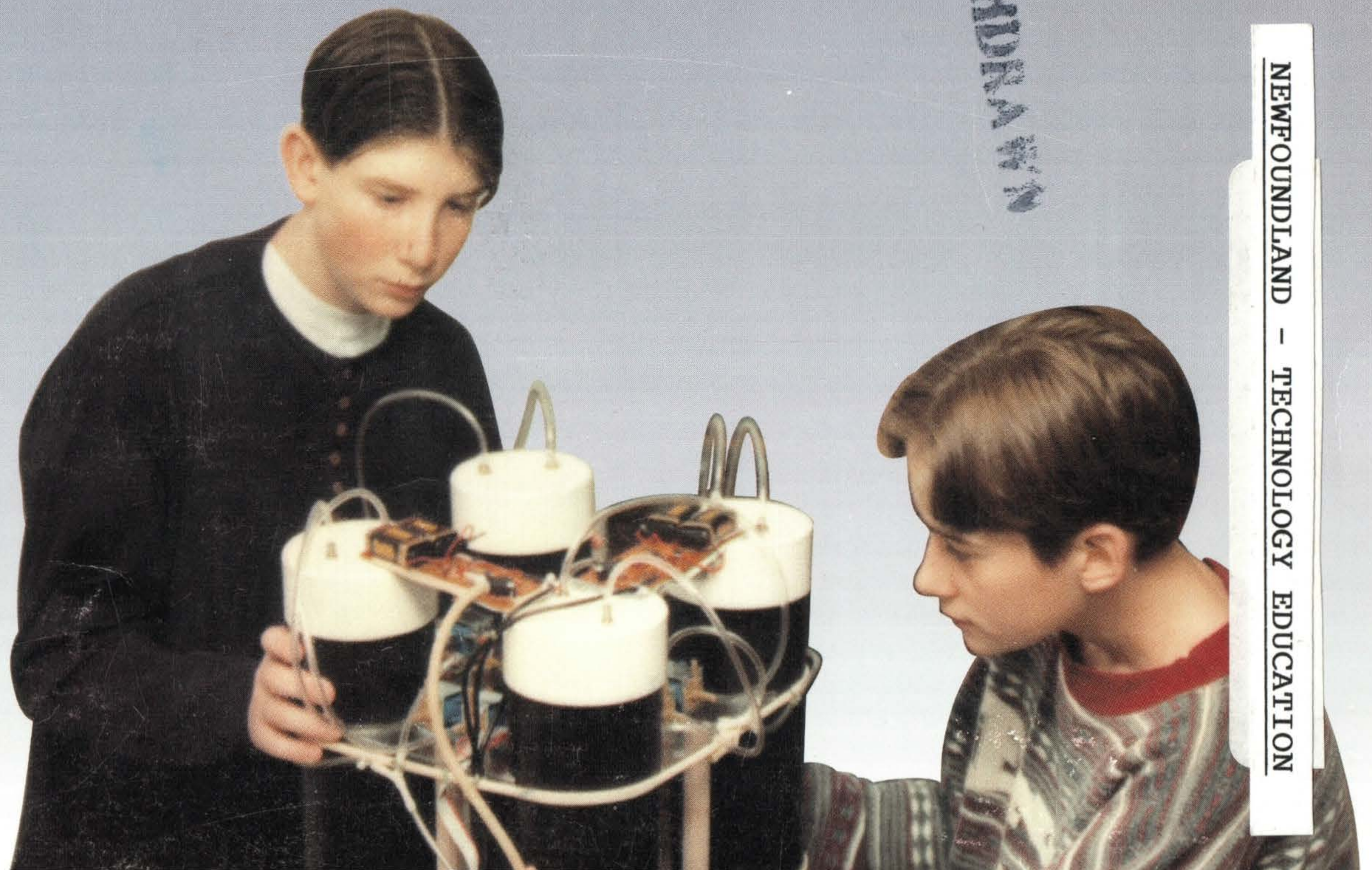
A Curriculum Framework for Technology Education:

LIVING IN A TECHNOLOGICAL SOCIETY



GOVERNMENT OF
NEWFOUNDLAND
AND LABRADOR
Department of Education
Division of Program Development

Authorized by the Minister

Preface

Students need to develop an understanding of design and technology problem-solving strategies and practices. This includes knowing a range of formal problem-solving models. Application of these models is central to the technology education instructional environment.

Purpose of this Document

The purpose of this document is to provide an overview of the technology education program for the primary, elementary and secondary schools in Newfoundland and Labrador. The primary audience is educators - school administrators, teachers, and curriculum developers. It should also be useful to district office staff, other educational institutions and members of the public.

The document identifies the rationale and nature of the technology education program, general curriculum outcomes, and program organizers. It summarizes the outcomes at the end of primary (grade 3), elementary (grade 6), intermediate (grade 9) and high school (grade 12). Additional material is provided on program design (modules and courses) for each level of schooling, implementation strategies, and facility and resource requirements.

Document Limitations

This document is not designed as a guide to curriculum implementation at the classroom level. The Department of Education provides a range of other documents for that purpose. These include curriculum and teaching guides for specific grades and courses. Curriculum and teaching guides will provide details on specific curriculum outcomes, performance expectations and standards, sample activities, teaching and learning resources, implementation and assessment strategies and other information necessary for implementation of the technology education curriculum.

About the Cover

The image on the cover is of two grade eight students, Frank Shapleigh, Jr., and Mike O'Reilly, along with their award-winning model of a semi-submersible oil platform. The computer controlled project won a gold medal and an engineering award in the 1996 Canadian Science and Technology Fair, and a place for the students on the 1997 Canadian team to the Louisville, Kentucky, International Science and Engineering Fair.

Acknowledgements

The Department of Education wishes to acknowledge the contributions made to the development to this document by a number of people. Some served on committees, others were part of a consultation process. The document evolved from an earlier draft framework for technology education, ***Technology Education: Living in a Technological Society***. Reactions from districts and individuals were considered when developing the final version.

During January/February, 1995, the Department conducted three regional consultations with stakeholders to examine the relationship of the science education and technology education programs at intermediate. The purpose of the round tables was to determine whether the programs should be combined or separated. The consensus of more than 120 people was to separate the two programs at the intermediate level. The Department wishes to thank all those who attended. Their contribution to the debate was very helpful.

This document is based on an articulation of technology education through outcomes statements. The following people participated at one or more times in formulating the general curriculum outcomes, the technological domains for technology education, and/or the key stage outcomes:

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Elementary key stage outcomes were developed in consultation with Margaret Wakeham and primary key stage outcomes were developed in consultation with Linda Coles. Ms. Wakeham is the K-6 French Immersion Specialist and Ms. Coles is the Primary Education Specalist with the Division of Program Development

Finally the Department would like to thank 120 or so primary, elementary, intermediate, and high school principals and district office personell who participated in five regional consultations on the implementation of this program. A number of changes in approach and program structure resulted from these discussions

This document was produced by Leon Cooper, Department of Education, Division of Program Development.

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Chapter 1 The Nature of Technology Education

"Any sufficiently advanced technology is indistinguishable from magic." Arthur C. Clarke

The Nature of Technology and Technological Society

Technology is a uniquely human endeavour. It is a conscious process by which people alter their environments. People use tools, materials and processes to create and modify artifacts, systems and environments. They interact with technology to extend human capabilities.

Technology modifies, and is modified by, all human activity. From simple to complex, from prehistoric to post-modern, all of our belongings, all the trappings of contemporary society are a result of technological activity. Technological activity and tools make it possible for people to create great works of art, music, and literature. They also make possible ordinary and everyday objects. People employ resources and tools, strategies and processes, which are purely technological - without which the mind could dream, but the hand could not create. Great works of art may transcend the technological resources, tools, and even the time and person that created them, but look closely enough and one may understand the technology, the person, and the society.

Technology cannot be separated from culture. Practices, customs, mores, and relationships evolve and take hold based on technologies of, for example, communications, transportation, production, and leisure. The evolution of communications and transportation technologies affects the evolution of societal and personal world views and the individual's sense of identity in that world. Moral values and ethical choices are tested and affected by technological change and new possibilities. Death and life, and the determination of both, are subject to technological influence and modification. Technology shapes, and is shaped by culture and values.

Technology cannot be separated from daily living. Technological resources are consumed, technological solutions are created and applied, and technological tools and products are routinely used. Yet people routinely misunderstand, misrepresent, and misuse technologies and technological products. Not everyone may think of technology as magic, but it may as well be if it is not understood. What happens when the telephone is used, the TV is turned on , or a key is pressed on the keyboard? What are the implications of genetic engineering? These questions, and others, can only be answered with knowledge of the technological and scientific principles, and by technological practices and outcomes.

Technology is often thought of as an "it" - that is, as a product. It is more of a "what, why and how". Technology has evolved as a set of strategies that people employ to develop solutions to needs and wants and to identify and meet opportunities. It consumes resources, has positive and negative outcomes, is characterized by a broad range of products, always results in a solution, requires choice, and is an indicator of the nature of a society. It is the role of technology education to ensure that students do not treat technology as magic, but as a logical component of the modern world.

Technology is often confused with science. Technology and science are symbiotic, but technology is not the same as science. They have different origins, serve different purposes, employ different methods, and have different outcomes. Modern technology depends heavily on a thorough understanding of scientific concepts and principles. Modern scientific practice cannot be conducted without employing sophisticated technological tools and processes. Each has effects which are felt in both social and personal contexts. Figure 1 (Trowbridge and Bybee, 1990) illustrates the practices of each and the relationships between them in their impact on humans.

Science is concerned with the natural world - technology with the human made. Science has an investigative focus - technology has a practical problem-solving focus. Science proposes explanations of the natural world while technology offers solutions to human needs and wants. Both have consequences. Science raises new questions and avenues of investigation, affects social issues and personal choices. Technological activity always results in new needs and wants that create new problems. It also affects social issues and is a major factor in determining the limits of personal choice.

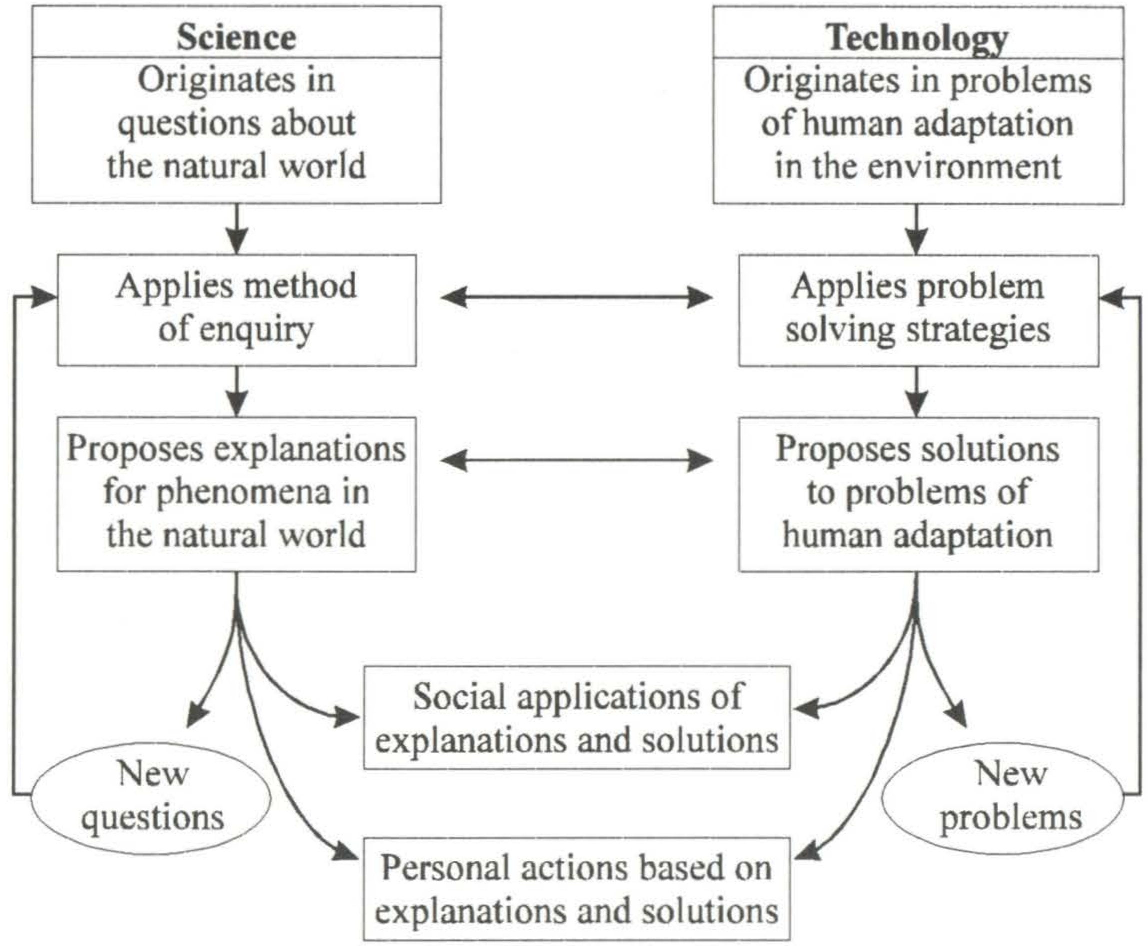

Figure 1, Technology-Science Relationships

As society adopts more complex technologies, the need for comprehensive technology education increases. Technology education becomes basic education in that it is an essential for all students. It should, therefore, provide students with a thorough understanding of the what, why, when, where, and how of technological practice and knowledge. It should ensure that students comprehend: technology as a human adaptation; technology as a means of control (ensuring that something happens as it should); the unintentional effects of technology (good and bad); that technologies often fail (wear out), and; the relationship between science, technology, and social issues.

The Nature of Literacy in a Technological Society

Being literate involves making meaning from a variety of sources and communicating it to a variety of audiences. Increasingly, those sources and the communications means are technological in origin. Literacy in a modern society requires a high degree of technological literacy. Technological literacy is not fixed. It is not a level that one achieves never to be concerned about again. Technology changes rapidly. Technological literacy is constantly changing. The technologically literate person is a person who can look beyond the obvious and apply creative, innovative thinking to a problem. It is a person who has a variety of strategies to cope with technological issues, respond to rapidly changing technological tools, and meet the needs of being a productive member of a technological society. There are points of reference for technological literacy which have common elements for all members of society, but with the possibility for unique referents for different members of society.

