the basic technical systems common to transportation systems.

CALENDAR

DAY	ACTIVITY
1	Complete the administrative details of the course and introduce the focus of the design and evaluation process in transportation industries.
2	Film or video tape about developing or revising a transportation system. Analyze each component of the "system."
3-4	Complete analysis forms for typical modes of transportation.
5	Review basics of transportation system; evolution, operation, and management.

PRESENTING THE MODULE

DAY	ACTIVITY
0	Obtain a short film/video tape which covers the design and evaluation process in today's world of transportation systems.
1	Introduce the course; complete necessary administrative details.
2	Show a film or video tape which illustrates the concepts of transportation systems, design and evaluation processes, and evolutionary aspects of transportation technology. Use the content of the media to reinforce those concepts learned previously introduced in earlier courses and help generate a broad base of understanding. This presentation should start with a quick look at the historical development of different systems and their link with society, culture, and environment. Also, the teacher must create and duplicate the forms for the next day's activity.
3-4	Divide students into four small teams and have each group attempt to complete the analysis form for a different medium--land, space, air, and water transportation. (See the sample form in the Appendix to visualize how students may complete this activity.)
5	On a chalkboard, the teacher should compile a master listing of the more common problems encountered in the world of transportation. Explain how the class is organized to allow students large amounts of laboratory time to solve problems like those identified.

BIBLIOGRAPHY

TEXTBOOKS

While there is no textbook written specifically for this type of course, these public school textbooks and reference materials cover many of the topics presented in the module.

Armstrong, J.H., The Railroad—What It Is, What It Does. Simmons-Boardman Publishing, Omaha, NE, 1982.

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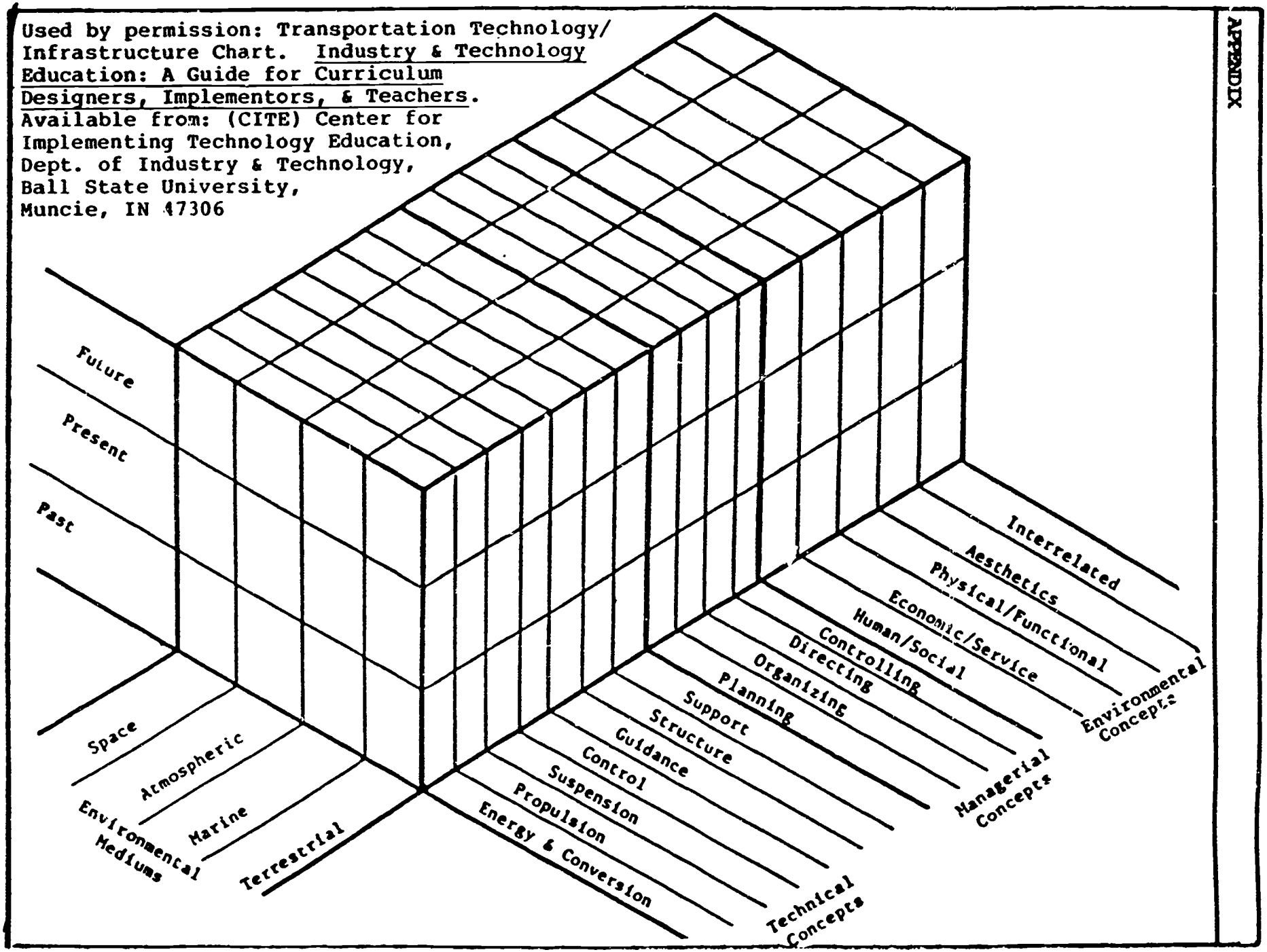

