16 - 4899A

PROGRAM OF STUDY

• SECONDARY

TECHNOLOGICAL EDUCATION

TECHNOLOGY OF ELECTROMECANICAL CONSTRUCTION

November 1988

QUÉBEC

TECHNOLOGICAL EDUCATION

TECHNOLOGY OF ELECTROMECHANICAL CONSTRUCTION

Direction générale des programmes
Direction de la formation professionnelle

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INTRODUCTION

Evidence dating back to prehistoric times shows that people have always sought to improve the conditions of life through technology and invention by making a variety of tools and technical products to meet many needs. While this process has been going on for many centuries, it has never been more widespread than it is now, in the second half of the 20th century, a period of unequalled industrial expansion. In societies such as ours, technical products, from the simplest to the most sophisticated, play an integral role in everyone's life and constitute a cultural dimension that cannot be ignored.

Great industrial nations, particularly those in Europe and North America, have developed systems of education which take into account the importance of technology in the lives of their people.

In Québec technology has evolved at a slower pace. Its cultural importance was only understood when it was identified and explained by the Royal Commission of Inquiry on Education in the Province of Québec in the early sixties. The Commission recommended that technology courses be offered to all secondary school students. The delay in recognizing the value of technological education has produced negative results: we have become consumers rather than inventors and producers of technical objects. As consumers, we are not always well informed nor do we understand the technical products we use. Rather than deplore this fact, we almost seem to be proud of it. How often do we boast of having no mechanical ability or understanding of technical matters? We feel that this area of knowledge is not our concern; yet as consumers, we should be concerned. We all use cars today; however, most of us do not understand even the most basic principles of auto mechanics, let alone the industrial processes involved in car manufacturing. This state of affairs cannot continue indefinitely.

People developed technology and technical products to improve the quality of life. It is therefore important that we control technology and not become slaves to it. Schools must demystify technology by making it available, as part of basic education, to both boys and girls, since understanding technology is important to everyone's development and autonomy.

Therefore Québec has adopted the following goals for technological education in secondary schools:

- to know how industries operate;
- to know that every technical product was invented to meet a particular need;
- to understand the process involved in constructing a technical product to meet an identified need;
- to discover and develop the ability to design and construct technical products;
- to acquire a basic knowledge of technology, particularly of technical drawing;
- to learn how to handle common tools and machine tools and to use computers both industrially and commercially;
- to learn about the organization and sociology of work;
- to understand the impact of technology on our lives and on the work environment.

PART 1

EDUCATIONAL FRAMEWORK

ABOUT TECHNOLOGICAL EDUCATION

Offering technological education courses to general education students at secondary level is not unique to Québec. Most industrialized nations and an increasing number of developing countries do so under a variety of titles such as **Technological Education, Industrial Arts, Practical Technology and Introduction to Technology.**

While philosophies for the teaching of technology may vary from one country to another, it is generally accepted that technological courses must focus on the technical object or product.

The study of a technical product involves learning
- why it was invented
- how it is made
- how and why it works
- how it can be produced

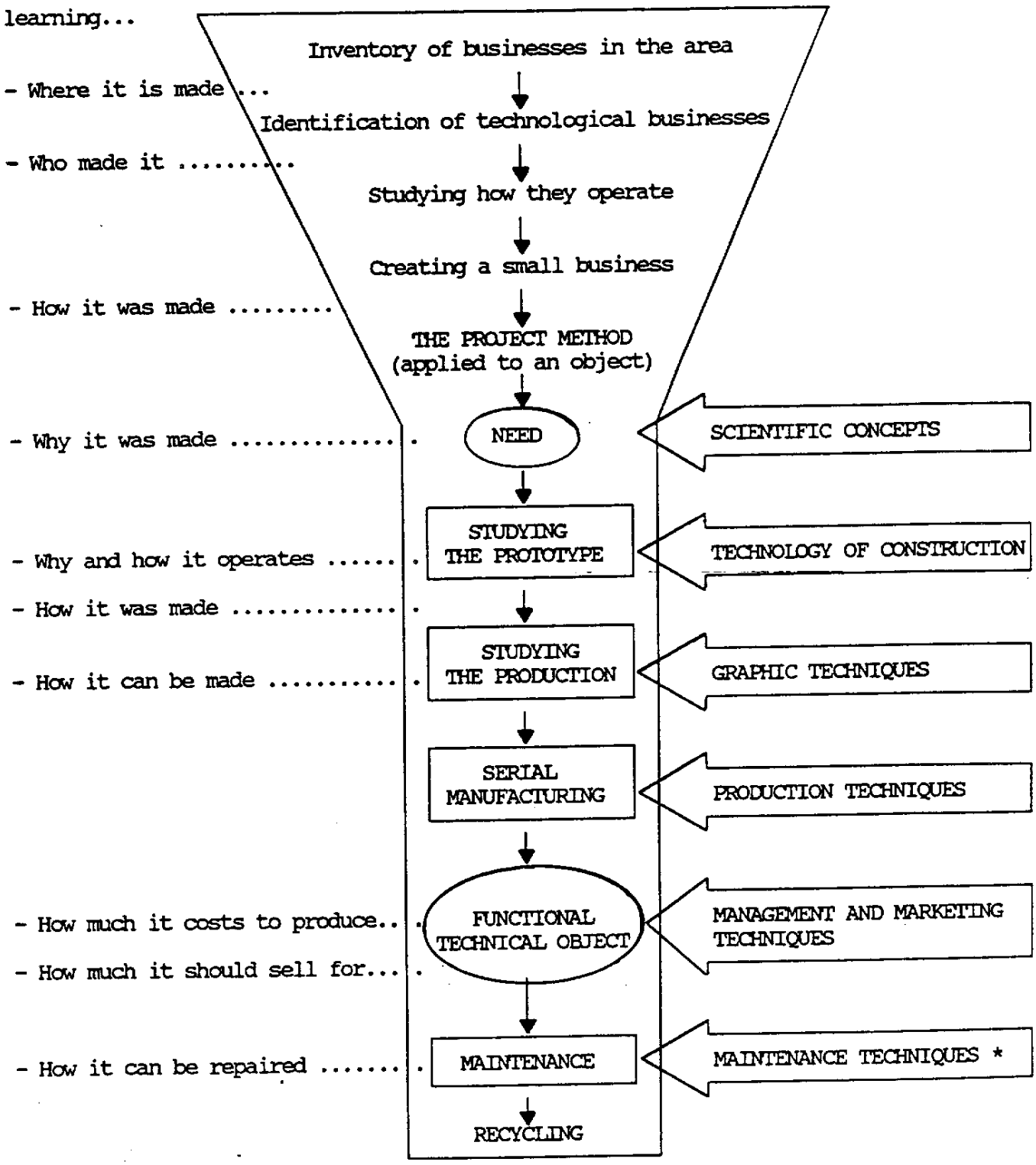
However, technological education courses must also focus on the technical object in its social, industrial and economic contexts. Therefore the study of a technical object will also include:
- where it is made
- who made it
- what it costs to produce
- how much it should sell for
- if it can be repaired

The Project Method

In Technological Education programs, the students answer these questions using the project method, a hands-on approach modelled on the technological process in industries. The students move step by step from the identification of a need to the production of everyday consumer objects, learning each concept or skill as the need for it arises.

The following diagram illustrates the processes involved in the study of a technical object.