The common elements for everyone with respect to technological literacy includes strategies for the following:

- choosing and using appropriate technology;
- evaluating the appropriateness of a technology;
- using technology to solve non-technical problems;
- developing technological solutions to problems;
- assessing the impact of technology, and;
- thinking critically and communicating within a relevant body of technological knowledge.

In essence, technology education should enable students to become technologically literate and acquire sound technological practices for lifelong learning. It should allow for multiple levels and kinds of technological literacy and foster innovative, creative practices.

The Nature and Purpose of Technology Education

Technology Education has evolved from industrial education. It reflects that heritage in the activity based nature of the program and in the way it expects students to make connections between technical skills and activity and the world at large. It retains much that was good about the older program, but it places it in the context of the modern technological world and modern technological practice. That world and practice is largely built around strategies to cope with rapid technological change and strategies to develop unique and appropriate technical solutions to a broad range of human needs and wants. It is often characterized by the systemic use of computer based communications technologies in all technological domains.

Technology education helps students develop understanding, skills, and attitudes needed for them to be knowledgeable consumers and users of technology. It engages students in active learning in which they construct knowledge from a broad range of sources and activities. It provides students with opportunities to develop technological solutions to problems and ways to determine if their prediction of outcomes is accurate. It expects students to distinguish between the processes and strategies of technological activity and the consequence or product of technological activity. It expects students to interpret and assess the pervasive role of technology in society. It expects students to choose appropriate technological resources and use tools effectively. It expects students to evaluate technological activity, products, and solutions and to effectively communicate their findings.

Technological activity, and hence technology education, employs multiple strategies, processes and skills. Regardless of which of Gardner's ***multiple intelligences*** a student is predisposed towards, technology education provides opportunities for challenge and excellence. For example, students read, write and communicate with and about technology (***linguistic***); identify and resolve problem situations (***logical-mathematical***); express ideas through design, technical drawing, and prototyping means (***spatial***); construct, test and manipulate physical devices and environments (***bodily-kinesthetic***); organize and manage group responses to problem situations (***interpersonal***); and set personal goals and work independently (***intrapersonal***). Technology education outcomes do not identify music (***musical***) in a specific sense. There are many and diverse opportunities, however, for technology education students to incorporate music as a fundamental component of technical solutions.

Technology education develops comprehensive, meaningful connections to, and among, other disciplines. Students employ scientific, technological, mathematical, social and other related knowledge in order to develop technological solutions. By providing students with opportunities to make these connections, technology education contributes to their success in other disciplines.
Technology education makes a cross curricular contribution by enhancing the development of the individual in a number of ways (see for example technology education framework documents from Northern Ireland, 1991; British Columbia, 1992; and New Jersey. 1987). It is broad-based and embodies the style of learning promoted in the Department of Education document, ***Learning to Learn: Policies and Guidelines for the Implementation of Resource-based Learning in Newfoundland and Labrador Schools***. Specific contributions include:

- development of analytical and critical thinking skills. Students actively participate in solving technological problems; assessing the appropriateness of the technological resources of information, people, materials, tools and machines, energy, time and money to the solution of a problem; and determining the outcomes of a solution;
- enhancement of communication skills to develop proficiency in understanding and using the language of design and technology; use information technology to acquire and assess information, to design solutions to technological problems, and to disseminate the results, and to communicate intelligently about technology, the solutions to technological problems, and their cultural, social and environmental impact;
- fostering self-esteem by acquiring knowledge, interests, and motor skills related to life and careers, and by encouraging pride in quality work;
- development of work habits and career understandings by exploring careers and the evolution of careers as technologies change; developing basic skills with various technologies, and becoming aware of, and responsive to, the impact of technological change in the workplace;
- development of an understanding of the practical uses of scientific, mathematical, and other knowledge and skills by applying them to solutions;
- contributing to the realization of the student's creative potential;
- development of self-confidence, adaptability, and attitudes necessary for lifelong learning in a society in which the average person will change careers many times.

Technology education also addresses issues of science-technology-society interactions. It is concerned, for example, with sustainable development as an appropriate technological response in such biotechnology areas as agriculture, aquaculture, and silviculture.

Technology education has a significant on the application of the tools and techniques of information and communications technologies. Information is considered an important commodity in all communications systems. Information sources include text and images as well as remote sensing of ocean data and satellite video distribution.

Chapter 2 Design of the Technology Education Program

Technology Education is a complex, multi-dimensional facet of the total education program. It is an essential component of general education. It assists students to understand the relationships of technology to science, society, and the world of work. It deals with the fundamental issues of technology as product, technology as process, and also with technological systems. It has an integrating influence which helps students understand the totality of the educational experience.

The Essential Graduation Learnings - Educational Requirements for all Students

The Atlantic Provinces Education Foundation, of which Newfoundland and Labrador is a signatory, has identified six **Essential Graduation Learnings (EGLs)**. These apply to all students in each of the four Atlantic Canada provinces, including Newfoundland and Labrador. These statements describe the characteristics of any graduate in either of these provinces. The six statements are:

- **Aesthetic Expression**
  Graduates will be able to respond with critical awareness to various forms of the arts and will be able to express themselves through the arts.
- **Citizenship**
  Graduates will be able to assess social, cultural, economic and environmental interdependence in a local and global context.
- **Communication**
  Graduates will be able to use the listening, viewing, speaking, reading, and writing modes of language(s), and mathematical and scientific concepts and symbols, to think, learn and communicate effectively.
- **Personal Development**
  Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.
- **Problem Solving**
  Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, and mathematical and scientific concepts.
- **Technological Competence**
  Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.

Each province may have one or more additional **EGL**s unique to that province. Newfoundland and Labrador has one additional **EGL**. It is stated as:

- **Spiritual and Moral Development**
  Graduates will be able to demonstrate understanding and appreciation for the place of belief systems in shaping the development of moral values and ethical conduct.

Technology education is about developing a level of technological competence and technological literacy. It is, therefore, an obvious choice to say that it contributes significantly to the ***Essential Graduation Learning*** of ***Technological Competence***. It would be simplistic to leave this as the only connection. Technology education contributes to the ***EGL***s in substantive, obvious ways and in substantive subtle ways. It also contributes in subtle, indirect ways. Mapping these connections can only serve to point out the obvious. More subtle, and very important, connections are made by individuals as cognitive processes are brought to bear on real, everyday, meaningful problems. By applying knowledge and skill to new situations, students build new knowledge and render meaning to what may often be seen as unconnected events, bits of information, and isolated technical skills. Chapter 2 provides a more detailed presentation of the contribution of Technology Education to these ***EGL***s. The following model (see Figure 2) illustrates the scope of interaction that technology activity develops with other disciplines and knowledge areas.

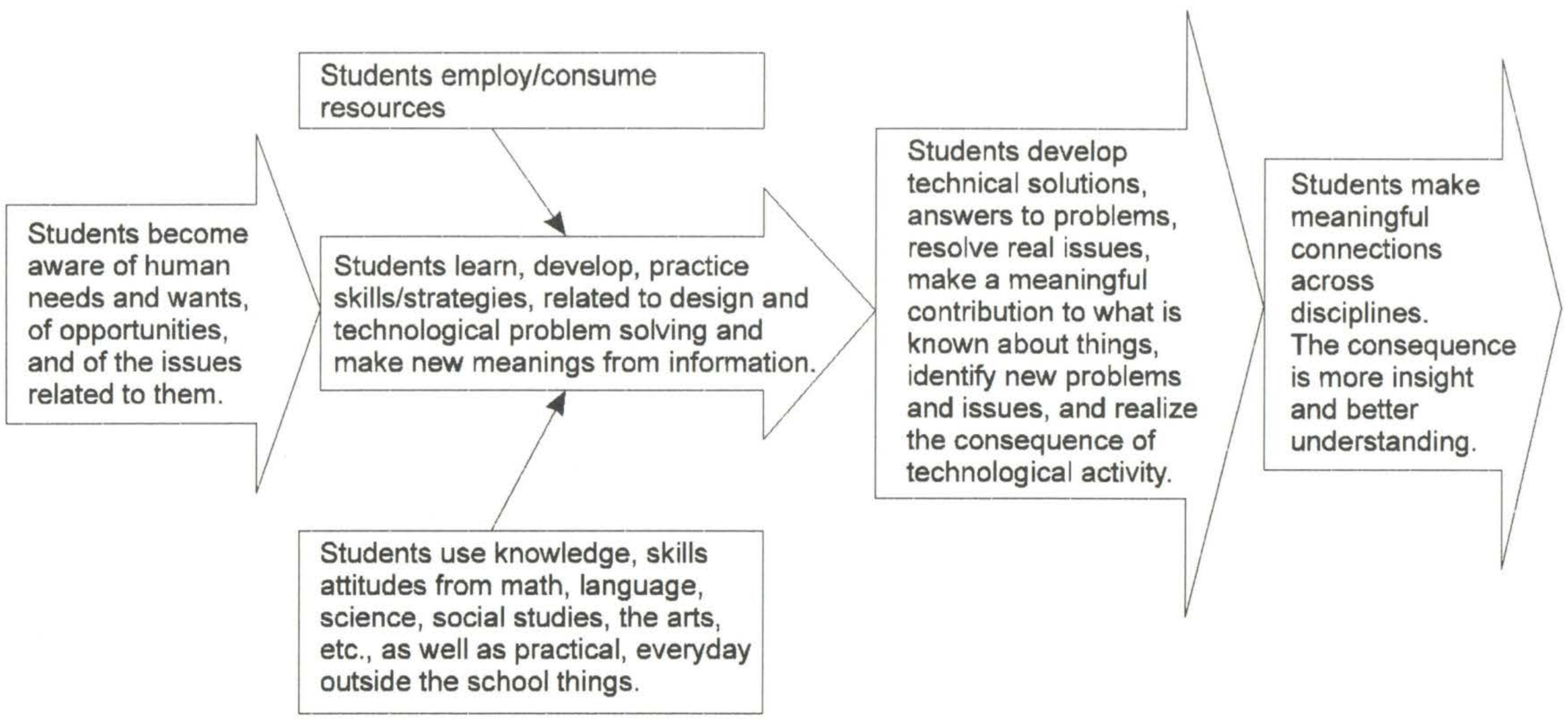

Figure 2 Interaction of Technology Education with other Disciplines

Relationship of Levels of Outcomes

Technology Education, like other programs, is defined in terms of ***General Curriculum Outcomes*** (***GCO***), ***Key Stage Outcomes*** (***KSO***) ***Specific Curriculum Outcomes*** (***SCO***), and ***Performance Standards*** (***PS***) (see Figure 3). ***GCO***s define the discipline in more general terms but in a very compact way. They apply to the program from kindergarten to grade 12. ***KSO***s define a curriculum area or subject in terms of requirements for the key stages of grade 3, grade 6, grade 9, and grade 12. These key stage outcomes, or end of levels statements provide an overview of the program at the primary, elementary, intermediate and high school levels. ***SCO***s are much more specific. They define the subject at a particular grade level or in a particular high school course. ***PS***s are a further specification of the grade level or course. They define, in measurable terms, expectations for student achievement. The relationship between the Essential Graduation Learnings (***EGL***) and a particular subject (curriculum or program area) is described in terms of the relationship between ***EGL***s and ***GCO***s. The relationship between ***GCO***s, ***KSO***s, ***SCO***s, and ***PS***s are described and defined as the program is developed. Thus one can establish clear relationships between ***EGL***s and all other levels of specification of the technology curriculum.

Technology Education is described in terms of six ***GCO***s. These outcomes apply to all grade levels and all technology education courses at high school. The level of attainment with respect to these outcomes will be significantly different from primary to high school. In addition, content is organized according to five ***Technological Domains***. For most of the program these domains are approached in an interrelated fashion. At intermediate the domains tend to be approached in a more detailed, segregated fashion. Although some high school courses focus more on one domain to the exclusion of others, most courses combine several domains.

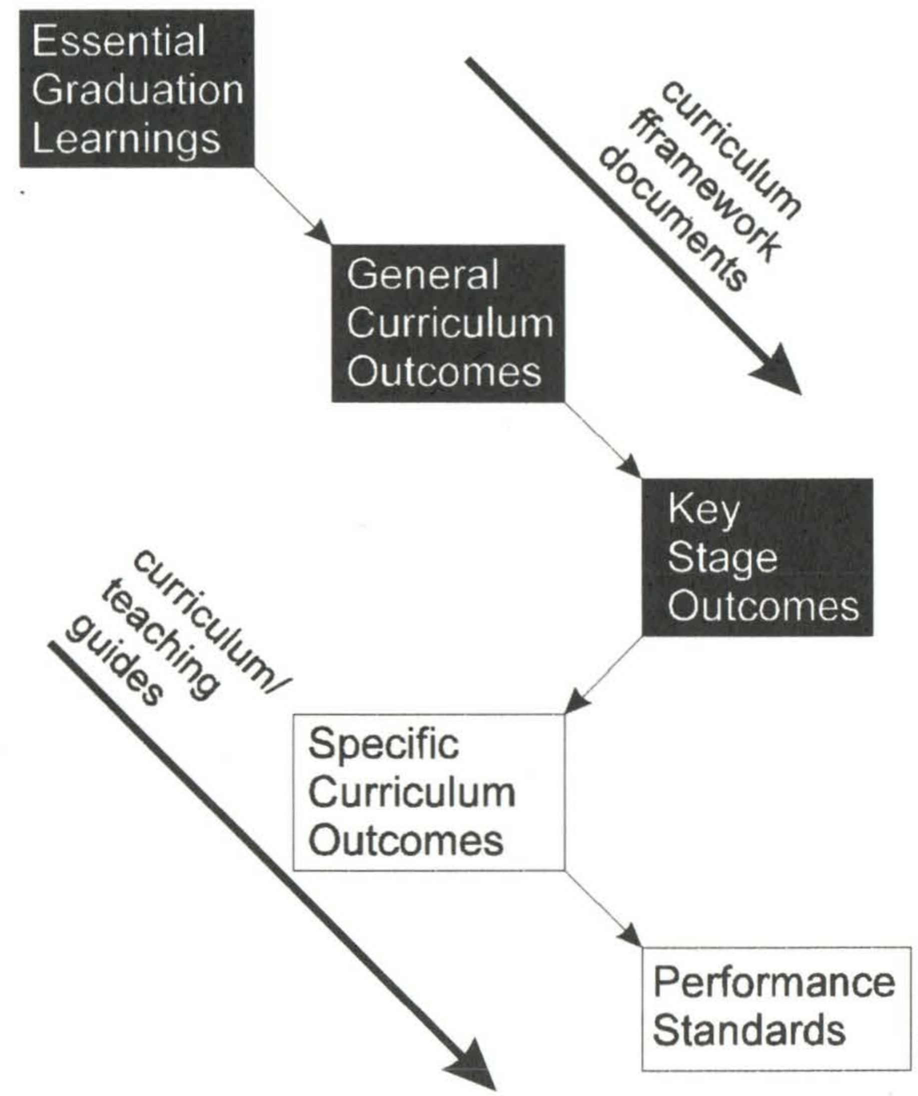

Figure 3 Outcomes Relationship

General Curriculum Outcomes

The six general curriculum outcomes for technology education are:

- **Nature of Technology**
  Students will demonstrate an understanding of the nature of modern technology, including the basic technological and scientific principles which underlie technology activities, processes, resource utilization, technological tools, and systems.
- **Technological Problem Solving**
  Students will solve technological problems by employing the design process to identify needs and opportunities, generate solution ideas, make and fabricate solutions, and evaluate and reflect on them.
- **Technological Impact**
  Students will demonstrate understanding of the impact of technology and technological change on self, society, the workplace, careers, and the environment.
- **Technological Literacy**
  Students will read, comprehend, write and use the language and terminology of technological problem solving and will make appropriate use of technological products.
- **Lifelong Learning**
  Students will demonstrate understanding of the role of technology to enhance the learning process, will use technology as learning tools, and will develop active learning strategies to employ technology for lifelong learning.
- **Technological Communications**.
  Students will demonstrate understanding of the role of information and communications technology in managing technological processes and resources, and will use them to manage and communicate effectively about technology.