APPENDIX

Create and reproduce a simple form like this for the lesson on analyzing transportation systems and potential problem areas. (Handout form)

ANALYSIS OF TRANSPORTATION SYSTEMS
"TYPICAL PROBLEMS"

Complete this chart by providing 1-2 examples (in each block) of common problems in past, present, and future modes of transportation. Refer to the examples on the first few lines.

SYSTEM:	PAST	PRESENT	FUTURE
TECHNICAL:			
Propulsion-speed	Stagecoach was very slow	Trains are fastest, practical land systems	New, more efficient fuels required
MANAGERIAL:			
Regulation of traffic flow	Traffic congestion a new problem in many cities	Regulating speed on interstates a problem	Problems with city "beltways"
ENVIRONMENTAL			
Vehicular "pollutants"	Horse-drawn vehicles caused problems	Air pollution major problem in most cities	Cleaner fuels & engines required

APPENDIX

Among the best resources for information and ideas to develop student activities to support the module, include the following:

MAGAZINES

High Technology, (Various Issues), High Technology Publishing Corporation, P. O. Box 2810, Boulder, CO 80322.

Popular Science, (Various Issues), P. O. Box 2871, Boulder, CO 80322.

The Technology Teacher, (Various Issues), International Technology Education Association, 1914 Association Drive, Reston, VA 22091

FILMS/MEDIA

MODERN TALKING PICTURE SERVICE
Film Scheduling Center
5000 Park Street, North
St. Petersburg, FL 33709

NASA LEWIS RESEARCH CENTER
Film Comm.
108 West Grand Avenue
Chicago, IL 60610

MODULE: 2 : The Design & Evaluation Process

LENGTH: 18 DAYS Transportation CLUSTER

The design and evaluation process is the method by which industry identifies and develops solutions to given problems. Although there are a variety of design procedures used in various industrial settings, all contain essentially the same series of steps. The basic steps described in this course include:

1. identifying problems
2. defining the problem
3. developing possible solutions
4. selecting an appropriate solution
5. tesing/refining solutions
6. implementing the solution
7. evaluating final solutions,

The content of this module is centered around the promoting of what takes place at each step of the design process with the emphasis being on problems of the transportation industry. The concepts involved with each step should be the goal and not the problem itself. Those traits which the designer/evaluator need are also examined and practiced by the students.

The module is organized to give the students a broad introduction to the design and evaluation process and emphasize the operations taking place at each stage. Finally, the students should enter into a review session where design concepts are reinforced.

OBJECTIVES

At the end of this learning module, students should be able to:

1. Define the design and evaluation process.
2. List and explain the seven steps of the design and evaluation process.
3. Apply the design and the evaluation steps to a given problem.
4. Identify those personal traits needed in the design and evaluation process.

CALENDAR

DAY	ACTIVITY
0	Teacher selects an activity which will become the focus of this learning module over the design and evaluation process.
1	Introduce the design and evaluation process; explain major activity to be used during the module.
2	Demonstrate equipment/devices; cover safety rules for the activity; begin laboratory activities.
3-4	Provide laboratory time to complete identification phase of the transportation problem; teacher-directed activity involving student brainstorming sessions.
5	Presentation on major issues in transportation - evolution of various systems, industries, etc.
6	Introduce "development of possible solutions" step in the design process.
7-8	Group work to define problems and select appropriate solutions.
9	Narrow the possible solutions to one "best" proposal.
10-12	Class/laboratory time to evaluate the proposed solution; document facts during review phase.
13-14	Implement and evaluate the best solution.
15	Class evaluation of developed ideas.
16-17	Preparing for presenting facts of the design and evaluation activity; present written or oral reports.
18	Wrap up presentation over content of the module.