THE STUDY OF A TECHNICAL OBJECT

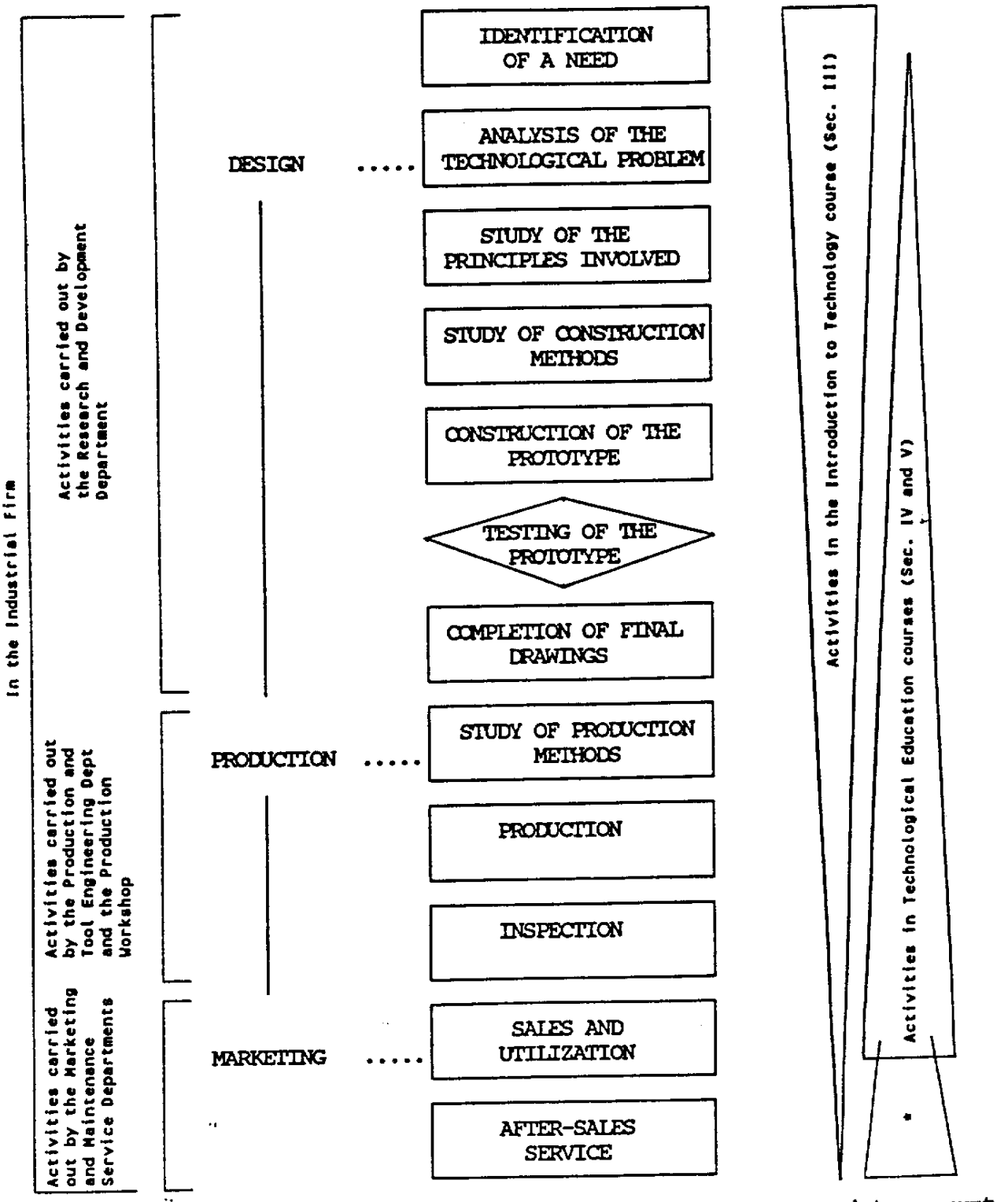


* To be included in future programs.

The Introduction to Technology course emphasizes the design of a prototype while technological education programs emphasize limited serial production of an object. Students first study the prototype to learn how it works and how it was made. Then they design and implement a production system, designing the tools and the manufacturing processes.

The following table illustrates the relationship between activities in the Introduction to Technology course and in Technological Education programs as related to the process of designing and producing a technical object.

Industry and the Process for Designing and Producing a Technical Object as Related to Activities in the Introduction to Technology Course and in Technological Education Programs



* Other Technological Education programs will take these aspects into account.

Studying the Technical Object

During the technological process, students study objects from two perspectives:

- as existing objects
- as objects being made

The first perspective includes:

- the study of the construction principles and techniques involved in producing an object, including component parts that were manufactured and purchased.

- the study of commercial products comprising original solutions which can be applied or whose technology can be transferred to the production of a new object.

The second perspective involves the application of the technological process to the production of an object, including the design and production of some of the necessary production tools.

Aspects of a Technological Study

A technological study focuses on:

- **intellectual knowledge** (Design requires logic, creativity, technological, scientific and mathematical knowledge.)

- **practical skills** (Production requires imagination, initiative, manual skills, perception of form and detail, and a sense of organization.)

Attitudes to Technology

Technological education should not be restricted to the study of a technical object but must also include discussions on technology, its purposes, its impact on people, their environment and their living conditions.

Conclusion

Technological education should not be confused with vocational education which is designed to teach students one or several trade skills. The teaching of technology which is described here is of a cultural nature and, in the same way as Literature, Arts and Science, is included in general education.

BACKGROUND

An Introduction to Technology course was first offered to all Québec secondary school students in the early seventies. That course was based on the technological program that the ministère de l'Éducation nationale in France had been using for some years. In 1975, the course was revised to meet the needs of Québec.

In 1979 and 1980, teachers in the field were consulted. The consensus was that the course, despite some weaknesses, met the needs of students reasonably well.

However, the orientations of the ministère de l'Éducation du Québec as outlined in **The Schools of Québec, Policy Statement and Plan of Action** necessitated further revisions. These revisions led to the Introduction to Technology course which is taught in secondary schools today. Nevertheless, it was only after the publication of **Vocational Education for Young People: Proposals for Revival and Renewal** in 1982 that technical and technological education were fully recognized as components of present-day culture. The document included a proposal that elective Technological Education courses be offered in the general curriculum for Secondary III, IV and V. These new programs are designed to respond in part to the recommendations of that report.

TECHNOLOGICAL EDUCATION IN SECONDARY SCHOOLS

The aims and values of our school system are designed to ensure the development of the student as a whole person. They must therefore include all the disciplines that play a role in the development of the individual and, in turn, in the furthering of society. Technological education contributes to the intellectual, sensorimotor, aesthetic, affective, social and moral development of the student and must be among the most important objectives of the Québec school system.

Technological Education programs of study reflect many of the values promoted in the Schools of Québec from which they draw their inspiration.

In terms of intellectual values, discovering and applying technological principles requires methodical work habits, whereas finding solutions to technical problems, using a systematic approach based on logic, requires intellectual discipline. Analyzing technical products and assessing their relative value calls for critical judgement and encourages the search for truth and intellectual honesty. Seeking technological solutions to practical problems encourages inventiveness and technical and artistic expression.

Learning to use a variety of tools and to process different materials enables students to develop their sensorimotor skills and eye-hand coordination. A minimum amount of technical knowledge gives them a degree of self-reliance in dealing with technical products. This self-reliance enables students to choose products more judiciously, to use and maintain them in a reasonable manner and even occasionally to detect and repair minor problems. Students might also be able to construct simple objects to meet some of their own needs.

Studying different technical objects enables students to gain a broader understanding of the affective, social and moral aspects of the world around them. Explaining solutions to specific problems helps students develop their communication skills and working in a team enables them to develop a sense of belonging, of respect for others, and of team spirit. The construction of technical objects develops precision and gives them a sense of pride in a job well-done.

It should be emphasized that technological education, in addition to contributing to the main objectives of the Québec school system, transmits basic values and provides the means to acquire special knowledge and skills and is particulary well suited to the inter-disciplinary approach. It is, in effect, a synthesis, a crossroads of all the different disciplines.

Target Population

The Technological Education program is part of the general program and is intended for all students in Secondary IV and V. It appears on the list of elective courses for Secondary IV.

Relationship Between the Program and Other Courses

This program follows the Introduction to Technology course which is compulsory in Secondary III.