Relationship of Technology Education to Essential Graduation Learnings

Technology education contributes significantly to the EGLs. A number of these contributions are identified below These are presented with respect to general curriculum outcomes.

Nature of Technology is concerned with the role and purpose of technology as a means of adaption. Students develop understanding of:

- technology as a modern endeavour;
- the evolution of technology;
- technology as a creative design and problem solving process employing invention and intuition;
- technology as product - tools, machines, consumables;
- relationships of technological activity to other disciplines; and
- the role and impact of information and communications technology in all areas of modern technological practice.

This outcome contributes primarily to the essential graduation learning ***Technological Competence***.

Technological Problem Solving is concerned with analysis of human needs and wants which may be met by technological activity. Students:

- identify, describe, formulate, reformulate, and analyse technological problems;
- show creativity and initiative in applying the design process;
- develop trouble shooting skills;
- solve technological problems individually and collaboratively;
- develop and use skills with tools and materials, including information and communications tools and techniques; and
- discover personal and creative ways to use tools and materials for aesthetic expression.

This outcome contributes primarily to the essential graduation learning

Problem Solving. It also contributes significantly to the **EGLs** ***Technological Competence*** and ***Aesthetic Expression***.

Technological Impact is concerned with, for example, the role of technology as a powerful change agent. Students examine:

- technological outputs - the consequences of technological activity. They may be desirable and expected; desirable and unexpected; undesirable and expected; or undesirable and unexpected;
- technology as a proactive/reactive personal, social, or environmental force;
- the rationale and necessity of sustainable development; and
- the consequence of convergence of all communications technologies into a single, multi-modal digital technology.

This outcome contributes primarily to the **EGL** ***Technological Competence***. Because the issues raised by this technology education outcome are based in a major way around students developing the capacity to apply moral and ethical standards to technological decision making, it also makes a major contribution to the **EGL** ***Spiritual and Moral Development***.

Technological Literacy is concerned in large part with language, reading, and communications with and about technological concepts, products and issues. Students develop abilities with:

- technical vocabulary and concepts;
- knowledge and understanding of technological, scientific and mathematical principles;
- reading and writing technical material;
- using communications networks effectively and efficiently;
- logic and programming; and
- making informed decisions about technology.

This outcome contributes primarily to the **EGL** ***Citizenship***, and contributes significantly to the **EGLs** ***Technological Competence*** and ***Communications***

Lifelong Learning is concerned with the ability of students to become more effective and capable learners, and with development of curiosity and a desire to understand the role of technology. For example, students:

- examine technology - career links;
- explore the technological future and its relationship to personal success, health and happiness;
- work and learn by collaborating with others near and distant; and
- use communications technology to acquire, produce, assess, adapt, present and share ideas, information, and technological solutions.

This outcome contributes primarily to the **EGL** ***Personal Development***.

Technological Communications is concerned with students' understanding of how communications technologies and tools are used in control, production, energy/power, and biotechnology. Students examine ways in which communications technologies are used for:

- design of systems and processes;
- development and application of communications devices and networks for a variety of technological endeavours;
- development/production of systems, tools and devices; and
- management of processes and systems.

This outcome contributes primarily to the **EGL** ***Communication***.

Figure 4 illustrates the major connections between the Essential Graduation Learnings and the technology education General Curriculum Outcomes. APEF means Atlantic Provinces Education Foundation in the following diagrams.

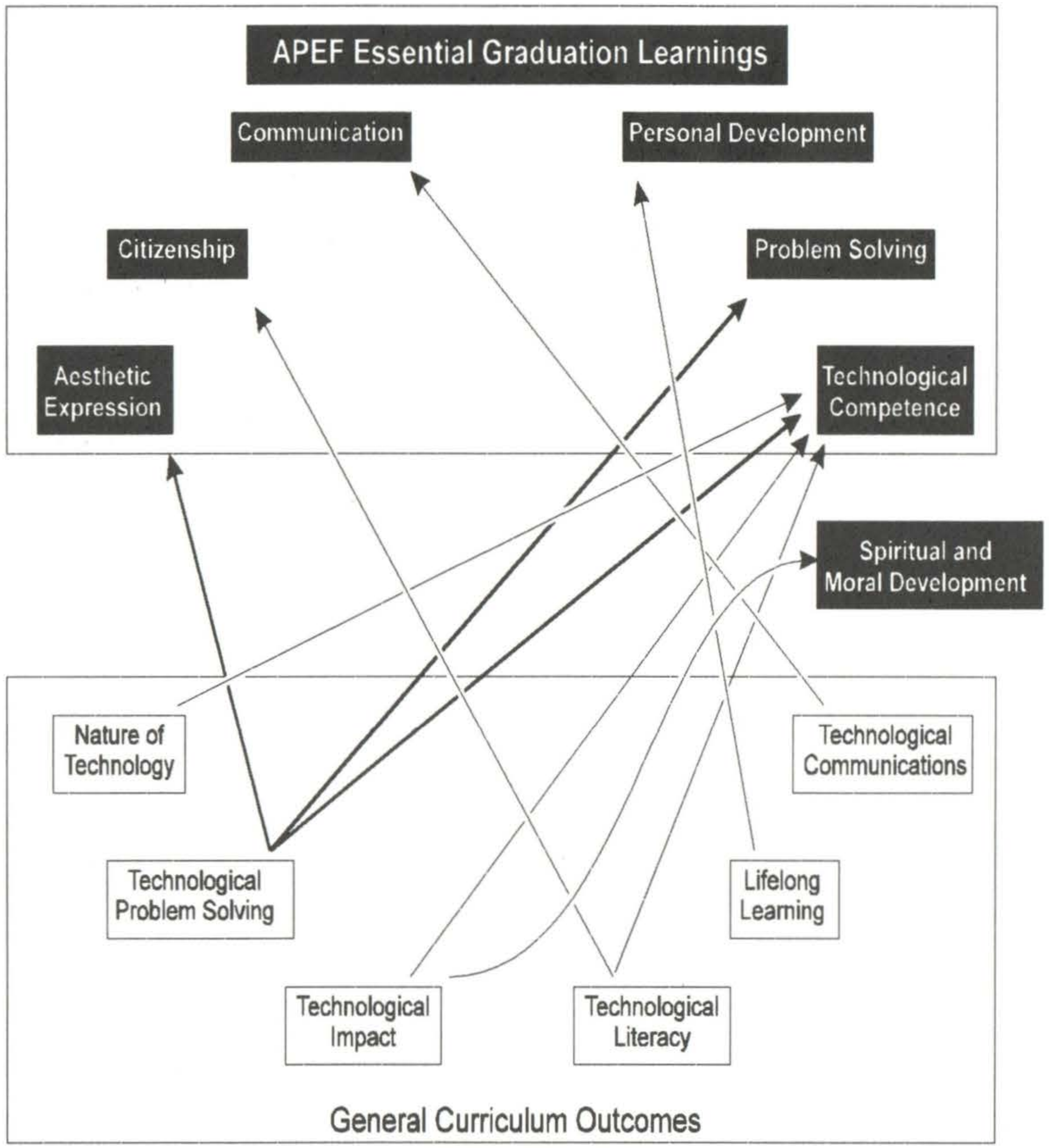

Figure 4 Relationship of ***GCO*s** to ***EGL*s**

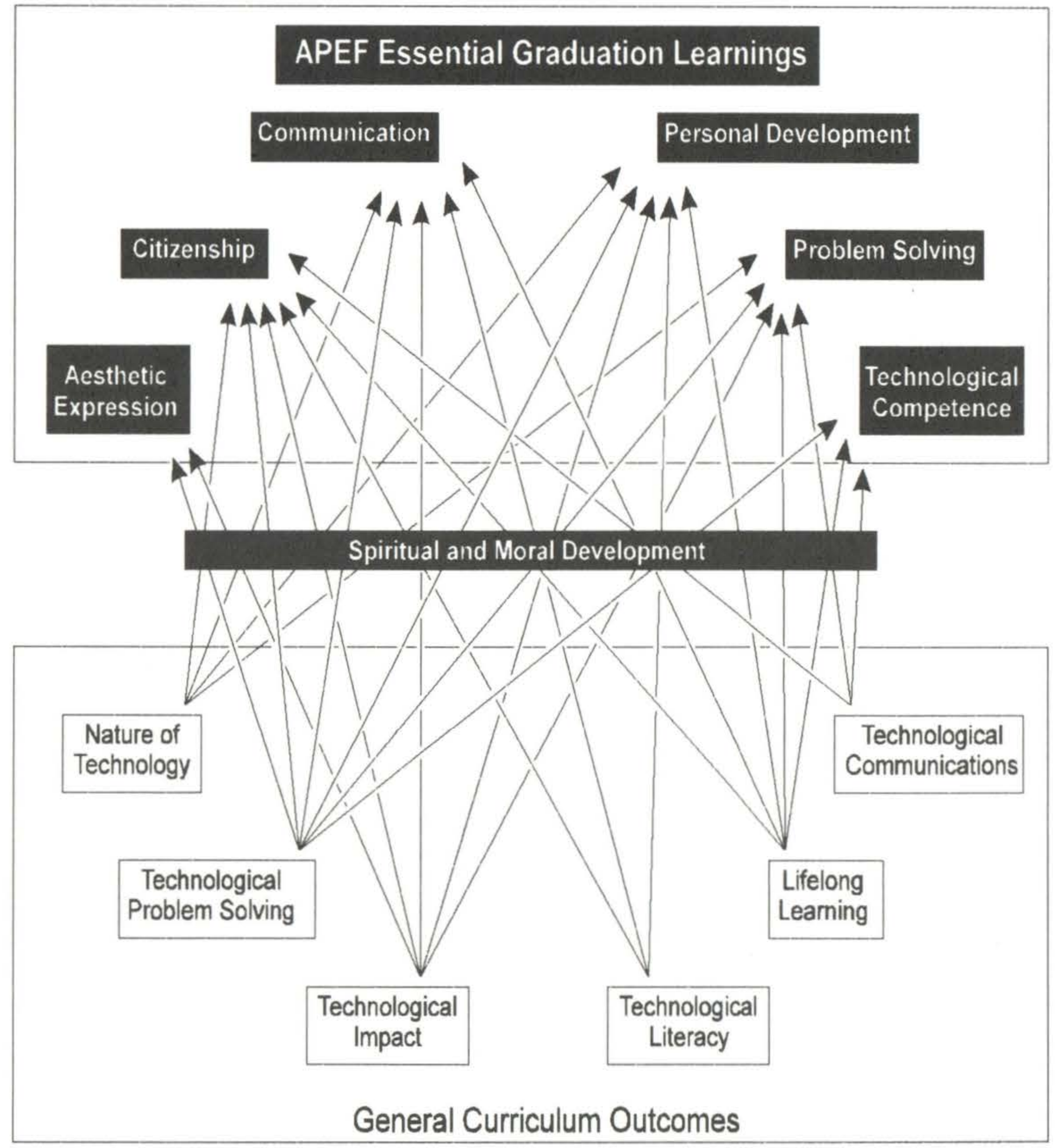

Figure 5 Complexity of ***GCO-EGL*** Interactions

Technology education is a complex mix. It allows and expects students to pursue and develop a wide range of experiences, knowledge, skills and attitudes. ***Figure 5*** illustrates some of that complexity of interaction.

Technology activities and products are an integral component of personal perceptions of who and what we are as individuals and societies. It is not surprising, then, that technology education impacts each of the essential graduation learnings in a myriad of ways. By doing so it contributes significantly to the development of the student as a whole person. Note that the **EGL *Spiritual and Moral Development*** can be seen as a filter through which students view and experience these interactions.

Domains of Technological Learning

Technologies can be organized for study in a variety of ways. This program is organized along five domains of technological learning. These are conceptual organizers which allow the study of any technological process, activity, product, or impact. The domains are:

- ***Communications***
- ***Control***
- ***Production***
- ***Energy and Power***
- ***Biotechnology***

These domains are described in the following section. Although they are discrete organizers, in actual practice, most technological activities in which students engage involve more than one domain. This is especially true for technological problem solving exercises. At some points in the program, however, students attention may be focused on one domain to the exclusion of others

As with the general curriculum outcomes, each of the domains is applied at all program levels. Concepts, tools, strategies, and activities are introduced appropriate to each grade level.

Communications

Communications refers to the technological processing of information, based on the fundamental processes of encode/decode, store/retrieve, and transmit/receive. The focus is on the tools, techniques, and strategies for development of solutions to communications problems. Encoding and decoding are methods of representing information and ideas through technological means e.g., writing, printing, technical drawings, and paintings. So, too, are ASCII and binary computer storage methods. Sending and receiving are means of getting encoded information from creator to audience, from place to place. Regular mail, electronic mail, newspapers, telephone, and television are all sending and receiving technologies.