PRESENTING THE MODULE

DAY	ACTIVITY
0	The primary purpose of this module is to teach the basics of the design and evaluation process. This may be easily done by organizing a sample activity and running through all the steps of the procedure. Therefore, the instructor must select several "quick" design and evaluation problems which students can attempt to solve. Possible activities include:

1. Using the Carbuilder software to develop sample vehicles and test various design factors directly on the computer screen. This example should appeal to many teachers since it involves little equipment and supplies; does not require elaborate safety instructions for a large facility and equipment; and, simulates the use of computerized systems in designing various transportation systems.

2. Using a wind tunnel, test various shapes of paper or model airplanes and record the effects of different aerodynamic features.

3. On a small waterway, develop and test simple boat hulls that reflect the variety of shapes from marine vehicles:
   a. barges
   b. canoes
   c. ore boats
   d. hydrofoils
   e. aircraft carriers
   f. pontoon boats
   g. other.

4. Compare the speeds of typical land or air transportation vehicles and how to efficiently improve the rate of travel for different commercial vehicles.

5. Explore the shapes of semi-trucks; why are they shaped the way they are, how might they be altered to improve mileage, etc. Again, this activity might include a wind tunnel experiment, or simply involve a research effort in a good library.

6. Other.

In selecting the most appropriate activity for this module remember that the assignment must be useful in covering all areas of transportation systems. Among the topics to focus on are the technical, managerial, system, and environmental considerations.

PRESENTING THE MODULE

DAY	ACTIVITY
1	Present a short discussion of "What is the design and evaluation process?". This presentation should start with student input on what the design process is. It should be emphasized that all industries use the design process and it is not limited by one specific area or industry. Introduce the activity which the class is going to be involved with and set up the guidelines, class rules, procedures, etc.
2	Explain the safety rules involved in the class design activities and demonstrate the proper use of computer equipment, machines, laboratory testing devices, etc.
3-4	Provide student laboratory time to analyze possible problems in the transportation system selected for the activity. This may be a teacher-directed session. Also, emphasize that this process is actually the first step in the design and evaluation process - Identifying Problems.
5	From a short period of library or classroom research, attempt to develop an overall picture of the problem at hand. Examine the following topics as applied to class activity: 1. Historical Development of Transportation 2. Principles of Transportation 3. Transportation Industries.
6	Present in lecture/discussion the next steps in the design process in detail. Give specific examples which take place during: Step # 1 - Defining the problem. Step # 2 - Development of possible solutions.
7	Provide one full laboratory period to define and propose possible solutions to the "class" problem.
8	Discuss solutions that the different groups (or the class) developed. Use student discussion to reinforce the need for completing each step of the process thoroughly. Review the design process steps used to date and the concepts of each phase. Have students discuss specific ways to solve their design problem.

DAY	ACTIVITY
9	The next phase involves selecting the best idea; the solution which meets the requirements best without further testing is chosen. Possibly more than one solution may be combined. Once a solution is picked, it is then implemented completely. This must be done to test the solution for satisfactory results. If during the evaluation steps there are errors discovered then a possible redesign or alternate solution should be done. Assign group or individual work on problem(s); have the students identify the single, best solution. Begin the testing phase.
10-12	Provide laboratory or classroom time to evaluate the proposed solution. Emphasize the importance of documenting experimental data during this review step. Also, prepare a short talk explaining the steps of testing/refining solutions.
13-14	Implement and evaluate the "proposed solution."
15	As a class, decide the success of the developed solution and evaluate the final design. Also, rate the accurate use of the design and evaluation process itself.
16-17	Organize student classroom/laboratory time to present the information collected during this activity. This may involve the development of: 1. Written reports 2. Oral presentation 3. Graphs/charts 4. Models/prototypes 5. Other. The instructor may need to demonstrate the use and production of audiovisual materials. This may involve using computers/word processing centers to keyboard reports or graph data.

DAY	ACTIVITY
18	Develop wrap-up discussion/illustrated presentation on the categories of modern transportation technology and systems.

The major emphasis is to tie all the topics together to present a complete picture of transportation systems.