GENERAL ORIENTATIONS OF TECHNOLOGICAL EDUCATION PROGRAMS

Link with the Introduction to Technology Course

The Introduction to Technology course comprises five themes:

- technology in the life of man
- building/construction technology
- mechanical technology
- electrical technology
- technology in the world of work

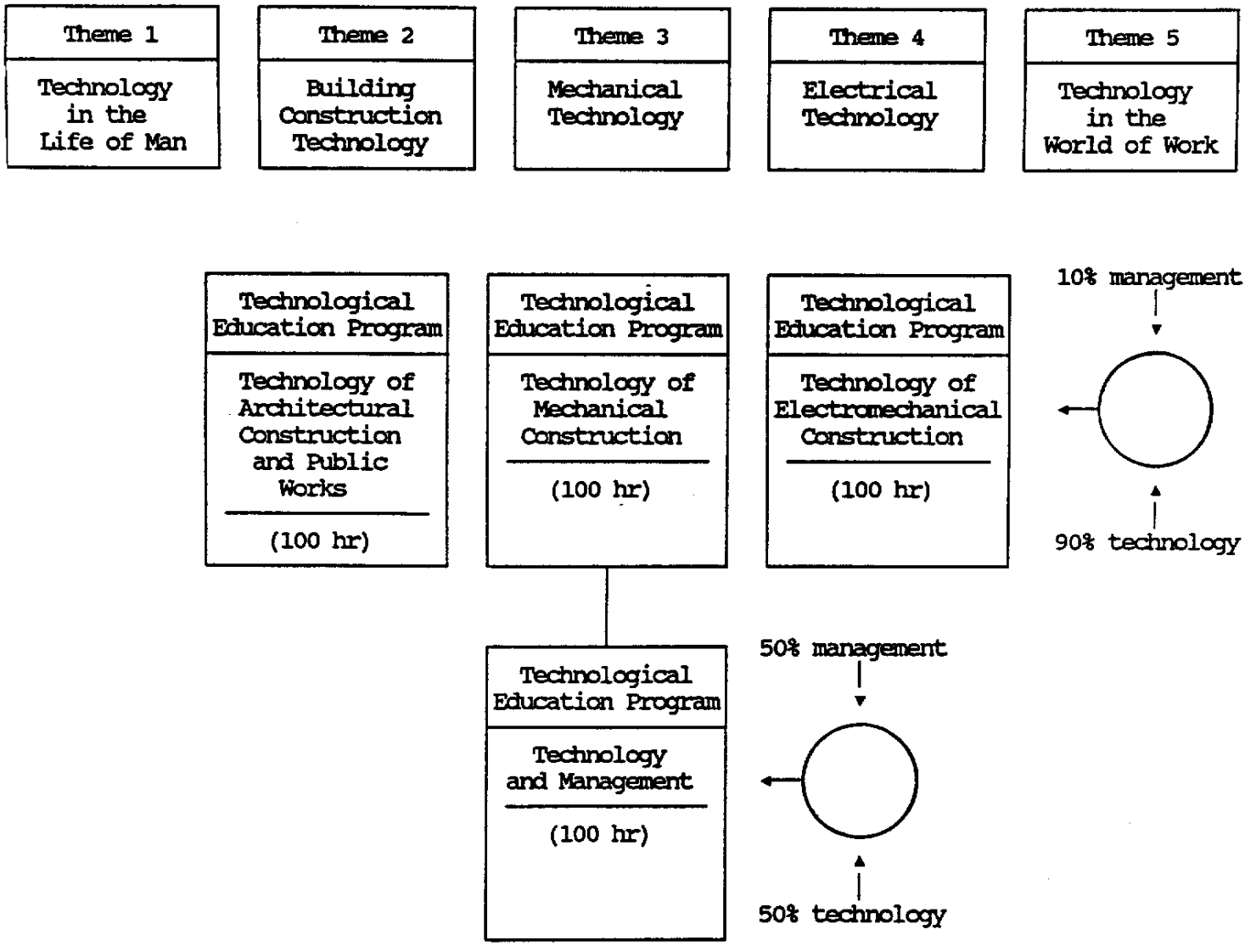
The second, third and fourth themes cover almost all technological activities, except biotechnology which is not accessible to students at this level. To enable students to develop their skills and knowledge in one or more specific areas, each of the three themes has been developed into a technological education program:

- Technology of Architectural Construction and Public Works
- Technology of Mechanical Construction
- Technology of Electromechanical Construction

A fourth program - Technology and Management (Entrepreneurship)- completes the list of new programs.

This first three programs emphasize technology and briefly introduce management concepts, while the Technology and Management program emphasizes management and production equally. The technological contents of the latter are essentially those of the Technology of Mechanical Construction program, although some of its products may resemble those produced in the other programs.

The following diagram illustrates the link between the Introduction to Technology course and Technological Education programs.



Technological Education and Computer Science

Technological education is often confused with computer science. This confusion arises partly from the sudden interest in technology generated by advances in microcomputers. Furthermore, people often confuse the technical object (technological product) with the technology used to produce it.

What is the role of computers in technological education? Computers are increasingly used in technology to perform such operations as:

- process simulation
- design and drawing (CAD)
- component manufacturing (CAM)
- initiating and monitoring various procedures
- all types of management functions

In these applications, the computer becomes a high performance machine that improves quality and effectiveness. In technological education, computers will be used as working tools and not as a means of introducing students to programming. Students will learn to produce simple drawings, to write using word processing software, to produce parts using numerical controls (in mechanical construction), and to perform mathematical operations (in management). They will learn how computers operate so as to broaden their technological education. In short, they will be introduced to the use of the computer as a design, production and management tool.

The Structure of Technological Education Programs

All programs in technological education have three sections:

- A basic section common to all the programs provides general information on technology and manufacturing firms, management concepts, technical drawing, materials and occupational health and safety.

- A specific section varies from one program to another and covers the particular area being studied

- A local complementary section chosen by each school depends on the projects elaborated with the students.

Each program comprises a number of terminal objectives organized according to the technological process to facilitate the study and production of the technical object. The list of terminal objectives is then divided, with each division corresponding to a step in the technological process.

Most terminal objectives are compulsory. Optional objectives are indicated as such to the teacher. The details of each project will complete the learning content of the objectives in the local section.

These terminal objectives contribute to the achievement of the general objectives and the aim of the program, all of which describe the results expected of the student at the end of the program.

The time allotted to each objective (shown in parentheses) is suggested as a guide to teachers. Each terminal objective is coded to a section of the program and to the general objective(s).

Codes:

B - Basic section of a program
S - Specific section of a program
L - Local section of a program

The basic section (B) is subdivided:

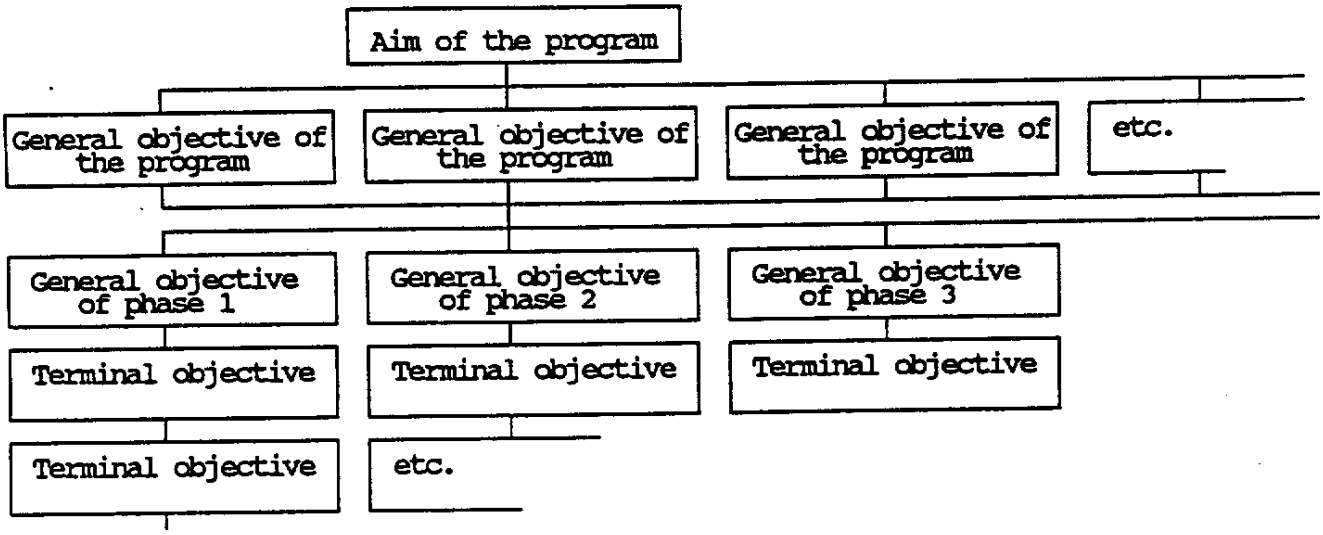
D - Drawing
Mg- Management
H - Health and Safety
Mt- Materials