Storing and retrieving are means of placing information in a specific location when not needed and getting it when it is needed. Books, bookshelves, and libraries are traditional technologies. Computers with random access memory, hard drives, optical drives, and floppy disks are more recent technologies. So too are digital video, multimedia, and interactive wide-area networks.

Communications technologies are also employed across all other technological domains. They are used for sensing and control, production design and management, computer integrated manufacturing, and for province wide management and control of the electricity grid. Biotechnology industries rely heavily on communications technologies for design, management of processes and measurement/assessment of outcomes.

Communications				
Fundamental Principles	Curriculum Directions	Sample Resources	Sample Activities	Sample Products
Decode/Encode. Send/Receive. Store/Retrieve.	Use technology to communicate effectively. Design and create products. Develop knowledge and skills with tools and techniques.	Modems Printers Scanners Computers Hard drives Plotters Video recorders CD-ROMs	Create publications and presentations. Create multimedia. Communicate at a distance. Develop ideas in orthographic and isometric styles.	Papers Newsletters Audio tapes WEB pages Multimedia apps. Graphic images Slide shoes Maps

Figure 6 Sample Components of Communications Domain

Control

Control refers to the application of devices and processes to manage, sort, monitor and regulate machines, systems, and activities. It employs the fundamental principles of sensing, switching, and regulating within mechanical, electrical/electronic, fluidic (hydraulic/pneumatic) and thermal systems.

Sensing is determining if an event or change has occurred. It can be used, for example, to determine if the temperature has changed, if something has moved, or if the weight of and object has changed. Sensors may be mechanical, electrical or some other type. They may sense pressure, motion, magnetism, oxygen, or some other characteristic. Sensing is often used to decide if particular events need to be initiated.

Switching is a process of making a single change in response to a sensed event. It can be used, for example, to start or stop a timer, to turn lights on or off, or to start or stop a motor. Pushing an elevator button is common example. The system senses the push of the button and responds by turning on the elevator motor.

Regulating is a continuous process. It is a regularly scheduled sequence of data collection through one or more sensors, making decisions about one or more choices based on the data collected, and carrying out those decisions. A car's fuel system is a good example. The position of the accelerator is constantly monitored (sensed): the embedded computer system uses that information along with additional information such as current gear, air pressure, engine temperature, current speed, and exhaust emissions to regulate the air-fuel mixture going into the engine. A common household thermostat is a simpler, less sophisticated regulating system.

Control				
Fundamental Principles	Curriculum Directions	Sample Resources	Sample Activities	Sample Products
Sensing. Switching. Regulating.	Application, design and creation of devices and systems that sense changes and manage or regulate events and processes. Using control systems to perform a range of activities.	Switches, wires, resistors. Sensors, interfaces. Pipes, gear trains, wheels. Pneumatics. Fiber optics. Computers, programming languages.	Manual/automatic remote control. Motion detector, alarms, warning devices. Conveyors, doors, lights, heating, fans. Robots, tools sound effects.	Computer programs. Toy solar car. Burglar alarm. Water alarm. Irrigation system. Door opener. Pet door. Temperature probe. Automatic lights

Figure 7 Sample Components of Control Domain

Production

Production focuses on the use of tools and materials to create artifacts (objects, products) and systems to satisfy human needs and wants. It includes the fundamental principles of combining, forming/shaping, separating, and finishing. Although producing refers to any activity which is used to create something, including non-commercial activities, manufacturing and construction refer specifically to those processes used in industry and business to create objects for commerce.

Combining refers to different ways of putting materials together. It includes mechanical fastening (glue, nails, screws), adhesion (gluing, soldering), and cohesion (welding, using solvents). Forming and shaping include a wide range of methods for changing a material's shape. Folding, casting, pressing, rolling, weaving, knitting, and extruding are some examples. Separating is the process of removing material. Methods include sawing, knife cutting, carving, arc cutting, and laser cutting. Finishing is the process of treating the surface of an object to give it special characteristics or to alter its look. Common examples include anodizing of aluminum to make it tarnish free and applying a surface coating (paint, enamel, etc.) by brushing, spraying, or rolling. Others include sand blasting, bleaching, burnishing and etching.

Production also includes digital products in print or electronic formats.

Production				
Fundamental Principles	Curriculum Directions	Sample Resources	Sample Activities	Sample Products
Combining. Forming/Shaping. Separating. Finishing.	Resource usage/conservation. Design and construction of prototypes and products. Evaluating products and materials	Wood, metal, cloth, paper, glue. Fasteners (nails, staples, screws) and jigs. Hand tools (saws, hammers, drills, scissors, paint brushes) Power tools (sanders, saws, glue guns)	Identifying best materials for a product. Identifying the best tools for a task. Designing and building a toy, a shelter for a pet, or a place to work.	Toy car. Desk, stool. Dog house. Tool box. Cloths storage. Greenhouse Model rocket Game, puzzle. Habitat.

Figure 8 Sample Components of Production Domain

Energy and Power

Energy and Power refers to the application of devices and processes to convert, transmit, and conserve various forms of energy including mechanical, thermal, light, chemical, electrical, and nuclear. Traditional and alternate energy and power systems are examined.

Energy is the ability to do work. Power is the controlled application of energy to do work. Power is created when energy is converted from one form to another. For example, the energy of moving water turns a turbine which generates electricity, which in turn provides a source of power for all sorts of equipment.

Conservation refers to the principle that energy cannot be created or destroyed, but its form can be changed. In technological terms it also refers to the practice of efficient use of energy. Energy using systems are designed to get maximum desirable effect with minimum wasted energy - for example, using florescent lights as an alternate to incandescent lights. Conversion refers to the transformation of energy from one form to another. Flashlights convert chemical energy (batteries) into light and heat energy. Cars convert chemical energy (fuel) into heat energy (the engine) and then into mechanical energy (motion of the car). Transmission refers to the moving of energy from one location to another. Electrical utility lines are one very basic example.

Energy and Power				
Fundamental Principles	Curriculum Directions	Sample Resources	Sample Activities	Sample Products
Conservation. Conversion. Transmission.	Develop good energy conservation practices. Examine a wide range of energy and poer systems and devices. Develop effecient energy and power devices and systems.	Wood, metal, cloth, paper, cardboard. Elastic bands, springs, engines, levers, gears Batteries, solar devices, electricity. Electrict motors, switches.	Create publications and presentations. Create multimedia. Communicate at a distance. Develop ideas in orthographic and isometric styles.	Papers Newsletters Audio tapes WEB pages Multimedia apps. Graphic images Slide shoes Maps

Figure 9 Sample Components of Energy and Power Domain

Biotechnology

Biotechnology is the practice of using biological processes to create products. It includes farming, aquaculture, genetic engineering, and environmental modification. Biotechnology is concerned with the fundamental processes of propagating (developing a living entity); growing (modifying the growth of living things); maintaining (supporting normal conditions for healthy existence), harvesting (gathering, storing, and reproducing); adapting (adjusting to environmental change); treating (applying a procedure to correct, modify or cure); and converting (changing into a different form).

Propagation, or the development of living entities, has significant implications. It includes development of new life forms as well as fermentation and the development of new proteins. Growing means to develop living things or increase their size, e.g., people, plants, animals and crystals. Maintenance of conditions for healthy existence includes nutrition and environmental issues. Harvesting, or gathering and storing entities, includes giving birth as well as collecting products of agriculture, silvaculture, horticulture,, aquaculture and bio-process production. Adapting is the essence of technology - human adaption. Protection, enhancement, management, services, production, waste management, and regulation are components of adaptation. Treatment includes application of curative procedures and substances to correct a disease or imbalance in humans, animals or plants. Converting involves changing something into a different form or giving it different properties. This includes, for example, combining potatoes with algae to make them more nutritious.

Biotechnology				
Fundamental Principles	Curriculum Directions	Sample Resources	Sample Activities	Sample Products
Propagating. Growing. Adapting. Treating. Maintaining. Harvesting. Converting..	Understanding of biotechnological processes. Biotechnology as a means of creating products. Integration of a wide range of technologies into biotechnology practices..	Sees, soil, microorganisms. Computers, sensors, control devices. Tools, machines, material resources. Fish, worms, containers.	Construct a composter, cold frame, or scale model greenhouse. Construct a device or system to process plants or animals as food. Process bio-mass for energy. Grow a range of plants or fish.	Compost. Smoked fish, dryed fruits or vegetables. Smoker or dryer. Fish hatchlings. Hydroponic system. Soil treatment system. Ornamental plants.

Figure 10 Sample Components of Biotechnology Domain

Technology Education Program Design

The Curriculum Model

The figure below illustrates the relationship of the curriculum components of general curriculum outcomes, technological domains, and levels of schooling.

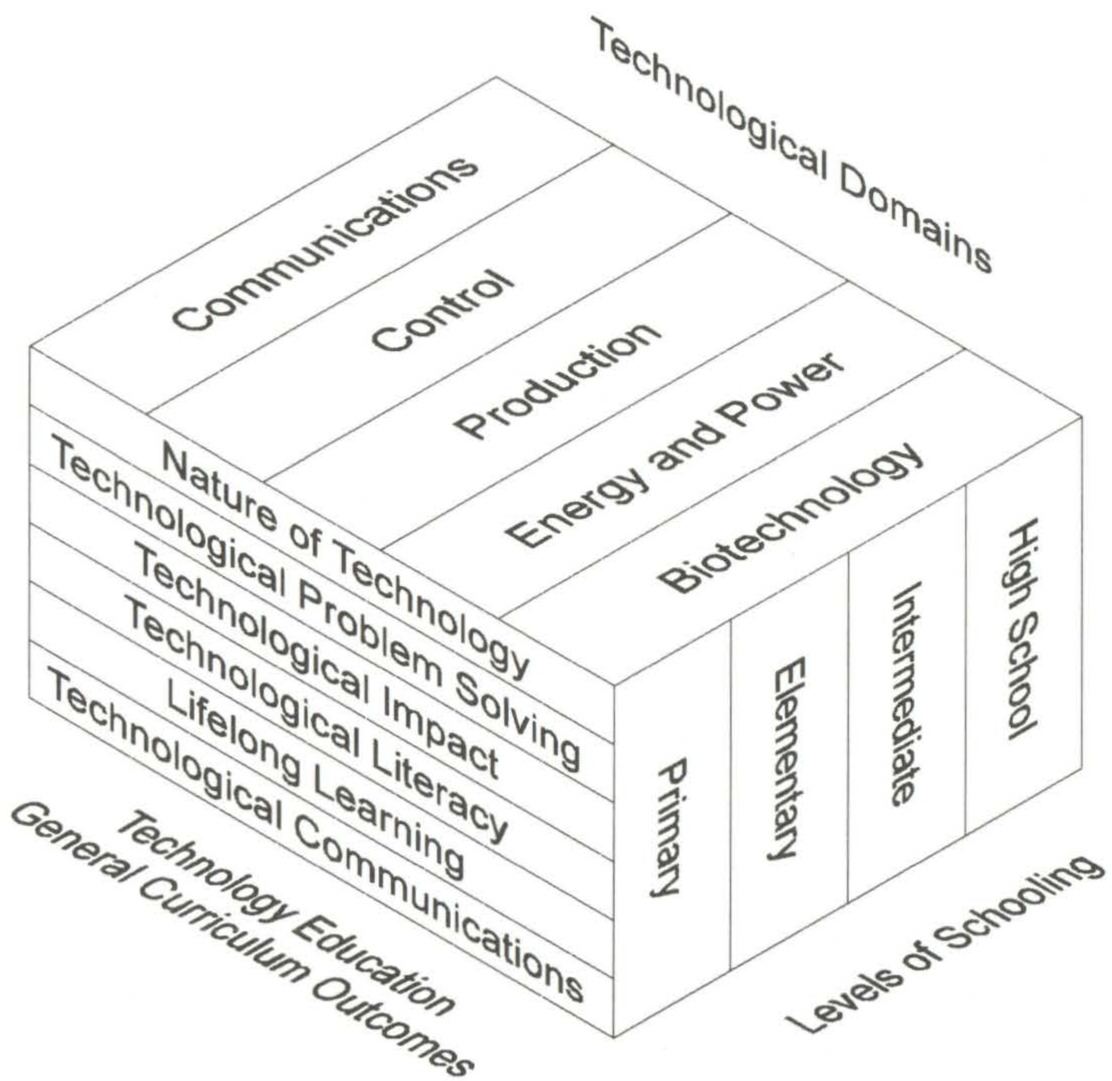

Figure 11 Relationship of Curriculum Components

As Figure 11 illustrates, the six general curriculum outcomes apply equally to all levels of the program. In addition they apply to each of the technological domains. One can proceed by looking at a single domain or by posing problem situations which apply equally along multiple domains. For most of the students's engagement with this program, the latter option will be implemented.

Technology education is concerned with developing a comprehensive understanding of concepts, relationships, and problem solving strategies. While placing a premium on student engagement through the higher level thinking skills of analysis, synthesis, and evaluation it also accommodates the full range of student responses and capabilities. It encourages growth in capability. Specific tool skills are important, but primarily in the context of particular problems and issues. Program implementation is designed to reflect that principle. The program applies a synergistic, systems based approach which both encourages and depends on making connections across the disciplines. Most of the knowledge, skills and attitudes that students acquire in the technology education program are encountered, understood and internalized in the context of problems and problem situations which have direct meaning to the student. For example, there is a focus on technological problem solving in each of the technological domains. Tools such as CAD (computer assisted drawing), DTP (desktop publishing), and the technical skills required to use them are encountered, learned, and used as needed.

The program levels of Primary, Elementary, Intermediate, and High School should not be considered as unrelated, discrete components. The general curriculum outcomes ***Nature of Technology***, ***Technological Problem Solving***, ***Technological Impact***, ***Technological Literacy***, ***Lifelong Learning***, and ***Technological Communications*** are reflected in every module, course, and grade level of the program. The program is designed to develop increasing complexity of skills and understanding from level to level, from the beginning of a course, to the end of a course. By solving problems ranging from simple to complex, innovation and creativity are fostered and the capacity to innovate and create is built.

Just as computers are pervasive tools in industry and society, they are key components of the technology program. They are fundamental to many of the practices and strategies employed in communications, control, production, energy and power, and biotechnology. They are, therefore, employed in the program as needed. Students develop an understanding that computers and related tools are part of a continuum of technological resources which may be employed in developing technological solutions to problems.