Transportation Operations

1. receiving
2. holding/storing
3. loading
4. moving
5. unloading
6. delivering

Management Functions

1. planning
2. organizing
3. directing
4. controlling

Social Aspects

1. governmental factors/laws/regulations
2. community factors
3. social attitudes

Environment Factors

1. the effects on land
2. pollutants
3. conservation
4. aesthetics

Business/Economic Factors

1. costs
2. profits
3. economics

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TEXTBOOKS

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MODULE: 3 : Solving A Transportation System

LENGTH: 50 DAYS Transportation CLUSTER

The purpose of this course is to allow students to explore what they perceive to be vital issues in transportation technology and propose a solution to the various problems they have identified. Most of the remaining time in the course is structured as laboratory time for student experimentation and research work. The result of this activity should be a better understanding of our modern transportation industry.

Before students begin their major activity, the teacher should present and describe the design and evaluation process to be used for the course. Also, a short description of laboratory procedures, safety instruction, and class requirements should be covered. The remainder of this introductory section deals primarily with the design process as applied to transportation problems. Information provided here should prove useful in structuring lectures and/or illustrated talks for the class.

To adequately solve any problem, we must fully understand the nature of the issue; positive and negative factors, impacts upon related systems, known technical means, criteria for change, etc. Once we have a grasp of the given problem, we have something to "attack". Solutions must always be directed towards the stated problem.

Identifying transportation problems is the first basic step in the design process. It is during this step that general problems are reviewed and compared to previously acquired information. From this information, a problem statement is developed. The problem statement should be very broad in nature. Common problem areas related to transportation technology include the following:

1. technical concept
2. managerial matters
3. environmental factors
4. interrelated/system concepts.

Interrelated problems often present a special challenge to transportation experts. A common example would be the cargo transfer facilities just off a major highway. Typical problems encountered at a truck terminal may relate to management (scheduling, labor, etc.), technical issues such as containerization or material handling techniques, or environmental concerns (traffic congestion, noise, etc. around the facility). At times, varying circumstances demand radical solutions to rather unconventional problems.

During the identification stage, there should be no attempts to solve the problem(s) identified. Again, if solutions do begin now they would lead to poor conclusions or inappropriate changes in a system.

To begin this module, have students identify various issues in the area of transportation. Hopefully, they will identify general problems with a system or device. Upon narrowing down the major topics, have each student or team propose a problem statement related to a major issue. The more fundamental the problem statement the better the process will work (i.e., it will be less limiting for the design and evaluation phase).

Defining transportation problems is the second step in the design process. It is during this step that the general problem statements just developed are analyzed in more detail and basic (root) problems identified. The four areas —technical, managerial, environmental, and system, are still the same, but now they are broken down further to identify the fundamental problem(s). See the course outline for information concerning specific content areas.

At this time, the basic problems can be followed by the students. There may (and probably will) be more than one root problem for each problem. This provides an opportunity to introduce the difficulties encountered by designers/engineers when trying to solve what appears to be a relatively simple problem. Also, the idea of priority planning could be introduced and then practiced on all research done from this point forward.

"Developing possible solutions" is the next stage in the design and evaluation procedure. This step involves the formulation of several "possible" methods of solving the specified problem(s). Generally, the more proposed solutions identified at this point the better the chance of developing an acceptable means. Solutions to root problems are usually the result of intensive research and the careful analysis displayed by the investigating team.

Possible solutions are often derived from a review of past applications or systems. A comprehensive look at present means, yields potentially valuable data. Quite often, trends for future applications are assessed as well. Again, the attempt is to collect a wide range of ideas and facts before proposing a set solution.

The fourth step involves selecting the "most appropriate" solution for the problem at hand. This idea should be closely related to the problem statement and appear to have a high probability for success. Feasibility from an economical, technical, and social viewpoint have been considered. The result is an educated, researched "guess" that will improve a technical system and benefit society. However, the proposed conclusion has yet to be tested under realistic conditions. Further evaluation is needed to verify the idea.

If all the previous steps have been developed properly then this "best" solution should be derived fairly easily. It is often not a single solution from the list, but actually a combination of several suggestions (illustrating the importance of a large quantity of solutions in the previous step). As before, the intended solution must have direct bearing on the problem statement, and have limited impacts upon unrelated systems.

Once a set solution is identified and accepted, the idea is ready for testing and refining. It is during this fifth step that perhaps the most observable work is done. The testing stage involves building or altering "something" in a system and evaluating the idea in a limited setting. Prototypes are often developed in a laboratory for review during this phase. Formal experimentation using laboratory or field apparatus may be performed and data collected for review. Comparative studies also result in a better understanding of other technical factors. Small-scale testing under actual conditions is often crucial to the successful evaluation of the proposed design.