Examples of coded objectives:

15 number of the objective

GO 1 general objective related to this terminal objective

BH basic section, health and safety



Number of Objects to be Produced in an Academic Year

Teachers should cover all terminal objectives at least twice each year. The total time for each objective should be distributed between two projects to ensure that students cover the whole technological process twice. The first project should be easier, to provide a gradual introduction to the process. Finished products should have an "industrial finish", fulfill real needs and be marketable on a small scale. The learning context should be based on the needs of the community (outside the school) or of the students themselves.

Choice of Objects to be Produced

The object to be produced varies with each program.

Mechanical Construction

Ideally, the object to be produced should include a mechanism and one or more parts should be produced on a numerical control (N/C) lathe.

Electromechanical Construction

This is a shortened version of the Mechanical Construction program to which elements of electronics have been added. The objects to be produced will include electronic as well as mechanical components (e.g. casing) mechanism.

Architectural Construction and Public Works

As this program does not lend itself to serial or full-size production, the teaching approach will focus on the design and production of a model illustrating the actual building. Furthermore, there will be only one project a year. However, where possible, students should take part in an actual building project, either in the school or in the community.

Technology and Management

In the Technology and Management program, the level of difficulty of the objects to be produced will be determined, in part, by the distinctive characteristics of the program.

GENERAL PRINCIPLES OF INSTRUCTION

Active Participation

Students themselves are primarily responsible for their own development. They must participate actively and should be encouraged to use all their faculties. Motivation to participate depends on personal tastes, interests and aptitudes. Students must be given real problems to which they must find their own solutions. This type of approach is called situational learning.

Seeking Solutions

Students in technological education classes must seek solutions to questions that a skillful and well-prepared facilitator raises or leads them to raise. Solutions will not all be of equal value. Students must learn to select the most appropriate solutions by using a combination of reasoning, logic and critical judgement. Thus learning how to learn must take precedence over learning facts. In the words of Montaigne, "It is better to have a well-trained mind than a well-filled mind".

GUIDELINES

Teachers should:

- explain to students, in simple terms, the aims and general objectives of the course;

- show the students that a teacher is not a "walking encyclopedia" but rather a facilitator, a guide who shares the process of discovery with students;

- avoid traditional lecture-type lessons. Discovery of laws and principles through observation, reflection, intuition and experimentation (inductive method) stimulates the interest of students more;

- avoid extremes. They should choose manufacturing processes that are technologically and commercially viable. Component parts, such as castings, which are difficult to produce in class should be purchased or subcontracted either within the school or to a local firm;

- plan attractive models which take into account the students' background, interest and capabilities;

- highlight the importance of concepts from many subject areas, especially the quality of spoken and written language;

- use attractive workshops set up according to the standards of the ministère de l'Éducation. The use of small machine tools is highly recommended;

- observe and integrate professional standards in the quality of activities and materials provided for students;

- necessarily have diverse technical backgrounds particularly in the specific subject area itself as well as in management, technical drawing, computer applications, manufacturing engineering, educational psychology, and use appropriate teaching methods.

EVALUATION AND MEASUREMENT INSTRUMENTS

In technological education, formative and summative evaluation will focus on knowledge, skills and attitudes.

General knowledge (covered in the introduction and conclusion of a project):

- the nature of technology
- businesses and legal forms of business ownership
- tasks and occupations

Scientific knowledge (covered in the analysis of how the prototype works and how it is made):

- concepts, rules, principles
- materials and their physical and chemical properties

Technological knowledge (covered in the study of the manufacturing process or the design of a tool):

- steps in the design and the manufacturing process
- the manufacturing processes
- the manufacturing process sheet
- commercially available components

Technical knowledge (covered while learning a skill):

- the principle of orthographic projection in technical drawing
- technical drawing lines
- names of machine tools, their components and their kinematics
- health hazards and safety regulations
- production cost, selling price and budgets

Methodological skills required for:

- starting and running a business
- planning and implementing serial production

Technical skills needed for various operations:

- calculating a cost price
- drawing with instruments or with the computer
- producing a plan
- disassembling and reassembling an object
- adjusting and reassembling a machine tool
- measuring, drawing with instruments
- assembling components

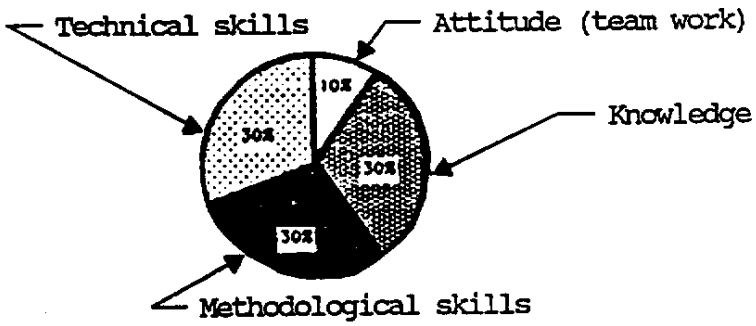
Attitudes

- formative evaluation by the teacher:
  - accepting tasks
  - being positive
  - being punctual
  - showing initiative and being autonomous

- formative and summative evaluation by the teacher:
  - striving for accuracy
  - taking pride in a job well-done
  - keeping the work station clean and organized (tools, arrangement of tools, neatness)
  - observing procedures
  - being safety-conscious
  - keeping course materials in order
  - showing originality in designing tools and procedures

- formative and summative evaluation by the teacher and summative evaluation by peers:
  - being able to work in a team

Summative evaluation is weighted as follows:



Choosing Measurement Instruments

One criterion in choosing examinations for evaluation should be to save time for teachers. Various types of knowledge will be evaluated by either essay-type or objective-type written examinations.