Curriculum Structure

The program will be structured as follows:

- ***Kindergarten*** students will complete a minimum of 3 modules in technology education. These modules will consist of 3 hours duration for a minimum total of 9 hours. Modules will be thematic and will provide guided activities in technology.
- ***Primary*** students will complete a minimum of 15 hours of technology education each year for a total of 45 hours during the 3 year period. This will consist of 3 design and technological problem solving modules of 5 hours duration each year. Since modules are implemented as thematic activities, this time allocation refers to the technology problem solving component of the module. A discussion of modules is offered below.
- ***Elementary*** students will complete a minimum of 25 hours of technology education each year for a total of 75 hours over the 3 year period. This will consist of 3 modules of 8-10 hours duration each year. Each module will represent three or more of the 5 technological domains.
- ***Intermediate*** students will complete a minimum of 130 hours of technology education during the 3 year program. It will consist of 5 modules of 26 hours duration, one from each technological domain. One will be completed in grade 7, and two will be completed in each of grades 8 and 9.

  Senior High school students will complete a minimum of 2 credits chosen from one and two credit courses in design, communications, computer technology, production technology and integrated technology.

Technology Education Modules

Modules are self-contained and are thematic in approach. They are sequenced from completely guided, simple events in primary to more open ended, complex issues in intermediate. Modules are based on ***Specific Curriculum Outcomes*** and ***Performance Standards***. Each is based on a technological problem solving exercise. These exercises employ design as a problem solving strategy. Design (examined in detail in Chapter 4) is not so much a single strategy as a strategy that has many possibilities. Problem situations and opportunities identified for, or by, the students are relevant to the students background, understanding, and needs. Care is taken that a progression is developed which provides students with experiences to expand their thinking and abilities.

Modules are implemented in a similar fashion at all grade levels. They provide a technology theme as a focus for activity related to all curriculum areas. In a theme that may take a number of weeks to implement, the design and problem solving exercise may take 5 hours, for example. Modules follow a curriculum infusion pattern. Each module contains a series of subject-based activities related to the technological theme. All subjects are included as appropriate. Relationships are developed in a tightly integrated manner without being contrived.

Program Design

The Primary Program - Awareness of Technology

Purpose	To make children aware that technological artifacts are not a part of the natural environment, but are purpose-made by people to solve problems and to meet human needs and wants.
Implementation	Students are introduced to basic concepts of communications as a means of sharing information, control as a means of managing devices and environments, production as a means of making physical objects, energy and power as the engine that allows us to do things, and biotechnology as a means of using living things for making useful products. They employ simple technological methods in each domain, and become aware of ideas and issues about technological impact. Students begin to build language and communications skills with and about a variety of technologies.
Program Design	Modules designed as themes which have a technology focus across all subjects as well as a specific technological problem solving exercise. Students will explore a variety of tools, methods, and products in an activity based format relevant to their age and development level. Modules (themes) may vary in duration. Each would have a 5 hour technology component. 3 modules are required in each year.

The primary program consists of the following pattern of modules:

Kindergarten	3 Modules (3 hour technology activity)
Grade 1	3 Modules (5 hour technology activity)
Grade 2	3 Modules (5 hour technology activity)
Grade 3	3 Modules (5 hour technology activity)

Modules are designed so that students have experiences with all five technological domains and all 6 general curriculum outcomes. No formal attempt is made to have students distinguish the particular domain to which technological tool or process belongs. Students are expected to deal with concepts related to the general curriculum outcomes.

Modules are designed to make connections to other disciplines and domains of learning. This is done by identifying connections from the disciplines to technological themes, concepts, practices, and specific activities.

The Elementary Program - Technology as Human Activity

Purpose	To make children aware of technology as a human activity.
Implementation	Students explore technology through solving problems. Tools, resources and problem solving strategies are introduced. Students begin to investigate real problems and create technological solutions to them. Activities are highly structured with a focused presentation of rudimentary technological problem solving strategies. Students learn to identify technological resources and how to cope with consumable resources and resource limitations. Students begin to make connections between the technology education program and subject areas. Technological activity, resources, strategies, and impact are linked to activities across the curriculum.
Program Design	Modules which have a technology focus across all subjects as well as a specific technological problem solving exercise. Students will explore a variety of tools, methods, and products in an activity based format relevant to their age and development level. Modules (themes) may vary in duration. Each has an 8-10 hour technology component. Three modules are required in each year.

The elementary program consists of the following pattern of modules.

Grade 4	3 Modules (8-10 hour technology activity)
Grade 5	3 Modules (8-10 hour technology activity)
Grade 6	3 Modules (8-10 hour technology activity)

Each module integrates content and knowledge from three or more technological domains. Each may provide a major focus on one domain. However, all five domains are covered during each school year. Each incorporates all technology general curriculum outcomes. Students will be expected to distinguish technological tools and processes from the different technological domains.

Modules are designed to identify explicit connections across disciplines. They are designed for delivery as stand alone exercises or as a focus for curriculum integration.

The Intermediate Program - Solving Technological Problems

Purpose	To increase capability with developing technological solutions to problems.
Implementation	Students identify specific problems related to identified needs and wants. They identify appropriate tools, resources and problem solving strategies. They employ an interactive design model to develop solutions, model and test them, and report on their findings. Students begin to develop technical skills and specialized knowledge about technological domains. Technological activity, resources, strategies, and impact are linked to activities outside the school and to the world of work.
Program Design	Five 26 hour modules are provided, one for each of the technological domains. Minimum of 26 hours for grade 7, minimum of 52 hours foreach of grades 8 and 9, for a total of 130 hours.

The intermediate program consists of a minimum of five modules, one for each of the technological domains. Each provides a range of activities related to specific outcomes from other subject areas. Each module is 26 hours duration for a total of 130 hours. The focus of each module is technological problem solving.

Implementation of modules is as follows:

Grade 7	1 Module	Communications
Grade 8	2 Modules	Control Production
Grade 9	2 Modules	Energy and Power Biotechnology

As with modules in primary and elementary, these modules will be designed to connect to activities across other disciplines. The 26 hour allocation is the minimum required for completion of the technological problem solving exercise. Additional time may involve activities in science, mathematics, social studies, art, or other subject areas. In these cases, specific curriculum outcomes and performance expectations for that particular subject will be identified. Where possible, modules are designed to correlate and co-exist with existing outcomes and activities in other subjects.

Curriculum developed for this program makes explicit connections across the technological domains. A module on control, for example clearly identifies and provides experiences for students in the other technological domains of communications, production, energy and power, and biotechnology. The focus of the module is control.

Flexibility in implementation is anticipated. The grade seven module may be implemented as a stand alone unit or in an integrated fashion. The double module structure for grades 8 and 9 is designed to be a semesterized, stand alone course. Each can be implemented in a more integrated fashion. In addition, each module is designed with considerable internal flexibility.

The Senior High School Program - Applying Technological Systems

Purpose	To develop capability with developing technological solutions to complex problems involving systems.
Implementation	Students examine systems which include multiple technologies and technological domains. Problems will be multidisciplinary in scope and treatment. Students will work independently and cooperatively. An understanding of technological and scientific principles as well as social, environmental and personal impact of technological decision making will be stressed.
Program Design	Series of 1 credit (55 hours) and 2 credit (110 hours) courses. 2 courses in Design Technology 2 courses in Communication Technology 1 courses in Computer Technology 2 courses in Production Technology 2 courses in Integrated Technologies.

The senior high school program consists of a number of one and two-credit courses. Each course incorporates, and contributes to, all of the general curriculum outcomes. Most courses incorporate elements of a number of domains of technological learning. Some cut across all domains. A few are very domain specific. One course, ***Integrated Technologies 1205***, is designed to provide a modular, flexible approach. This course provides a broad view of technological practices, with opportunities for in-depth treatment of several issues.

Other courses are more specialized, and are designed to be delivered with a more focused approach and more depth of coverage.

Design Technology

Although design, as a major technological problem solving strategy, is a key component of the technology education program at all levels of schooling, it is also the focus of 2 high school courses. Both of the design courses are in-depth treatments of the technological problem solving general curriculum outcome. Each uses a particular area of human endeavour as a focus. Each draws on knowledge and skills from multiple domains of technological learning.

Design Technology 1109 is a one-credit course based on industrial (product) design principles.
Design Technology 2109 is a one-credit course based on residential design principles and practices.

Communications Technology

Communications technology courses focus on tools and strategies for computer based communications. Human-human, human-machine, and machine-machine systems and applications are examined. The communications domain is a primary focus.

Communications Technology 2104 is a one-credit introduction to a broad range of communications technologies (strategies and tools)
Communications Technology 3104 is a one-credit, more advanced, course in communications

Production Technology

Production courses are primarily concerned with issues in the production domain. Connections are made to control, communications, and energy and power. Production of biotechnology products may also be examined.

Production Technology 2108 is a one-credit course which explores design and production of artifacts in a variety of materials, including wood and metal. The role of computers and control technologies in design and production systems is examined. *Production Technology 2109* is a one-credit course which examines more advanced techniques for production including computer integrated production systems. It also explores the consequence of production technologies and systems.

Integrated Technologies

Integrated Technology 1205 is a two-credit introductory course which includes a range modules. This course is designed to provide maximum flexibility to students and schools. It has 1 required module and 3 additional elective modules. Each is 25% of the course.

The required module provides a focus on the role of communications systems and tools across a broad range of technological activities. This includes access, development and production tools; information design and presentation tools; data collection, control and production uses for information systems; and how computers are integrated into a range of control, production, energy and power, and biotechnological systems. Elective modules include options for students to focus on local issues and problem situations. Each module covers multiple technological domains. Students/schools may choose one module from each of the following, up to a total of three:

- 1 module digital information production systems
- 1 module integrated production systems
- 1 module integrated biotechnology production systems
- 1 module integrated control systems
- 1 module integrated remote sensing and control systems
- integrating technology into cultural industries
  - 1 module in tourism
  - 1 module in the arts
- 1 module integrating technology into local industries

Integrated Technology 3205 is a 2 credit, more advanced, integrated systems course designed to provide students with opportunities to develop solutions to complex, systems-based, technological problems. Its focus is the use of computer and communications based technologies as development and process management tools across all the technological domains including biotechnology. It includes an option for a major independent work by the student.

Computer Technology

Computer Technology 3200 is a two-credit course which examines the development and construction of electronic circuits as components of computer interfacing devices and control. Students develop computer programs to manage these interfaces in order to sense and control events outside the computer.

Chapter 3 The Technology Education Program - *Key Stage Outcomes*

A map of outcomes for technology education is provided in summary form. Key Stage outcomes determine the knowledge, skills and attitudes that students must achieve. These are provided for Primary (grade 3), Elementary (grade 6), Intermediate (grade 9) and Senior High School (grade 12). Specific curriculum outcomes, performance expectations, sample activities, and implementation strategies developed for each grade level and/or course (found in curriculum and teaching guides) provide the level of detail required to achieve the end of levels statements.

Key stage outcomes are organized in the manner illustrated in Figure 12. On first reading, there may seem to be a large number of discrete outcomes to be acheived. If one looks at the primary key stage outcomes for nature of technology in the domains of communications, control, production, etc., for example, a pattern will emerge. Statements found in nature of technology for communication are very similar to those for nature of technology for control, and so on. In a similar fashion, if one were to compare the primary, elementary, intermediate and high school key stage outcomes for technological impact in, for example, bio-technology a progression of difficulty, depth, and range of issues would imerge.

The curriculum developed from these outcomes is based on activities and practices which integrate the different types of outcomes and technological domains. Thus, in primary, for example, a theme or module may simultaneously accomplish outcomes from all general curriculum outcomes and from three or more domains (e.g., control).

Organization of Key Stage Outcomes

Organizer (Domain of Technological Learning - e.g. Communications)			
General Curriculum Outcome (e.g. Nature of Technology)			
Primary	Elementary	Intermediate	Senior High School
Outcomes	Outcomes	Outcomes	Outcomes
General Curriculum Outcome (e.g. Technological Problem Solving)			
Primary	Elementary	Intermediate	Senior High School
Outcomes	Outcomes	Outcomes	Outcomes

Figure 12 Organization of Key Stage Outcomes

Communications

Nature of Technology -By the end of each level. it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• demonstrate knowledge of the evolution of communications tools; • demonstrate knowledge of the basic communications principles of encoding/decoding, transmitting/receiving, storing/retrieving; • demonstrate knowledge of the characteristics of several media; • recognize the effect of resource availability on choice of communications tools.	• demonstrate knowledge of the nature and evolution of communications tools and processes; • demonstrate knowledge of the basic communications principles of encoding/decoding, transmitting/receiving, storing/retrieving; • demonstrate knowledge of the nature and characteristics of a variety of media and communications systems; • recognize the effect of resource limitations on choice of communications tools.	• demonstrate understanding of the nature and evolution of communications tools and processes; • demonstrate understanding of the basic communications principles of encoding/decoding, transmitting/receiving, storing/retrieving; • differentiate between analog and digital communications principles and technologies; • demonstrate understanding of the nature and characteristics of a variety of media and communications systems; • explore new and emerging communications systems; • recognize the effect of resource limitations on choice of communications strategy.	• demonstrate understanding of the basic communication principles of encoding/decoding, transmitting/receiving, storing/retrieving and how they are employed in a variety of communications tools and media; • demonstrate understanding of analog and digital means of encoding/decoding, transmitting/receiving, and storing/retrieving information; • demonstrate understanding of analog to digital and digital to analog conversion principles and means; • demonstrate understanding of the nature and characteristics of electronic and non-electronic media; • explore and develop an understanding of video, audio, graphic, network and other communications systems; demonstrate understanding of new and emerging communications systems.

Technological Problem Solving -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify and clearly state communications problems; • identify and present several options to solve the problem;	• identify and investigate real life communication problem situations and opportunities; • identify and clearly state communications problems;	• identify and investigate real life communication problem situations and opportunities; • identify and clearly state communications problems;	• devise and implement a strategy which employs a variety of sources for identifying and investigating real life communication problems and opportunities;

- examine the solution options and select the most appropriate;
- develop and present a plan for developing the solution;
- produce the solution using appropriate communications tools;
- evaluate communications products, both their own and others.

- develop a design brief which clarifies and states the communications problem to be resolved;
- identify and present a variety of options to solve the problem;
- examine the solution options and select the most appropriate;
- develop and present a detailed plan for developing the solution;
- produce the solution using appropriate communications tools;
- evaluate communications products, both their own and others, in terms of intended use and effectiveness.