Many refinements are required at this stage in the process. Any problems encountered (shapes, sizes, efficiency, operation, etc.) are observed and the proposed agenda modified. Based on this careful evaluation, the proposed idea is usually analyzed for the following:

1. costs vs. benefits
2. efficiency
3. environmental impacts
4. system feasibility
5. human/service factors
6. economic considerations
7. practicality
8. other.

Problems encountered at this junction (shapes, sizes, costs, operations, devices, etc.) are observed and refinements suggested to improve the idea. It is not out of the question to revise key elements and retrace several design steps. In other instances, the research project is terminated at this point due to the identification of significant problems or a lack of potential seen in the work.

Implementation of a refined solution follows this early evaluation process. One may point out that implementing and evaluating steps go hand-in-hand. However, for clarification purposes we have tried to separate them for educational purposes. Testing is presented as a limited process while implementation activities involve a full-scale deployment of the new solution. In practice, these steps often overlap or are alternated to fulfill the needs of the program.

Generally, implementation involves the phasing in of a new process, technology, or system to complete the final evaluation work (our seventh and last step). The final phase should be the full and complete implementation of the solution. While varying factors may still be changed at this point, the further along into this step the more costly it will become to prepare alternative plans. This is a major concept in developing transportation systems; often the resulting solutions are not considered worth changing at late stages of development.

Perhaps the best way to present the whole design and evaluation process to your students is to structure several class periods for describing the practice. Be sure to draw upon periods for describing the practice. Be sure to draw upon examples from the previous module (actual events in that unit which fit into the model). This promotes an understanding of basic steps in the development activity.

In structuring the major activity for the class, flexibility is critical. The selection of a specific topic should be left to the students. Also, the instructor should not limit the work to only individual activities or team assignments but allow a combination based on the needs of each proposed study of a transportation problem. In addition, remember to develop a working atmosphere where students will be productive and safe.

While most of the module is devoted strictly to laboratory time, the instructor may want to schedule weekly update periods to review individual, and team progress. In addition, a daily procedure sheet may be necessary to complete administrative tasks and facilitate cleanup. As before, exact procedures are determined by the individual instructor, and the needs of the students.

OBJECTIVES

At the end of this learning module, each student should be able to:

1. Discuss how technical factors affect transportation systems and their design.

2. Discuss how managerial concerns have and will affect transportation system development and operation.

3. Explain the impact of environmental concerns on transportation systems in the past, present, and future.

4. Discuss how the different problem areas are interrelated and how they have to be addressed as such.

5. Apply the design and evaluation steps to a given problem.

6. Discuss and demonstrate various brainstorming techniques.

7. Explain and demonstrate the evaluation process on a given solution and test results.

8. Describe how redesigning and new solutions are fed back into the design process from this step.

CALENDAR

DAY	ACTIVITY
1-3	Establish the classroom procedures to be followed for the major design and evaluation activity; outline possible topics to explore for the assignment. Demonstrate general classroom and laboratory equipment for use by the class; cover all safety rules that apply for the activity.
4	Begin student work on individual or team activities; approve all topics before students get very far into the assignment.
5-48	Provide laboratory time to complete all design and evaluation work; assess the progress of the students on a weekly basis. The instructor should work with the students to complete all design, research, and evaluation work for the major assignment.
49-50	Wrap up the major activity; clean up the laboratory and classroom; disassemble special fixtures and devices.

DAY	ACTIVITY
1-3	Outline the procedures to be used for the activity on designing and evaluating the specific transportation problem; list and explain example "topics" to explore during the assignment; demonstrate all critical equipment and materials to be used by the students; cover individual safety rules and procedures.

Allow students to come up with their own ideas to investigate, or suggest one of the activities listed below for individual or small group exploration.

1. Develop a magnetic levitation vehicle using permanent magnets.
2. Produce a vacuum-powered elevator.
3. Develop a subway system; vehicles, propulsion system, control system, station facilities, etc.
4. Design a system that separates sand, pea gravel, and larger rocks into different piles.
5. Modify the gearing on a small go-cart to improve efficiency.
6. Devise a hovercraft that will carry a 3-pound box across a bench top.
7. Compare the aerodynamics of various wing designs on model airplanes.
8. Develop a new design for a helicopter-type craft.
9. Create a pipeline system that can be used to pump small gravel across the classroom.
10. Design a vehicle that has no motor but can travel 10 feet, stop, start again, and travel another 10 feet, and back up to the original spot.
11. Modify an old lawn mower deck into a remote-control vehicle.
12. Explore the operation of a local airport and revise the scheduling system to make reduced traffic around the terminal area.