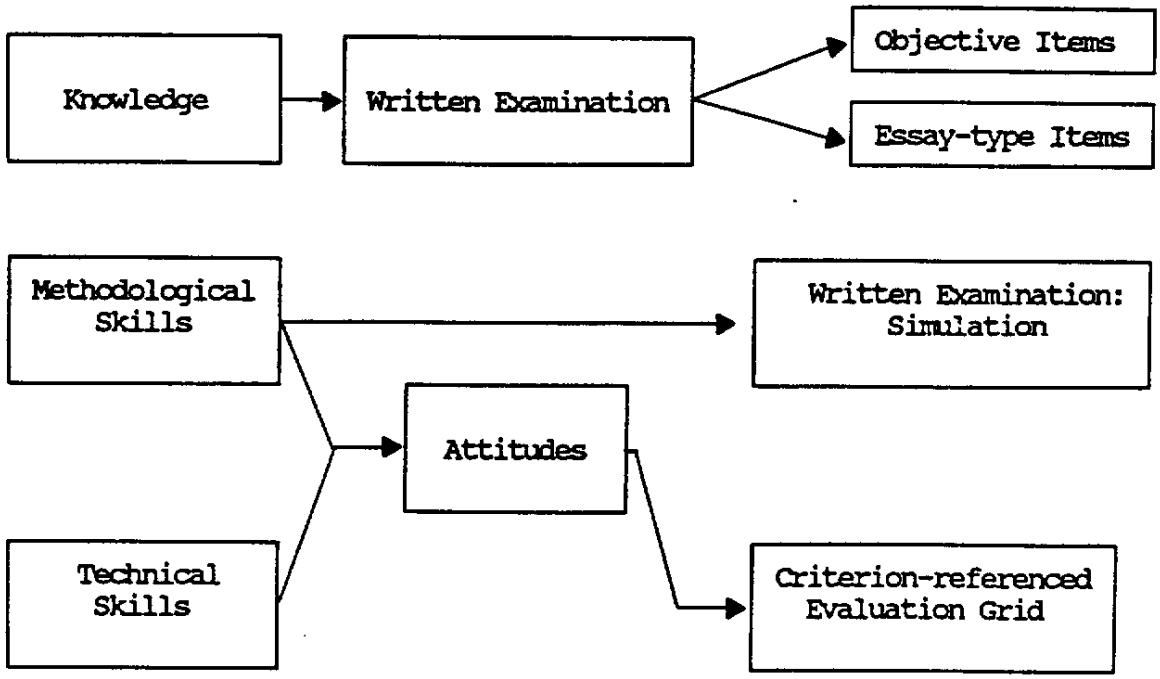
It is difficult to evaluate the students' technical skills because:

- the programs do not emphasize mastery of all the techniques;
- the programs do not emphasize a high level of performance;
- the application of the process and mastery of the techniques cannot be evaluated solely by observing objects obtained through serial production.

Technical achievements can best be evaluated by observing the students' attitudes throughout the process. Repeated use of a criterion-referenced grid will facilitate this kind of evaluation.

Methodological skills can also be evaluated by observing attitudes or by requiring the students to find solutions to hypothetical situations (simulations) in a written examination.

The following diagram illustrates possible evaluation methods:



PART 2

DESCRIPTION OF THE PROGRAM

TECHNOLOGY OF ELECTROMECHANICAL CONSTRUCTION

AIM OF THE PROGRAM

To develop positive and judicious attitudes toward technology and to acquire knowledge and skills by applying the technological process related to electromechanical construction.

General Objectives

The student will be able:

01 To study a technological product and specifically:
- to apply certain steps in the technological process
- to use technical drawings
- to apply concepts from many subject areas
- to acquire a basic knowledge of materials
- to consider the economics of products by applying basic market research and project management concepts

02 To participate in the actual production of a technological product and specifically:
- to apply the planning and production steps in the technological process
- to use up-to-date manufacturing techniques
- to observe relevant health and safety regulations

03 To understand the social and economic impact of technological and electromechanical products.

04 To become aware of the various career opportunities in the industrial sector.

NOTE: The term "technological product" refers to a technical object produced commercially.

TERMINAL OBJECTIVES

Basic Section 25 hours

DRAWING (11 hours)

The student will be able:

- to know the types of drawings and their uses and to correlate technical drawings with the steps in the technological process;
- to identify drawing instruments;
- to use a ruler and a measuring tape;
- to produce full-size and scale drawings;
- to read and draw orthographic projections;
- to understand the concept of tolerance and limit dimensions and to read tolerated and dimensioned drawings;
- to interpret manufacturers' technical instructions.

MATERIALS (3 hours)

The student will be able:

- to know the essentials of how materials are produced;
- to differentiate ferrous alloys from copper alloys;
- to associate certain materials with their physical and chemical properties;
- to judge the strength of a part by its shape alone.

HEALTH AND SAFETY (2 hours)

The student will be able:

- to understand and observe the safety regulations applicable to manufacturing activities;
- to recognize health hazards and their effects on people;
- to use the required protective equipment during manufacturing activities;
- to handle tools, machinery and various products safely.

BUSINESS AND MANAGEMENT (9 hours)

The student will be able:

- to know the components of an industrial system;
- to identify the different departments of an industrial firm;
- to distinguish various legal forms of business ownership;
- to identify the types of businesses and their respective goals;
- to conduct a market survey;
- to draw up a simple operating budget;
- to estimate the production cost of a project;
- to determine the selling price of a product based on certain factors;
- to inventory stock;
- to compare the variances between budgeted and actual costs and revenues.

Specific Section 40 hours

ELECTRONICS (20 hours)

The student will be able:

- to explain the electron theory of electricity and describe the methods for producing electricity;
- to use electrotechnological instruments;
- to know conductors and insulators;
- to understand and apply Ohm's Law;
- to use certain measuring instruments for control purposes;
- to analyze series circuits;
- to analyze parallel circuits;
- to analyze series-parallel circuits;
- to assemble various types of circuits;
- to determine the power of an electrical device (optional);
- to identify the different types of resistors (optional);
- to identify the different types of protection;
- to identify the different types of cells (optional);
- to connect cells (optional);
- to select the appropriate wire for connections;
- to install electrical accessories in assemblies;
- to identify the different electrical accessories used in assemblies;
- to understand the principles of magnetism and electromagnetism (optional);
- to explain the operating principles of certain motors (optional);
- to identify certain electronic components (optional).

MECHANICS (20 hours)

The student will be able:

- to list the steps of the technological process;
- to identify the occupations, tasks and services generally associated with electromechanical construction;
- to read a detail drawing of the field of electromechanics;
- to know certain elements of mechanical construction;
- to read general and detail drawings;
- to disassemble and reasssemble a mechanism in order to study it;
- to know some of the processes used to transform materials;
- to know the processes used to protect and finish materials;
- to read and understand a manufacturing process sheet;
- to use certain layout tools;
- to read and understand an assembly process sheet.