- develop a rationale for solving a particular problem, and effectively communicate that rationale to others;
- develop a design brief which clarifies and states the communications problem to be resolved;
- identify and present a variety of options to solve the problem;
- incorporate a number of representation techniques in developing and communicating design ideas;
- examine the solution options and select the most appropriate;
- develop and present a detailed plan for developing the solution;
- produce the solution using appropriate communications tools;
- evaluate communications products and systems, both their own and others, in terms of intended use and effectiveness, and act on that evaluation.

- identify and clearly state, needs, problem situations and opportunities related to human-human, human-machine, and machine-machine communications;
- develop a rationale that a need, opportunity, or problem situation in communications is worth pursuing, and effectively communicate that rationale to others;
- develop a design brief which clarifies and states the communications problem to be resolved;
- explore, analyse, plan and devise products and systems which communicate visually, aurally, and kinaesthetically through analog and digital forms of audio, graphic, video other means;
- incorporate advanced representation techniques in developing and communicating design ideas;
- incorporate knowledge, concepts and problem solving strategies from other disciplines in solving technological problems;
- examine the range of ideas explored, and the strategies used, in the context of the design brief as a means of improving the solution, and present a coherent plan for developing the solution.
- employ a broad range of communications tools, techniques, and processes;

			• produce solutions using visual, acoustical, telecommunications, networks, and interfacing devices and processes; • evaluate their own and others communications products and systems in terms of intended use and effectiveness and act on that evaluation.

Technological Impact -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify ways in which information and communications tools are used; • identify advantages and disadvantages of selected communications tools, • examine why they make particular technological choices.	• identify ways in which information and communications technologies are used; • identify advantages and disadvantages of selected communications technologies; • explore ethical decision making and intellectual honesty as factors in making technological choices.	• explore convergence in a variety of information and communications technologies; • find solutions to communications problems in the home, school, and/or community; • identify advantages and disadvantages of selected communications technologies; • explore ethical decision making and intellectual honesty as factors in making technological choices.	• demonstrate understanding of the impact of technological convergence in information and communications, on the interrelationships among individuals, communities, and global societies, and on the nature of work. and the workplace; • find solutions to communications problems at the home, school, and community level; • discriminate between the advantages and disadvantages of communications products and services on a local and global perspective. • evaluate the impact of global economic decisions on future careers and lifestyles; • examine the consequence of personal choice, ethical decision making, and intellectual honesty in choosing, using, and developing communications products and processes.

Technological Literacy -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• develop a vocabulary of terminology and language, related to selected communications technologies; • use the language and terminology of communications processes and communications tools when solving technological problems and when describing their solutions to others; • use drawing techniques when communicating solutions and ideas; • use several communications media.	• develop a vocabulary of terminology and language, related to selected communications technologies; • employ the language and terminology of communications processes and communications tools when solving technological problems and when describing their solutions to others; • use drawing techniques when communicating technical solutions and ideas; • work effectively in several communications media.	• employ the language and terminology of communications processes and communications tools when solving technological problems and when describing their solutions to others; • understand and use a range of 2-dimensional and 3-dimensional representational techniques when communicating technical solutions and ideas; • work effectively in a variety of communications media.	• employ the language and terminology of communications technology and communications tools when solving technological problems and when describing their solutions to others; • understand and use a range of 2-dimensional and 3-dimensional representational techniques when communicating technical solutions and ideas; • describe specifications relative to the selection of computer and network systems.

Lifelong Learning -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify careers in communications related fields; • identify ways in which people, including themselves, are affected by technological change; • identify information and communications tools in daily use at home and in school; • use communications technologies to build new knowledge from existing information;	• investigate careers in communications and communications related fields; • identify ways in which people, including themselves, are affected by technological change; • explore and identify information and communications tools in daily use at home and in school;	• investigate careers in communications and communications related fields; • examine ways in which people manage and accommodate technological change; • explore and identify information and communications tools, systems and networks in daily use at home and in school;	• examine and consider careers in communications and communications related fields; • develop strategies and skills to manage and accommodate technological change; • comprehend the role of information and communications tools, systems and networks in daily life, in the workplace, and in society;

• use communications tools for a variety of purposes.	• use communications technologies to build new knowledge from existing information; • use communications technology as a tool for a variety of purposes.	• use communications technologies to build new knowledge from existing information; • examine the effect of rapid change in communications technologies on themselves; • examine the role of communications technology as a tool for lifelong learning.	• develop and adopt strategies to employ communications technologies in building new knowledge from existing information; • develop and adopt strategies to adapt to continuous change in communications technologies, products and systems; • effectively use communications technologies as an integral component of technological problem solving in all technological domains, as well as in non-technological endeavours.

Technological Communications -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• use a variety of communications technologies and tools; • use communications tools to access, evaluate and select appropriate information, and to create, modify and disseminate information.	• use a variety of communications technologies and tools; • use communications tools to access, evaluate and select appropriate information, and to create, modify and disseminate information.	• use a variety of communications technologies and tools; • use programing languages as a means of control of simple technological processes and tools; • use communications tools to access, evaluate and select appropriate information, and to create, modify and disseminate information.	• develop proficiency with a variety of communications technologies and tools; • understand and develop proficiency with programing languages as a means of control or management of other technological processes and tools; • demonstrate understanding of how information and communications tools are used to access information, to evaluate and select information appropriate to the need, and to create, modify and disseminate information; • use communications networks and networking tools to create, manipulate, acquire, and disseminate information in print, video and electronic forms.

Control

Nature of Technology -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• demonstrate understanding of the basic control concepts of sensing, switching and/or regulating; • demonstrate understanding of the concepts of calibration and accuracy; • examine simple control devices to determine how they work.	• demonstrate understanding of the basic control concepts of sensing, switching and/or regulating within systems; • demonstrate understanding of the concepts of calibration, accuracy, precision, and repeatability; • demonstrate understanding of programming as a means to manage control systems; • analyse simple control systems to determine how they work.	• demonstrate understanding of the basic control devices which sense, switch and/or regulate within systems; • demonstrate understanding of the principles of fluidic (hydraulic and pneumatic), electronics, and mechanical devices and how they interact in systems; • demonstrate understanding of the concepts of calibration, accuracy, precision, repeatability, and reliability and apply them to the design and construction of control systems; • demonstrate understanding of the operating environmental constrains and resource limitations which affect the choice of a control mechanism; • demonstrate understanding of the role of programming as a mechanism to manage control processes and will incorporate programmable devices into systems; • demonstrate an understanding of the interconnectedness of control devices and systems; • analyse existing control systems to determine how they work; • demonstrate understanding of flexible, adaptive control systems.	• demonstrate understanding of the basic control devices which sense, switch and/or regulate within systems; • demonstrate understanding of the principles of fluidic (hydraulic and pneumatic), electronics, and mechanical devices and how they interact in systems; • demonstrate understanding of the concepts of calibration, accuracy, precision, repeatability, and reliability and apply them to the design and construction of control systems; • demonstrate understanding of the operating environmental constrains and resource limitations which affect the choice of a control mechanism; • demonstrate understanding of the role of programming as a mechanism to manage control processes and will incorporate programmable devices into systems; • demonstrate an understanding of the interconnectedness of control devices and systems; • analyse existing control systems to determine effectiveness and efficiency; • demonstrate understanding of flexible, adaptive control systems.

Technological Problem Solving -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• work from a plan to construct simple control devices; • evaluate control devices, both their own and others, and present their findings.	• identify problems, including those at home and school, which may be resolved by developing a control device or system and communicate them clearly in the form of a design brief; • based on a design brief, examine a variety of options for control systems, select the most appropriate, and develop construction plans; • work from a plan to construct mechanical, fluidic, electronic devices and/or control systems; • evaluate control devices and/or systems, both their own and others, and present their findings.	• investigate situations, including those at home, school or industry, to determine opportunities for design of control systems; • identify specific problems for design and development of control devices and systems and communicate them clearly in the form of a design brief; • based on a design brief, examine a variety of options for control systems, select the most appropriate, provide justification for the choice, develop detailed construction plans; • work from a detailed plan to construct mechanical, fluidic, electronic devices and/or open loop control systems; • using established trouble-shooting routines, trouble-shoot and test components and systems; • analyse and evaluate control devices and/or systems, both their own and others, and present their findings.	• investigate situations, including those in production, transportation, communications, construction, agriculture, marine, and bio-related industries, to determine opportunities for design of control systems; • identify specific problem situations or opportunities for design and development of control devices and systems and communicate them clearly in the form of a design brief; • based on a design brief, examine a variety of options for fixed or flexible control systems which manage, sort, control and organize, select the most appropriate one, develop detailed plans to construct it, and provide justification for the choice and the recommended procedures; • explore, devise and plan devices and/or control systems which sense changes, and switch and/or regulate processes based on that change; • incorporate programmable devices in control systems; • work from a detailed plan to construct mechanical, fluidics, and electronic devices and/or open and closed loop control systems; • develop criteria to analyse the application of control devices and consider factors which will make them efficient and effective;

			• devise trouble-shooting routines, trouble-shoot and test components and systems; • analyse and evaluate their own and others control devices and/or systems in terms of defined need, range of options and resources identified, choice of control mechanisms and materials, performance, elegance of the solution, and possibilities for improvement, and present the findings.

Technological Impact -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• explore ways control technology affects daily life in familiar surroundings.	• demonstrate knowledge of how control technologies affect technological processes; • examine the effect of control technology on life forms; • explore the use of computer technology in control technology systems; • explore ethical decision making and intellectual honesty as factors in making technological choices.	• explore and develop understanding of the impact of control technologies on other technological processes; • examine the impact of control technology on life forms; • explore the use of computer technology in control technology systems; • explore ethical decision making and intellectual honesty as factors in making technological choices.	• explore career opportunities in control technologies and the development of fixed or flexible control systems; • examine and develop understanding of the impact of control technologies on production processes, transportation, communications, and bio-related technology systems; • demonstrate understanding of the role and ethics of control technology in the home, school, workplace, and environment; • demonstrate understanding of the role of computer technology in control technology systems; • examine control systems, estimate the effects and consequences of the control mechanisms and devices, and provide reasoned recommendations for improvement;

Technological Literacy -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• use terminology and language related to selected control technologies; • identify control technologies in everyday mechanisms.	• develop a vocabulary of terminology and language, related to selected control technologies; • explore control technologies in everyday mechanisms and systems found in the home, school; • use appropriate language and terminology when communicating about control technology issues and problems; • use communications technology to research ideas and information and to communicate findings, solutions, and/or consequences effectively.	• develop a vocabulary of terminology and language, related to control technology, used in pneumatic, mechanical, and electronic systems; • explore control technologies in everyday mechanisms and systems found in the home, school; • use appropriate language and terminology when communicating about control technology issues and problems; • use communications technology to research ideas and information and to communicate findings, solutions, and/or consequences effectively.	• comprehend the terminology and language of control technologies and devices used in pneumatic, mechanical, and electronic systems; • demonstrate understanding of the role and operation of control technologies in everyday mechanisms and systems found in the home, school, workplace, and public services; • use appropriate language and terminology when communicating about control technology issues and problems.

Lifelong Learning -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify careers in control technology and related fields.	• explore careers in control technology and related fields; • explore and determine how control technologies are used in other areas of technology, including new areas; • investigate how developments in control technologies affect everyday life and work.	• explore careers in control technology and related fields; • examine ways in which control technologies are used to manage information; • explore and determine how control technologies are used in other areas of technology, including new areas; • investigate how developments in control technologies affect everyday life and work, and why it is important to remain knowledgeable about current issues.	• examine and consider careers in control technology and related fields; • demonstrate understanding of the role of control technologies in systems used to deliver information and to manage information flow, and comprehend how this can be used to enhance the learning process; • demonstrate understanding of the role of control technologies in enabling growth and development in new areas of technology, including biotechnology;

			• demonstrate understanding of how developments in control technologies affect everyday life and work, and why it is important to remain knowledgeable about current issues.

Technological Communications -By the end of each level it is expected that students will:

Primary	**Elementary**	**Intermediate**	**Senior High School**
• identify ways that communications technologies are used to control things; • collaborate with distant students and teachers on control projects and problems.	• explore the use of communications technologies as a component of a control process; • collaborate with distant students and teachers on control projects and problems.	• explore the use of communications technologies as a component of a control process; • create simple computer programs to regulate control systems; • use communications technologies to regulate and manage control processes from a distance; • collaborate with distant students and teachers on control projects and problems.	• demonstrate understanding of process management in integrated control and communications technologies; • develop and implement communications systems and processes to manage fixed or flexible control systems; • design, write, and implement computer programs to regulate control systems; • use communications technologies to regulate and manage control processes from a distance; • collaborate with distant students and teachers on control projects and problems.

Production

Nature of Technology -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• determine the properties of selected materials; • demonstrate knowledge of selected materials processing techniques (separating, combining, forming, and finishing); • demonstrate understanding of safety practices and procedures.	• determine the properties of selected materials; • demonstrate knowledge of selected materials processing techniques (separating, combining, forming, and finishing); • demonstrate understanding of standard safety practices and procedures.	• examine materials and determine their properties; • demonstrate understanding of the principles and practices of materials processing techniques (separating, combining, forming, and finishing); • determine the key events in the development of production and manufacturing technologies; • demonstrate understanding of standard safety practices and procedures; • demonstrate understanding of the concepts of integrated, flexible production systems; • research, and demonstrate understanding of, technological systems used for production of goods and services;	• demonstrate an understanding of materials and their properties and employ specific criteria when selecting materials for a particular purpose; • demonstrate understanding of the principles and practices of materials processing techniques (separating, combining, forming, and finishing); • research selected technological systems used in forming, separating, combining, conditioning, and finishing. demonstrate understanding of the production processes. tools and machines used in construction and manufacturing; • examine the evolution (past, present, future) of the technologies of materials, manufacturing, and production processing; • demonstrate understanding of industry and workplace standard safety practices and procedures; • demonstrate understanding of the principles, practices and outcomes of integrated, flexible production systems; • explore and develop an understanding of production systems used to prepare and modify material resources to make components and/or consumer products and services;

- research production systems including exploration, extraction, processing, manufacturing, and construction;
- research technological systems which provide services;

Technological Problem Solving -By the end of each level it is expected that students will:

Primary

- identify problems which may be resolved by making things;
- identify different ways to make an object, and list the steps required to make it;
- construct objects, working from a plan;
- when making things, use tools correctly;
- present an evaluation of products, both their own and others.