DAY	ACTIVITY
	13. Design a containerization system for the supplies that are sent to the school.
	14. Create an operating model of a canal and lock system.
	15. Develop a master plan for a space colony or orbiting station.
	16. Others.
	Help students begin their activities; approve all preliminary plans early in the process.
5-48	Structure laboratory periods to allow students to work individually or in small groups to complete their design, research, and evaluation work. Have daily or weekly update sessions to track the progress of the work.
	Duplicate and use the progress forms provided in the Appendix to insure students complete their work in the proper sequence. Also, this provides a chance to check on the daily efforts of each student.
49-50	Wrap up the major activity; organize the class to clean up the laboratory area; disassemble special devices, fixtures, equipment, etc.

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While there is no textbook written specifically for this type of course, these public school textbooks and reference materials cover many of the topics presented in the module:

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Prepare a handout such as this and have every student submit it for approval after completion of each phase of their work.

DESIGNING AND EVALUATING TRANSPORTATION SYSTEMS

"PROGRESS CHART"

Name:_____ Class Period:_____

Description of Major Activity:_____

_____

_____

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Design/Evaluation Steps	Completed Date	Approved By
Identify Problem		
Defining Problem		
Possible Solutions		
Select Best Solution		
Testing/Refining Ideas		
Implementing Solutions		
Final Evaluation		

MODULE: 4 : Presenting Solutions

LENGTH: 7 DAYS Transportation CLUSTER

The development of new and better transportation systems is not something to be hidden; rather, the results of design and evaluation efforts are to be shared with a variety of audiences. Typically, this information would go to top management, industrial designers, community planners, system specialists, or other related parties. Technical research findings are generally for distribution among the industrial community.

Communicating the results of student work in this class is of no less importance. Each individual or group should be expected to explain their laboratory study to the class, instructor, and other interested people. This may take several class days but represents a major part of the course.

The teacher should describe the concept of presenting information early in the class and alert each student or group that they will be giving a formal presentation towards the end of the term. In other words, do not leave this module a "mystery" until the last week of the course. Students should be preparing for their presentation throughout the activity.

Developed solutions to specific transportation problems can be described in a variety of ways. Perhaps the most common is a written report. Certainly, the instructor should review any graphic documentation—reports, charts, sketches and drawings, journals, etc. Also, a folder containing laboratory notes may be required of each member of the class.

Another basic form of communication involves giving an oral presentation of research findings. Individual or group speeches provide an opportunity to explain their efforts, models, displays, etc. It also allows other members of the class to ask specific questions of the system designers. By standing in front of an audience, students can quickly communicate their design and development work.

Materials such as models and display boards constitute the third major form of describing technical information. Often the results of a design and evaluation program are placed on display for review by others. Devices or media may also be used to support the oral report or written materials. For example, prototypes or test vehicles may become the focus of a short illustrated talk on improving suspension systems.

This module is divided into three parts. First, the instructor should describe how to prepare for and give a formal research presentation. Explain the fundamentals of presenting technical information to an educated audience. Second, students must have time to finalize their presentations; charts, papers, or related items must be produced. In the case of group reports, class time must be set aside for each team to organize their materials. Finally, a few days should be scheduled for students to present their developed ideas. It may be "fun" to videotape these presentations or displays.

OBJECTIVES

At the end of this learning module, students should be able to:

1. Prepare a technical presentation related to modern transportation systems.

2. Describe formal design and development activities in the transportation industry.

3. Explain the results of individual and group investigation in a laboratory setting.

4. Complete the visuals or display materials to communicate technical facts and data to a specific audience.

CALENDAR

DAY	ACTIVITY
1	Explain the importance of presenting technical research to various groups; demonstrate how to prepare speeches, visuals, and display materials.
2–4	Allow time for students and groups to develop materials for their presentation.
5–7	Schedule group and individual presentations; evaluate as appropriate.

PRESENTING THE MODULE

DAY	ACTIVITY
1	Organize a short presentation on the importance of communicating the results of technical design and research activities. Describe how engineers and managers in the transportation industry inform others of their design efforts. Also, demonstrate how to prepare visuals and oral presentations for large audiences.
2-4	Provide laboratory time for students to prepare materials that will be used for formal presentations to others in the class.
5-7	Schedule individual and group presentations for these days. Invite interested parties to each class period to observe these reports along with the members of the course.