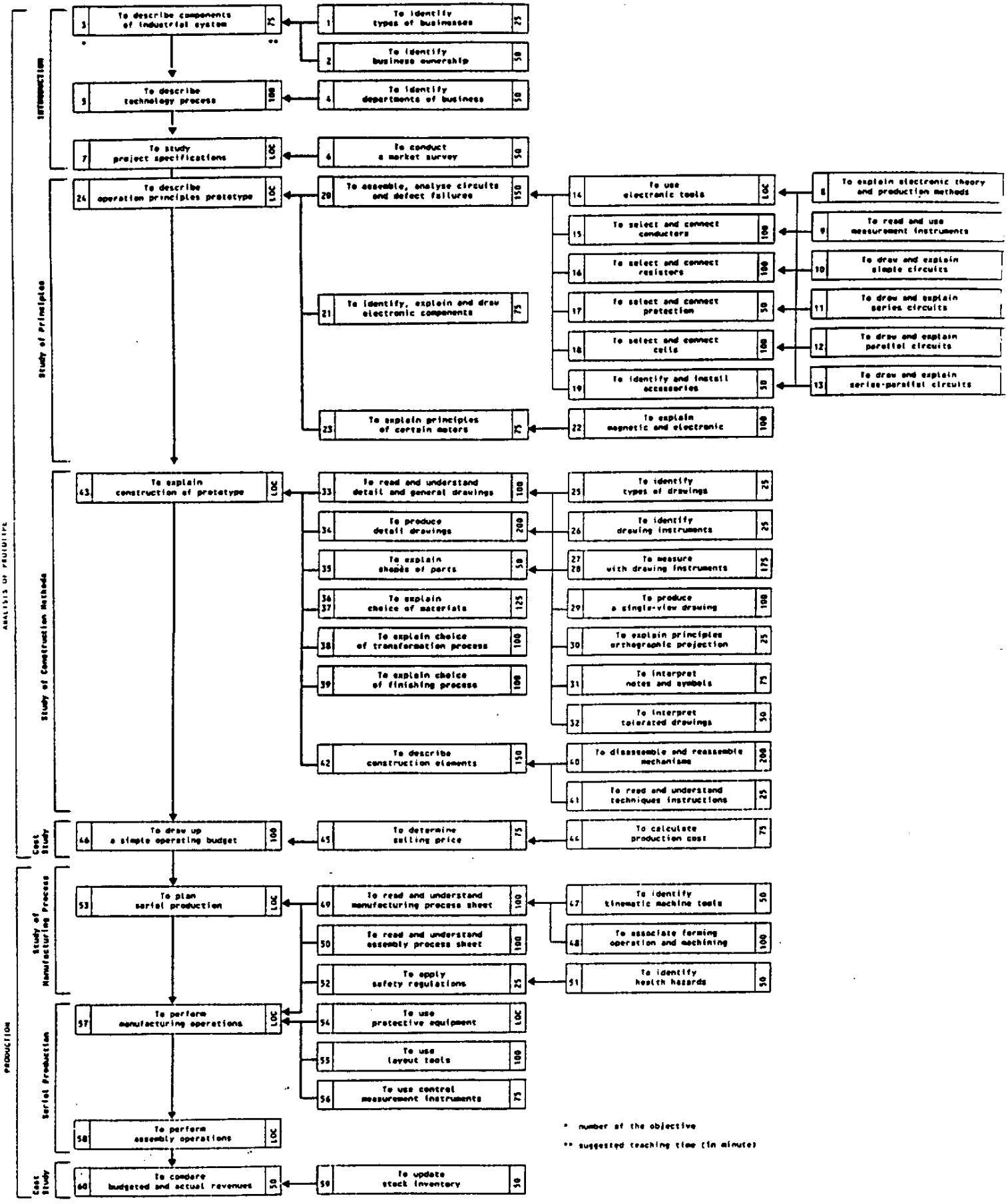
Local Section 35 hours

The student will be able:

- to read and understand project specifications;
- to explain the operating principles of the object to be produced;
- to explain the construction methods used by a manufacturer;
- to participate in designing and producing part of the equipment and assemblies used in serial production;
- to participate in organizing an ergonomic work station;
- to manufacture one or more parts;
- to use measurement instruments for control purposes;
- to perform certain assembly and adjustment operations.

RELATIONSHIP BETWEEN TERMINAL OBJECTIVES

TECHNOLOGY OF ELECTROMECHANICAL CONSTRUCTION



DESCRIPTION OF TERMINAL OBJECTIVES

PHASE: ANALYSIS OF PROTOTYPE

Step: Introduction

This step will focus on:

- the structure and operation of a manufacturing firm;
- the findings of a market survey conducted for the the object to be produced.

TERMINAL OBJECTIVES		LEARNING CONTENT
	00 Without reference materials, the student will be able:	**Nature and Goals of the Technology Courses**
GO 1-2-3-4 B	- to explain the nature and goals of technology courses in secondary general education.	- general objectives - teaching approach - education and employment - recognition of studies
	(50)	
	01 Without reference materials, the student will be able:	**Essential Factors in Starting and Running a Business**
GO 1-3-4 EMg	- to identify the essential factors in starting and running a business;	- consumer need(s) - producing goods or services - selling goods or services - distributing revenues and profits
	- to identify the types of businesses and their respective activities;	**Types of Businesses**
	- to identify businesses which use the technological process.	- manufacturing - distribution - service
	(50)	**Technological Process**
		- primary sector - secondary sector - tertiary sector
	02 Without reference materials, the student will be able:	**Types of Business Ownership**
GO 1-3 EMg	- to distinguish the different types of business ownership;	- sole proprietorship - partnership - corporation - cooperative
	- to describe briefly the advantages and disadvantages of each type.	**Names and Features**
		- advantages and disadvantages
	(50)	

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 3 BMg	03 The student will be able: - to describe briefly the major components of an industrial system; - to identify the relationships between the departments of a business and the socio-economic environment. (50)	**Components of an Industrial System** - input: · natural resources · human resources · financial resources - management process: · production · finance · marketing · research and development · personnel - output: · goods (durable and non-durable) · services (to customers) **The Socioeconomic Environment**
GO 1-3-4 S	04 The student will be able: - to describe the main tasks involved in producing a technical object; - to identify the occupation related to each task; - to describe the qualifications required for each occupation. NOTE: This objective should be introduced once a product has been completed or before another is produced.	**Departments** **The Technological Process** **Tasks** **Occupations** - engineer - technologist - draftsperson - estimator - technician - skilled worker - unskilled worker - other **Qualifications**

	TERMINAL OBJECTIVES	LEARNING CONTENT
	05 Without reference materials, the student will be able:	**Technological Process**
GO 1-2-4 S	- to list the different steps in conducting a market survey, and in designing, producing and marketing a technical object; - to briefly describe these steps. (100)	- identification of a need - market survey: · identifying the market · assessing technological capabilities · assessing the competition - design: · analysis of the technological problem · study of principle(s) involved · study of construction methods · production of prototype or mock-up - production: · study of manufacturing process · serial or unit production - marketing: · distribution · sales · after-sales service
GO 1 BMg	06 Based on a given project, the student will be able: - to conduct a basic market survey. (50)	**Basic Market Survey** - target market - technological capabilities - competition
GO 1 L	07 Based on the project specifications, the student will be able: - to state in his/her own words the technological problem to be solved (the need to be met); - to read any accompanying graphic documents. (time to be determined locally)	**Project Specifications** - general data - specifications and restrictions (related areas) - overall function of object to be produced - explanatory diagrams

PHASE: ANALYSIS OF PROTOTYPE

Step: Study of Principle(s)

This step will focus on:

- the operating principle(s) of the prototype (object to be produced)

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 S	08 Using illustrations, the student will be able: - to explain briefly yet accurately the electron theory of electricity; - to describe the different ways in which electricity can be produced. (100) NOTE: Objectives 08 to 19 are included here so that students will be able to assemble and analyze circuits (objective 20).	**Structure of Matter** - components of matter - law of electric charges - electron flow - electromotive force **Methods of Producing Electricity** **Electric Current** - unit of measure - types of current: · direct · alternating - advantages and disadvantages
GO 1 S	09 Without reference materials, the student will be able: - to read the measuring instruments used for the project; - to use these instruments for control purposes during the project. (100)	**Measuring Instruments** - voltmeter - ammeter - ohmmeter - multimeter - other **Operating and Wiring Techniques**

	TERMINAL OBJECTIVES	LEARNING CONTENT
	10 Based on specific data, the student will be able:	**Components of a Simple Circuit**
GO 1 S	- to determine the relationship between voltage, current and resistance in a simple circuit; - to solve certain practical problems using Ohm's Law. (150)	**Voltage** - definition - units of measure **Current** - definition - units of measure **Resistance** - definition - units of measure - Ohm's Law (formula)
	11 Based on data related to a specific project, the student will be able:	**Components of a Series Circuit**
GO 1 S	- to explain the nature of a series circuit by drawing a schematic diagram; - to calculate the voltage, current and resistance in a series circuit. (75)	**Symbols and Schematic Diagrams** **Series Circuits** - calculation of voltage - calculation of current - calculation of resistance
	12 Based on data related to a specific project, the student will be able:	**Components of a Parallel Circuit**
GO 1 S	- to explain the nature of a parallel circuit by drawing a schematic diagram; - to calculate the voltage, current and resistance in a parallel circuit.	**Symbols and Schematic Diagrams** **Parallel Circuits** - calculation of voltage - calculation of current - calculation of resistance: · equal values · two different values · three or more different values

	TERMINAL OBJECTIVES	LEARNING CONTENT
	13 Based on data related to a specific project, the student will be able:	**Components of a Series-Parallel Circuit**
GO 1 S	- to explain the nature of a series-parallel circuit by drawing a schematic diagram;	**Symbols and Schematic Diagrams**
	- to calculate the voltage, current and resistance in a series-parallel circuit.	**Series-Parallel Circuits** - calculation of values
	(75)	
	14 While working on a project, the student will be able:	**Selection of Tools**
GO 2 S	- to use appropriately the tools listed under learning content.	**Techniques for Using** - pliers - wire strippers - screwdrivers - soldering irons - unsoldering tools - punches
	(time to be determined locally).	
	NOTE: Depending on the project requirements.	