Elementary

- identify and clearly state problems which may be resolved through the design and production of physical goods;
- develop multiple options for a solution, and identify the most appropriate solution considering suitability of the solution, outcomes of the solution and the technical activity required to produce it;
- develop an appropriate sequence of steps to produce the solution, taking into account aesthetics, function, quality construction, and the user;
- examine different ways to process materials;
- construct products, working from a plan;
- choose and correctly use appropriate tools;
- use appropriate safety equipment, and maintain an orderly work environment;

Intermediate

- investigate a variety of situations in familiar environments, identify and clearly state needs, problem situations, and opportunities which may be resolved through the design and production of goods and services;
- develop multiple options for a solution, and identify the most appropriate solution considering conservation of resources, suitability of the solution, outcomes of the solution and the technical activity required to produce it;
- develop an appropriate sequence of steps to produce the solution, taking into account aesthetics, function, quality construction, and the user;
- explore different tools, materials, and processes when designing artifacts and systems;
- examine different ways to process materials;
- construct products, working from a detailed plan, by employing a variety of materials and technical processes;
- choose and correctly use appropriate tools;

Senior High School

- develop and apply appropriate objective and subjective criteria for evaluating need;
- investigate a variety of situations in less familiar environments, identify and clearly state needs, problem situations and opportunities which may be resolved through the design and production of goods and services;
- investigate situations in which existing solutions can be extended to meet additional needs;
- develop awareness of the competitive market forces surrounding technological innovation in the design and manufacture of products;
- develop multiple options for a solution, and identify the most appropriate solution considering conservation of resources, suitability of the solution, outcomes of the solution and the technical activity required to produce it;
- develop design specifications and design studies taking into account aesthetics, function, quality construction, and the user;

- present an evaluation of products, both their own and others, including suggestions for improvement.

- produce quality products by minimising waste of resources - materials, time, money, energy;
- use appropriate safety equipment, and maintain an orderly work environment;
- present a critical evaluation of products, both their own and others, including suggestions for improvement, .

- explore a broad range of tools, materials, and processes when designing artifacts and systems;
- devise specialized processes for working with materials to improve accuracy, safety, efficiency and/or quality;
- construct products and fixed or flexible systems, working from a detailed plan, by employing a variety of materials and technical processes including flexible manufacturing systems which integrate computer assisted drafting, control and production;
- choose and correctly use appropriate tools, machines and computer integrated systems in the construction of artifacts;
- efficiently produce quality products by minimising waste of resources - materials, time, money, energy
- use appropriate safety equipment;
- maintain an orderly work environment with minimum supervision;
- critically assess and evaluate their own and others products and systems, particularly for aesthetics, appropriateness, quality, resource usage, performance of materials, production methods, economic and social considerations;
- critique technological products and services;

			• present an evaluation of products, their own and others, including suggestions for improvement, which addresses: the relationship of materials chosen to procedures and processes used; justification of possible improvements; suitability of the product for manufacture; an estimate of the effects and costs, including environmental and economic.

Technological Impact -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• explore ways that locally produced goods affect the environment and people.	• investigate production processes; • identify the impact of local construction and manufacturing on everyday living; • explore ethical decision making and intellectual honesty as factors in making technological choices.	• investigate production processes; • examine the impact of manufacturing and construction; • examine the impact of technological change on production related workplaces and careers; • examine the impact of local technological products; explore ethical decision making and intellectual honesty as factors in making technological choices.	• investigate emerging trends in production processes; • examine the impact of construction and manufacturing systems on consumers, the environment, society, personal life, and the economy; • examine the impact of technological change on production related workplaces and careers; • examine local technological products and services in a global perspective; • examine the impact of consumer lobbies, environmentalists, politics, and the economy on construction and manufacturing systems and technological products.

Technological Literacy -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• use the language and terminology of selected production technologies.	• develop a vocabulary of the language and terminology of selected production technologies; • use appropriate production related language to describe problem situations, solution ideas, procedures and processes to implement the solution (including drawings), and to assess and report on the effectiveness of the solution.	• develop a vocabulary of the language and terminology of production; • use appropriate language to describe and write about production related issues such as procedures, tools, machines, resource processing, waste management strategies, and environmental issues; • use appropriate production related language to describe problem situations, solution ideas, procedures and processes to implement the solution (including technical drawings), and to assess and report on the effectiveness of the solution.	• demonstrate understanding of the language and terminology of construction and manufacturing; • use appropriate language to describe and write about production related issues such as procedures, tools, machines, resource processing, waste management strategies, and environmental issues; • use appropriate production related language to describe problem situations, solution ideas, procedures and processes to implement the solution (including technical drawings), and to assess and report on the effectiveness of the solution; • recognize how the diverse needs and circumstances of individuals and groups may significantly affect choice of a technological solution.

Lifelong Learning -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify careers in production related industries; • use technology problem solving as a means of making connections between knowledge and skills learned in other curriculum areas.	• explore careers in production and production related industries; • examine production technologies and identify ways in which they affect quality of life, sustainable development, and other related issues;	• explore careers in production and production related industries; • examine production technologies and determine how they affect quality of life, sustainable development, and other related issues; • use technology problem solving as a means of making connections between knowledge and skills learned in other curriculum areas.	• examine and consider careers and professions in production and production related industries; • comprehend the role of production technologies in quality of life and sustainable development and the need to be aware of developments and current issues;

	• use technology problem solving as a means of making connections between knowledge and skills learned in other curriculum areas.		• demonstrate understanding of the importance of engaging in production activities as a means of enhancing knowledge scientific and technological principles, social and environmental issues, and as a means of providing relevance to a variety of other subject areas.

Technological Communications -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify ways communications technologies are used in production processes; • use communications technologies to collaborate with students, teachers, and others at a distance in order to develop and implement solutions to production problems.	• identify ways communications technologies are used in production processes; • use communications technologies to collaborate with students, teachers, and others at a distance in order to develop and implement solutions to production problems.	• use communications technologies as an integral component of production processes; • incorporate communications technologies in production related problem solving activities; • use communications technologies to collaborate with students, teachers, and others at a distance in order to develop and implement solutions to production problems.	• demonstrate understanding of the role of communications technologies in production processes and in related technological activities such as transportation, marketing, and just in time delivery; • incorporate communications technologies in production related problem solving activities; use communications technologies to collaborate with students, teachers, and others at a distance in order to develop and implement solutions to production problems.

Energy and Power

Nature of Technology -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• demonstrate knowledge of the sources and uses of energy.	• demonstrate knowledge of the sources, conversion, transmission, and uses of energy; • examine and develop an understanding of ways in which energy is converted into power.	• demonstrate understanding of the sources, conversion, transmission, conservation and uses of energy; • examine and develop an understanding of ways in which energy is converted into power; • analyse the functions of mechanisms used power and energy systems; • demonstrate an understanding of the interconnectedness of energy and power systems.	• demonstrate understanding of the concepts of energy and power; • demonstrate understanding of the forms of energy and the ways in which energy can be converted from one form to another, e.g. mechanical, thermal, light, chemical, electrical, and nuclear ; • demonstrate understanding of ways in which energy can be conserved, how it can be transmitted from one location to another, and ways in which energy can be employed to perform useful functions; • demonstrate understanding of the importance of conservation of energy; • demonstrate understanding of the reasons for the development of efficient power systems; • analyse the functions of mechanisms used in machines and equipment; • determine the benefits and costs of energy when produced by sources such as fossil fuels, nuclear, hydroelectric, solar, wind, bio-mass, tidal and geothermal; • explore and develop an understanding of how mechanical, fluidic, electrical, and other systems conserve, convert and transmit energy for power production;

- demonstrate an understanding of the interconnectedness of energy and power systems;
- analyse existing power and energy systems to determine effectiveness and efficiency;
- research the use of energy conservation systems.

Technological Problem Solving -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• given a problem and an idea for a solution, identify ways to implement the solution; • construct a control device or mechanism; • evaluate solutions, both their own and others, and communicate the results to others.	• identify problems which may be resolved by the design and development of energy and power systems; • develop a range of possible solution ideas, and select the most appropriate; • develop plans for the construction of a product or system which uses energy and transmits, multiplies, or reduces power; • construct products and systems that use one or more sources of energy; • determine power consumption of devices and systems which are considered as components of solutions; • evaluate solutions, both their own and others, to determine suitability;	• investigate the application and use of energy and power systems; • identify and clearly state problems which may be resolved by the design and development of mechanisms and systems which convert, transmit, and conserve energy and power; • develop a range of possible solution ideas, and select the most appropriate; • develop detailed plans for the construction of a product or system which uses energy and transmits, multiplies, or reduces power; • construct products and systems that use one or more sources of energy; • explore power and energy systems which may be interfaced to, and regulated by, computers and other control devices; • determine power consumption of devices and systems which are considered as components of solutions;	• investigate the application and use of energy and power systems in communications, production, and transportation systems; • identify and clearly state needs, opportunities and problem situations which may be resolved by the design and development of mechanisms and systems which convert, transmit, and conserve energy and power; • develop a range of possible solution ideas, and select the most appropriate; • incorporate the concept of flexible, adaptive systems, including computer integrated control systems, when selecting appropriate devices for design of energy and power systems; • develop detailed plans for the construction of a product or system which uses energy and transmits, multiplies, or reduces power in an efficient manner, and suggest alternate ways to produce it;

	• communicate effectively about their solution, and the processes used, and recommend changes or improvements based on test results.	• evaluate solutions, both their own and others, to determine suitability; • communicate effectively about their solution, and the processes used, and recommend changes or improvements based on test results.	• construct models, devices, mechanisms, and systems that use one or more sources of energy, and convert, store and distribute energy in usable forms; • construct a variety of power and energy systems which may be interfaced to, and regulated by, computers and other control devices; • examine how power differs from energy and develop the ability to measure different forms of energy and power; • determine ways to measure overall performance of a mechanism or system; • evaluate their own and others mechanical, fluidic, electrical/electronic and/or other mechanisms and systems to determine suitability as a solution to the problem and performance of the system; • communicate effectively about the processes involved in creating solutions to energy and power related problems, and recommend changes or improvements based on test results.

Technological Impact -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• explore ways that people can conserve energy.	• examine the political, ethical, and stewardship issues of using renewable and non-renewable energy sources;	• examine the political, ethical, and stewardship issues of energy and power production systems which rely on natural resources;	• develop an understanding of the effects of energy and power systems on quality of life, the environment, and resource depletion and of the political, ethical, and stewardship implications;

	• identify ways of disposing of, or further processing, waste products from energy and power systems.	• investigate safe ways of disposing of, or further processing, waste products from energy and power systems; • examine the role and impact of energy and power technologies.	• demonstrate understanding of the consequence of implementing renewable versus non renewable energy sources, and vice-versa; • determine and adopt personal responsibility for good health and safety practices when using, modifying, or creating systems that use energy or power; • investigate safe ways of disposing of, or further processing, waste products from energy and power systems; • investigate and analyse the interrelationships of external influences (e.g., governments, economics, interest groups, and markets) on the development of energy sources and power systems; • examine the role and impact of current and future energy and power technologies on careers and the workplace.

Technological Literacy -By the end of each level it is expected that students will:

Primary	**Elementary**	**Intermediate**	**Senior High School**
• use language and terminology from selected energy and power technologies	• develop a vocabulary of the language and terminology used in selected energy and power technologies; • use appropriate energy and power related language to describe problem situations, solution ideas, procedures and processes to implement the solution (including drawings), and to assess and report	• develop a vocabulary of the language and terminology used in energy and power systems; • use appropriate language to describe and write about energy and power related issues such as energy conservation and conversion, power production and transmission, waste management strategies, and environmental issues;	• demonstrate understanding of the language and terminology of energy and power systems; • use appropriate language to describe and write about energy and power related issues such as energy conservation and conversion, power production and transmission, power consumption, waste management strategies, and environmental issues;

Primary	Elementary	Intermediate	Senior High School
	on the effectiveness of the solution; • research and report about energy and power related issues at home and in school.	• use appropriate energy and power related language to describe problem situations, solution ideas, procedures and processes to implement the solution (including technical drawings), and to assess and report on the effectiveness of the solution; • research and report about energy and power related issues at home and in school.	• use appropriate energy and power related language to describe problem situations, solution ideas, procedures and processes to implement the solution (including technical drawings), and to assess and report on the effectiveness of the solution; • research, describe, and write about energy and power related issues in areas such as transportation, communication, production, the home, and the workplace.

Lifelong Learning -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify careers in energy and power related industries; • identify ways in which energy and power technologies are used in modern society.	• examine and consider careers and professions in energy and power related industries; • examine ways in which energy and power technologies are used in modern society; • determine how energy and power systems affect people, society, and the environment.	• examine and consider careers and professions in energy and power related industries; • comprehend the role of developments and new technologies in energy and power on the future of work, society and the environment, and the need to remain aware of these issues; • examine ways in which energy and power technologies are used in modern society; • determine how energy and power consumption affects people, society, and the environment.	• examine and consider careers and professions in energy and power related industries; • comprehend the role of developments and new technologies in energy and power on the future of work, society and the environment, and the need to remain aware of these issues; • demonstrate understanding of the importance of energy and power technologies in all aspects of modern society; • consider the consequence of energy and power consumption in making decisions about personal, social, and work related issues.

Technological Communications -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify ways in which communications technologies are used in energy and power systems; • use communications technologies to collaborate with students and teachers at a distance in order to develop solutions to energy and power problems.	• identify ways in which communications technologies are used in energy and power systems; • use communications technologies to collaborate with students, teachers and others at a distance to gain understanding of, develop, and implement solutions to, problems and opportunities in energy and power.	• examine ways in which communications technologies are used to control and manage energy and power systems; • communicate effectively about energy and power management systems, problems and issues; • use communications technologies to collaborate with students, teachers and others at a distance to gain understanding of, develop, and implement solutions to, problems and opportunities in energy and power.	• demonstrate understanding of the application of communications technology as a control and management system for energy and power systems such as power utilities and transportation systems; • demonstrate an understanding of the integration of communications technologies into the management of energy and power systems such as electrical utilities and transportation systems; • communicate effectively about energy and power management systems, problems and issues; • use communications technologies to collaborate with students, teachers and others at a distance to gain understanding of, develop, and implement solutions to, problems and opportunities in energy and power.