	TERMINAL OBJECTIVES	LEARNING CONTENT
	15 Based on a specific project, the student will be able:	**Conductors**
GO 1 S	- to differentiate a conductor from an insulator;	- electrical resistance - high conductance - average conductance - types and uses of conductors - semi-conductors - insulators
	- to explain why a specific conductor is selected for a a given purpose;	
	- and to connect the conductor according to current standards.	**Choice of Conductor**
	(150)	- circuit resistance - conductor resistance - gauges - form of conductors
	NOTE: This objective should cover several learning and manufacturing activities.	**Connecting Conductors**
		- stripping - connecting - splicing - connectors - lugs - solder
GO 1 S	16 Using reference materials, the student will be able:	**Types of Resistors**
	- to describe the different types of resistors;	- power - security factor - colour code
	- to explain why a specific resistor is selected for a given purpose in a project.	
	(100)	
	NOTE: To be included if required by the project.	

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 S	17 Using reference materials related to a specific project, the student will be able: - to describe the different protective devices; - to describe their functions; - to explain why a specific protective device is selected for a given purpose in a project; - to determine its value. (50) NOTE: To be included if required by the project. This objective should cover several learning and manufacturing activities.	**Protective Devices** - fuses - circuit breakers **Functions** **Expressing Value**
GO 1 S	18 Using reference materials related to a specific project, the student will be able: - to describe the operating principles of different types of cells; - to represent cells symbolically; - to connect them correctly for a specific purpose by calculating their values; - to justify the type of cell used in a project. (100) NOTE: To be included if required by the project.	**Primary Cells** - main components - operating principles - symbols used for representation - designation of cells **Connecting Cells** **Secondary Cells (storage or accumulator)** - brief description of components

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 S	19 Using illustrations, the student will be able: - to identify the installation accessories listed; - to install these accessories. (100) NOTE: Content may vary depending on the project.	**Installation Accessories** - controlling devices - electrical boxes - receptacles - plugs - switches - other
GO 1 S	20 Without reference materials, and using appropriate materials, the student will be able: - to assemble circuits according to current standards; - to analyze circuits in order to detect and correct power failures. (150) NOTE: Objectives 20 to 23 are included here so that students will be able to explain the operating principles of the prototype (objective 24).	**Various Types of Circuits** **Assembly Techniques** **Power Failure Detection** - continuity - short-circuits
GO 1 S	21 Using illustrations or samples, the student will be able: - to identify the electronic components listed; - to describe their function and to identify the symbols used to represent them. (75) NOTE: To be included if required by the project.	**Electronic Components** - semiconductors · diodes · transistors · integrated circuits - conductors - other **Symbols**

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 S	22 Without reference materials, the student will be able: - to explain the principles of magnetism and electromagnetism. (100) NOTE: If required by the project.	**Magnetism** - magnetic field - magnetization/demagnetization **Electromagnetism** - magnetic field - solenoids - induction (applications)
GO 1 S	23 Without reference materials, the student will be able: - to describe briefly the operating principles of the motors listed under learning content. (75) NOTE: If required by the project.	**Motors** - D.C. motors (with permanent magnets) - A.C. motors (with armature) - universal motors (A.C. or D.C.)
GO 1 L	24 Using diagrams, drawings or prototypes, the student will be able: - to describe the operating principles of the object to be produced. (time to be determined locally) (100)	**Multidisciplinary Concepts** - applied scientific principles - mathematics - terminology **Schematization**

PHASE: ANALYSIS OF PROTOTYPE

Step: Study of Construction Methods

This step will focus on:

- the construction of the prototype in terms of shapes, dimensions, materials and finishing process.

	TERMINAL OBJECTIVES	LEARNING CONTENT
	25 Without reference materials, the student will be able:	**Types of Drawings**
GO 1 BD	- to identify the types of drawings listed under learning content;	- artistic: · ideograms · figures · abstracts · sketches
	- to explain what each is used for;	- technical: · diagrams · sketches · orthographic projections · figures
	- to relate the types of drawings to the steps in the technological process.	**Uses**
	(25)	
	NOTE: Objectives 25 to 32 are included here so that students will be able to read general drawings (objective 33).	
	26 Without reference materials, the student will be able:	**Drawing Instruments**
GO 1 BD	- to identify the drawing instruments listed under learning content.	- drafting table - T-square - set square - pencil - ruler - protractor - parallel rule - circle template - sharpener - compass - drafting machine - computer and plotter
	(25)	

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 BD	27 Using a millimetric ruler, the student will be able: - to measure line segments, drawings and objects to the nearest millimetre. (25) NOTE: In objectives 27 to 33, the students can measure, draw, or trace parts of the objects to be produced.	**International System of Units (SI)** - units of length **Technique** - scale ruler - steel measuring tape - steel ruler
GO 1 BD	28 Using drawing instruments, the student will be able: - to measure scale drawings; - to produce drawings to a specific scale. (150) NOTE: These drawings need not relate to the project.	**Scales: Principles, Uses and Techniques**
GO 1 BD	29 Using appropriate instruments, the student will be able: - to produce a single-view drawing using standard lines. (100)	**Steps in Producing a Drawing** **Description and Characteristics of Standard Lines** - construction lines - centre lines - extension lines - dimension lines - hatching lines - object lines - hidden lines - break lines (long and short) - section lines **Use of Instruments**

	TERMINAL OBJECTIVES	LEARNING CONTENT
	30 Without reference materials, the student will be able:	**Principle of Orthographic Projection**
GO 1 BD	- to explain in his/her own words the principle of orthographic projection;	**Purpose**
	- to list its purpose and advantages.	**Advantages**
	(25)	
	31 Based on illustrations of a specific project, the student will be able:	**Details**
GO 1 S		**Notes**
	- to identify details, notes and dimensions;	- drilling - tapping - threading
	- to read and understand them.	**Dimensions**
	(75)	- shape - location - surface condition
	32 Without reference materials, the student will be able:	**Concept of Tolerance**
		- purpose of tolerances - tolerance dimensions · high limit · low limit · interval
GO 1 BD	- to explain in his/her own words the concept of tolerance (stated or unstated);	**Interpretation**
	- to read a drawing with tolerance dimensions.	- limit dimensions · size · location
	(50)	
	NOTE: Limit dimensions only.	

	TERMINAL OBJECTIVES	LEARNING CONTENT
	33 Without reference materials, the student will be able:	**Orthographic Projections**
GO 1 BD	- to read and understand dimensioned orthographic projections of average difficulty (U.S. standard).	- visualizing shapes - standard lines - dimensions: · width · height · depth
	(50)	**Reading Drawings**
	NOTE: Limit dimensions only.	- one view - two views - three views - sectional - general
	Objectives 33 to 42 are included here so that students will be able to describe how a prototype is constructed (objective 43).	
	34 Using drawing instruments, the student will be able:	**Techniques for Orthographic Projection of Solids**
GO 1 BD	- to draw the views required to represent a component in orthographic projection.	- choice of views - number of views chosen - choice of scale - layout of views - steps in drawing views
	(200)	
	NOTE: Drawing of a template	
	Maximum of three views	

	TERMINAL OBJECTIVES	LEARNING CONTENT
	35 Using examples, the student will be able:	**Shapes of Materials**
GO 1 BMt	- to judge the strength of a piece of material by its shape.	- side of a rectangular section - edge of a rectangular section - round section (solid and hollow) - "I" section - thin embossed section - other
	(50)	
	36 Without reference materials, the student will be able:	**Materials**
GO 1 BMt	- to describe in his/her own words how ferrous and non-ferrous materials are produced; - to state in his/her own words the differences among the materials listed under learning content.	- iron - ferrous alloys: · cast iron · steel - copper - copper alloys · brass · bronze - aluminum
	(50)	**Production Processes**
		- iron and its alloys: · extraction · sorting · blast furnace · electric furnace · converter - copper and its alloys: · extraction · reduction or roasting · refining - aluminum: · extraction · preparation of aluminum oxide · electrolysis

TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 BMt 37 Using reference materials, the student will be able: - to match materials with the physical and chemical properties listed under learning content. (75) NOTE: Additional materials needed for the project should be included to broaden the scope of this section.	**Metallic Materials** - ferrous: · cast iron · steel - non-ferrous: · aluminum · magnesium · copper · brass-bronze · zinc · nickel · lead · other **Non-metallic Materials** - softwood - hardwood - nylon - rubber - fiberglass - plexiglas - glass - other **Physical Properties** - brittleness - ductility - elasticity - hardness - plasticity - tensile strength - compressive strength - other **Chemical Properties** - conductivity - resistance to corrosion - resistance to chemical action - other

	TERMINAL OBJECTIVES	LEARNING CONTENT
	38 Using reference materials, the student will be able:	**Transformation Processes**
GO 1 S	- to describe briefly the transformation processes for the materials listed under learning content. (100)	- forming: · casting · stamping · forging · folding · rolling · roasting · extruding · other - machining: · drilling · sawing · shearing · other
	39 Using reference materials, the student will be able:	**Protective Coating and Finishing Process**
GO 1 S	- to explain the protective and finishing process(es) used.	- electroplating - galvanizing - tinning - rubberizing - anodizing - painting - lacquering - varnishing - dyeing - oiling - waxing - types of coating: · fabric · vinyl · stratified plastic - other

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 S	40 Based on general drawings or a diagram and using the appropriate tools, the student will be able:	**Reading the Drawings, Diagrams and Notes**
		Techniques for Handling Tools
	- to disassemble and reassemble a mechanism in a logical sequence;	**Disassembly and Reassembly Procedures**
		Components of the Mechanism
	- to name the components of the mechanism;	**Function of Components**
	- to briefly describe their functions.	
	(200)	
	NOTE: Objectives 40 and 41 are included here so that students will be able to describe the elements of construction (objective 42).	
	41 The student will be able:	**Instructions**
GO 1 BD	- to read and understand manufacturers' technical instructions.	- maintenance - disassembly and reassembly

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 S	42 Based on the general drawings of an electromechanical object or the object itself, the student will be able: - to identify certain mechanical construction elements; - to describe the functions of the overall mechanism. (100)	**Construction Elements** - fasteners: · bolts · nuts · washers · screws · rivets · circlips · springs · pins · nails · other **Other Components** **Functions of Components** - fastening - guiding - sealing - supporting - lubricating - directing movements: · rectilinear translation · rotation · helical - other
GO 1 L	43 Based on diagrams, drawings or the prototype, the student will be able: - to explain the construction methods used by a manufacturer. (time to be determined locally)	**Processes for Producing Components** **Materials Used** **Assembling Techniques**

PHASE: ANALYSIS OF PROTOTYPE

Step: Cost Study I

This step will focus on:

- the financial management of a product.

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 BMg	44 Based on a project, the student will be able: - to identify the main factors in determining the production cost of a project; - to estimate the unit production cost based on the particulars of the project. (75)	**Concept of Costs** - fixed - variable **Production Cost of the Project** - direct manufacturing costs: · raw materials · various supplies · contracts (subcontracting) - indirect manufacturing costs: · raw materials (templates) · various supplies · miscellaneous - administrative costs: · printing and stationery · postage · telephone - additional business expenses
GO 1 BMg	45 Based on the market survey, the student will be able: - to determine the unit selling price of a product. (75)	**Factors in Determining the Selling Price** - production cost of the project - marketing costs: · advertising · packaging · other - competitor's price - expected earnings · break-even point (chart)

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 BMg	46 Based on a project and using data obtained when determining the production cost and selling price, the student will be able: - to draw up a simple operating budget. (100)	**Operating Budget** - definition - use - components: · production · marketing - budget period

PHASE: PRODUCTION

Step: Study of the Manufacturing Process

This step will focus on:

- the main factors in planning a limited serial production.

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 2 S	47 Based on an illustration or a machine tool, the student will be able: - to describe the kinematics of the various machine tools listed under learning content. (50) NOTE: Objectives 47 and 48 will enable the student to read and understand a process sheet (objective 49).	**Machine Tools:** - folding machine - shearing machine - sensitive drill - punching machine - other
GO 2 S	48 Using reference materials, the student will be able: - to match basic forming or machining operations with one or more machine tools used to perform the operations. (100) NOTE: Content may vary depending on the manufacturing process sheet required for the project.	**Basic Operations** - folding - bending - shearing - drilling - sawing - turning - milling - surface planing - planing - mortising - spindle moulding - sanding - other
GO 2 S	49 Without reference materials, the student will be able: - to read and understand a manufacturing process sheet. (100) NOTE: Objectives 49 to 52 are included here so that students will be able to organize a limited serial production (objective 53).	**Elements of a Manufacturing Process Sheet** - phases - operations - drawings - symbols - tools and instruments - other

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 2 S	50 Without reference materials, the student will be able: - to read and understand an assembly process sheet. (100)	**Assembly Process Sheet** - phases - operations - drawings or descriptions **Assembly Procedures** - screwing - riveting - welding - gluing - other
GO 2 EH	51 Without reference materials, the student will be able: - to identify health hazards and their effects on people. (50)	**Health Hazards** - noise - dust - fumes **Effects**
GO 2 EH	52 Without reference materials, the student will be able: - to understand and apply safety regulations to be observed during manufacturing activities. (25)	**Safety Regulations** - behaviour - movement - rules for using machines: · start up · operation · shut down · cleaning - safety regulations for using electricity

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 2 L	53 Based on the technical specifications of a project, the student will be able: - to participate in designing and producing the assemblies and tools required for the serial production of one or more parts; - to participate in organizing an ergonomic work station. (time to be determined locally)	**Technical Specifications of the Project** - specifications - drawings **Technological Process** - drawing concepts and techniques - transformation concepts and techniques **Safety Regulations**

PHASE: PRODUCTION

Step: Serial Production

This step will focus on:

- limited serial production.

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 2 BH	54 During manufacturing activities, the student will be able: - to use the protective equipment required for each operation. (25) NOTE: The time required for attaining this objective is distributed throughout the manufacturing activities.	**Protective Equipment** - safety goggles - visors - gloves - masks - other
GO 2 S	55 While carrying out the project, the student will be able: - to correctly use the layout tools listed under learning content. (100)	**Selection of Instruments** **Handling Techniques** - rulers - set squares - scribers - marking gauges - compasses - needles - other
GO 2 S	56 Without reference materials, the student will be able: - to read the measuring instruments required for a specific project; - to use these instruments for manufacturing and control purposes. (75)	**Measuring Instruments** - protractors - digital micrometers - digital sliding calipers - other

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 2 S	57 Using the manufacturing specifications for a given project, the student will be able: - to manufacture one or more parts for the project in accordance with safety regulations; (time to be determined locally)	**Manufacturing Specifications** - drawings - manufacturing process sheets **Handling of Tools and Machine Tools** **Safety Regulations**
GO 2 L	58 Using an assembly process sheet for a project, the student will be able: - to carry out various assembly and adjustment operations; - to complete the finishing process. (time to be determined locally)	**Assembly Process Sheet** **Techniques for Handling** **Finishing Techniques** **Safety Regulations**

PHASE: PRODUCTION

Step: Cost Study II

This step will focus on:

- the financial management of a product.

	TERMINAL OBJECTIVES	LEARNING CONTENT
GO 1 BMg	59 Using information for a project, the student will be able: - to update stock inventories. (50)	**Inventory Cards** - dates - stock in - stock out - balance of stock - taking inventory **Calculating Cost of Goods Sold**
GO 1 BMg	60 Using a model and figures based on a project, the student will be able: - to compare the variances between actual and budgeted revenues and expenses. (50)	**Comparing Variances** - budget - statement of revenue and expenditure **Analyzing Variances**

NOTE: Refer to objective 46.

PART 3

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