Biotechnology

Nature of Technology -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• develop knowledge of simple bio-production processes of growing, maintaining, harvesting, treating, and converting.	• develop knowledge of the bio-production and bio-related processes of propagating, growing, maintaining, harvesting, adapting, treating, and converting.	• explore and develop understanding of selected biotechnology techniques and processes which employ living organisms to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses; • develop an understanding of the bio-production and bio-related processes of propagating, growing, maintaining, harvesting, adapting, treating, and converting; • examine and develop an understanding of bio-products, organisms, and/or mechanisms, used in the biotechnology domains of agriculture, aquaculture, and environmental management.	• demonstrate understanding of the biotechnology techniques and processes which employ living organisms to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses; • develop an understanding of the bio-production and bio-related processes of propagating, growing, maintaining, harvesting, adapting, treating, and converting; • examine, develop and understand bio-products, organisms, and mechanisms used in the biotechnology domains of agriculture, aquaculture, environmental, medical, bio-processing, genetic engineering, and biochemical systems.

Technological Problem Solving -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify problems which may be resolved with biotechnology; • identify solution ideas; • create or produce biotechnology products; • evaluate solutions, both their own and others, and communicate the results to others.	• identify problems which may be resolved with biotechnology; • identify solution ideas, and plan biotechnology products; create or produce biotechnology products; • evaluate solutions, both their own and others, to determine suitability;	• identify and clearly state problems which may be resolved with biotechnology; • investigate, generate solution ideas, and plan biotechnology products; • create or produce biotechnology products; • evaluate solutions, both their own and others, to determine suitability;	• identify and clearly state needs, opportunities and problem situations which may be resolved by the development of bio-technologist and bio-related systems in the biotechnology domains; • investigate, generate solution ideas, and plan biotechnology products;

	• communicate effectively about their solution, and the processes used, and recommend changes or improvements based on test results.	• communicate effectively about their solution, and the processes used, and recommend changes or improvements based on test results.	• investigate, generate solution ideas and plan bio and bio-related systems which can be used to propagate, grow, maintain, harvest, adapt, treat or convert biotechnology products; • create or produce biotechnology products; • make or fabricate and maintain bio and bio-related systems which can be used to propagate, grow, maintain, harvest, adapt, treat or convert biotechnology products; • evaluate their problem solution, and the processes used to generate it, to determine if it resolved the need or opportunity, its applicability to other situations, and the consequence of implementation.

Technological Impact -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify concerns that people have with biotechnology products.	• identify ways of disposing of, or further processing of, waste products from biotechnology activities examine the effects and ethics of biotechnology activities.	• explore health and safety issues for biotechnology production processes; • investigate safe ways of disposing of, or further processing of, waste products from biotechnology activities examine the effects and ethics of biotechnology activities.	• demonstrate understanding of health and safety issues and requirements for biotechnology production processes; • examine the effects and ethics of biotechnology; • examine the consequence of personal choice and responsibility, ethical decision making, and intellectual honesty in choosing, using and developing biotechnology processes and products;

			• examine legal, moral, ethical, and social issues involved in biotechnology choices including those in patenting of life, genetic engineering, agrochemical use, and medical technologies.

Technological Literacy -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• use language and terminology from selected bio-technologist.	• develop a vocabulary of the language and terminology used in selected biotechnology processes; • use appropriate language to describe and write about biotechnology related issues; • use appropriate biotechnology related language to describe problem situations, solution ideas, procedures and processes to implement the solution (including drawings), and to assess and report on the effectiveness of the solution.	• develop a vocabulary of the language and terminology used in biotechnology processes of propagating, growing, maintaining, harvesting, adapting, treating, and converting; • use appropriate language to describe and write about biotechnology related issues; • use appropriate biotechnology related language to describe problem situations, solution ideas, procedures and processes to implement the solution (including technical drawings), and to assess and report on the effectiveness of the solution.	• read, comprehend, write, and use the language and terminology of the processes of propagating, growing, maintaining, harvesting, adapting, treating, and converting as they apply to the biotechnology domains.

Lifelong Learning -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify careers in biotechnology; • identify ways in which biotechnology is used to create products.	• explore careers and occupations in biotechnology; • identify ways in which biotechnology is used to create products and explore ideas about future developments.	• explore careers and occupations in biotechnology; • examine the field of biotechnology as an area of interest which provides opportunities for future personal growth and development;	• examine the field of biotechnology as an area of interest which provides opportunities for future personal growth and development; • examine opportunities for careers and occupations in biotechnology.

- examine the uses of biotechnology as a means of creating products and explore ideas about future developments.

Technological Communications -By the end of each level it is expected that students will:

Primary	Elementary	Intermediate	Senior High School
• identify ways in which communications technologies are used in biotechnology; • use communications technologies collaborate students and teachers at a distance to solve biotechnology problems.	• identify ways in which communications technologies are used in biotechnology; • use communications technologies to research biotechnology issues and problems, collaborate with others on solving biotechnology problems, and communicate the outcomes to others.	• research ways in which communications technologies are used in biotechnology systems and processes; • use communications technologies to remotely sense and control biotechnology processes and systems; • use communications technologies to research biotechnology issues and problems, collaborate with others on solving biotechnology problems, and communicate the outcomes to others.	• demonstrate understanding of the role of computers, computer interfacing devices, and computer based control systems in biotechnology systems and processes; • demonstrate understanding of communications systems which monitor and control biotechnology processes or systems, and which communicate the results of this interaction to humans; • use communications technologies to remotely sense and control biotechnology processes and systems; • use computer based technologies to research biotechnology issues and problems, collaborate with others on solving biotechnology problems, and communicate the outcomes to others.

Chapter 4 The Technology Education Learning Environment

> ***Aquiring basic capability in designing and making is as important for young children as reading, writing and arithmetic. At higher levels a more advanced capability is as important as any part of the curriculum.***

As an activity based program, technology education engages students in real world problem solving exercises. Students are expected to make connections between the world of information and knowledge, often associated with academics, and the everyday world of creating practical solutions to basic, and not so basic, problems. Students may be expected, for example, to relate the scientific principles of Boyle's Law and the coefficient of friction with the practical realities of developing a pump that can work in a variety of conditions.

The program is designed to progressively develop students abilities and skills with technological problem-solving. Design, as a major problem-solving strategy is integral to this process. In the early years, most of the design activity is structured with carefully planned opportunities for expression of students' ideas and problem solutions. By high school level, students are independently identifying and solving quite complex technological problems.

Students need to develop an understanding of design and technology problem-solving strategies and practices. This includes knowing a range of formal problem-solving models. Application of these models is central to the technology education instructional environment.

Technological Problem-solving: Issues for Instruction

Technological problem-solving is a universal response to human needs and wants. A need or want is identified and a solution is sought. There are many ways of getting from one point to the other. Collectively, these ways may be analysed and implemented as the technological problem-solving model. In its simplest form, the model involves the following steps:

- ***Needs and Opportunities***. Needs are basic such as food, shelter and other things considered essential to survival. Wants are much broader and include the full range of things people wish for. By clarifying these needs or wants, one can identify a particular problem (or problems) to be resolved if one is to meet the need.
- ***Clarification***. Problems are usually specific and require immediate, or near term, solutions. Opportunities, on the other hand, are more futures oriented. Often, a want is perceived by an individual only after an opportunity to meet it is presented. This is frequently the case in a consumer society.
- ***Application of Resources***. Technological activity always involves the application and consumption of resources including information, knowledge, capital (money), time, raw and synthetic

material, tools, machines, and people.

- ***Options***. Solution options are identified. Variations are determined. Best possible solutions are identified based on a careful consideration of the problem and available resources.
- ***Solutions and Outcomes***. After appropriate evaluation a solution is adopted. The solution always has outcomes - some known, some unknown, some positive, some negative. Invariably, technological solutions lead to more needs, wants, problems, and opportunities and the cycle continues.

The model in Figure 13 illustrates this sequence.

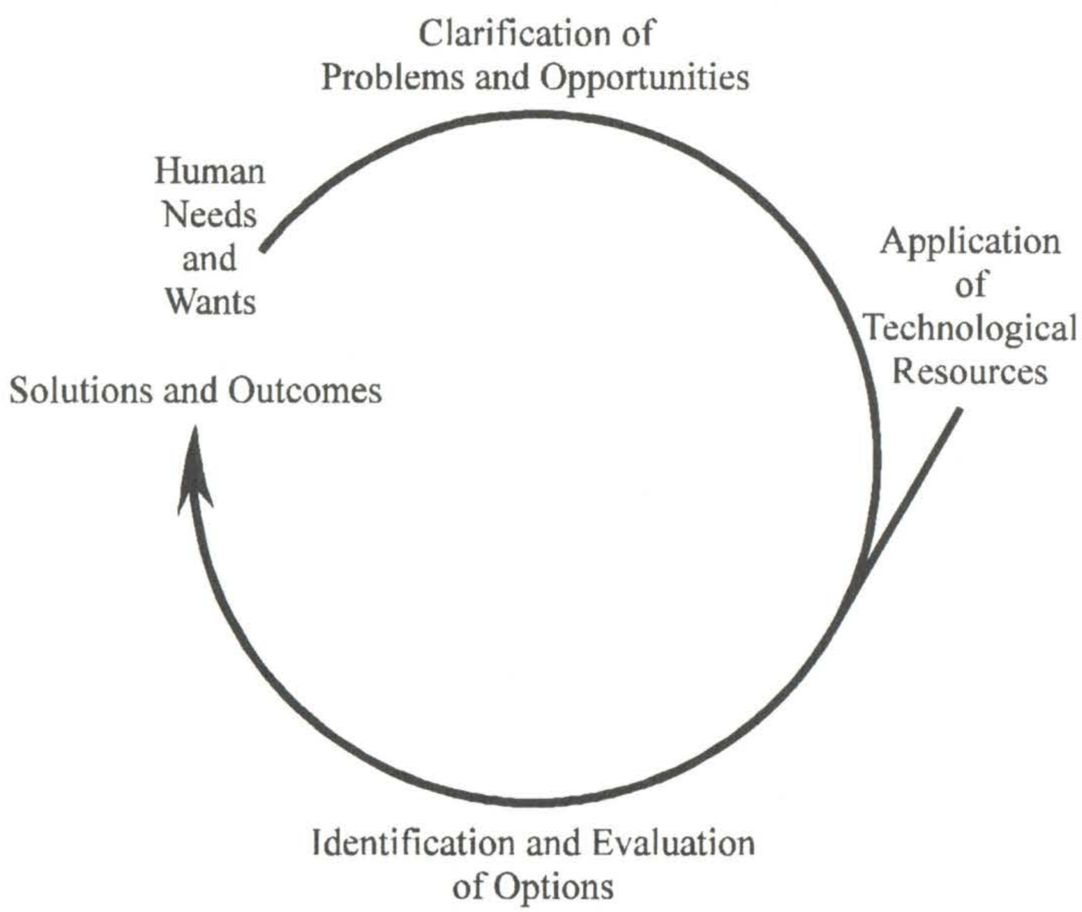

Figure 13 Technological Problem Solving

Design as a Problem-solving Strategy

Design is a comprehensive set of technological problem-solving strategies. It is employed across a wide range of situations and results in all the products and many of the services available in modern society. The major purpose of design is creation of objects, systems, or environments in response to problems or opportunities. It consumes resources, operates in an entrepreneural environment, responds to needs and wants, and results in goods and services. The degree to which these goods and services respond to considerations such as ergonomics and usability, economy and value, and visual appeal determines their success in the marketplace. As shown in Figure 14, design is responsive to a number of conditions and criteria (adapted from Hubel and Lussow, 1984).

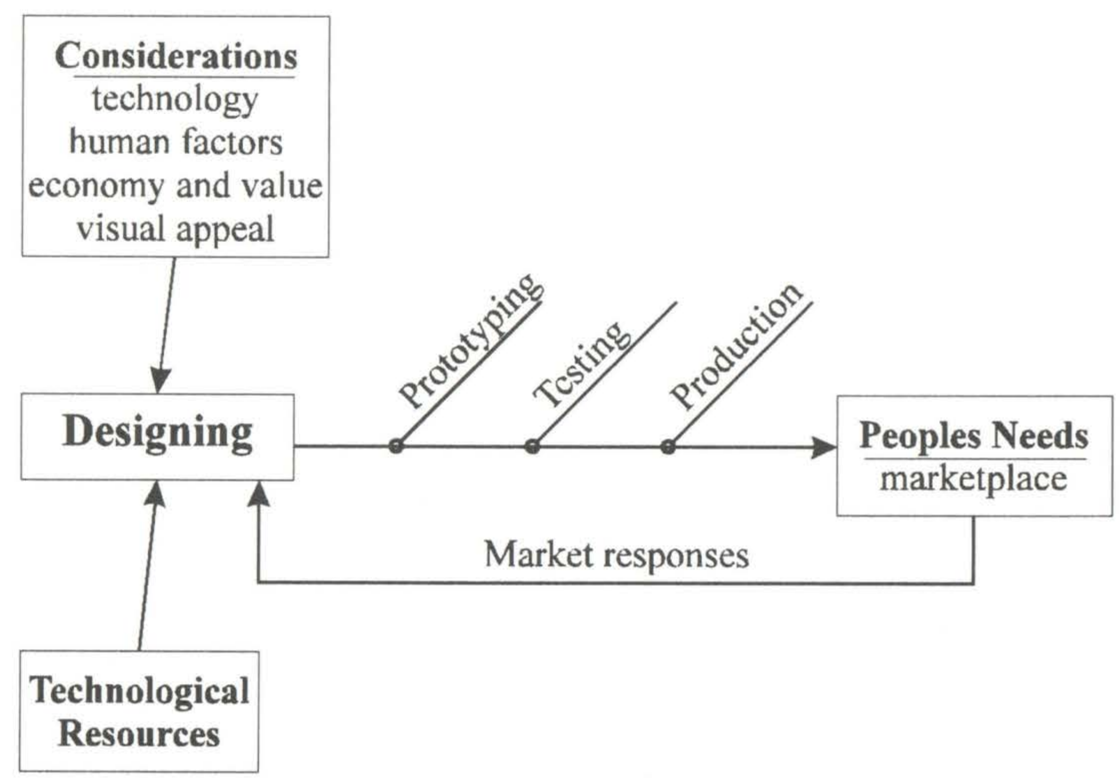

Figure 14 Design as a Marketplace Response

Design is a challenging process which expects the designer to bring about improvements, and invent and create new ideas and products. It involves visualizing, putting things together in new ways, planning, and making choices. It is performed on many levels. It often has a range of subtleties and nuances of which only practitioners of a particular industry or profession are aware. It also has many elements that people practice all the time.

Some models for design practise are illustrated below. The first is a simple, linear model (see Figure 15). It implies a sequential series of events for developing problem solutions. In this model, each problem is considered in isolation of other problems. This is a suitable model for primary students. Actual practice is often more complex.

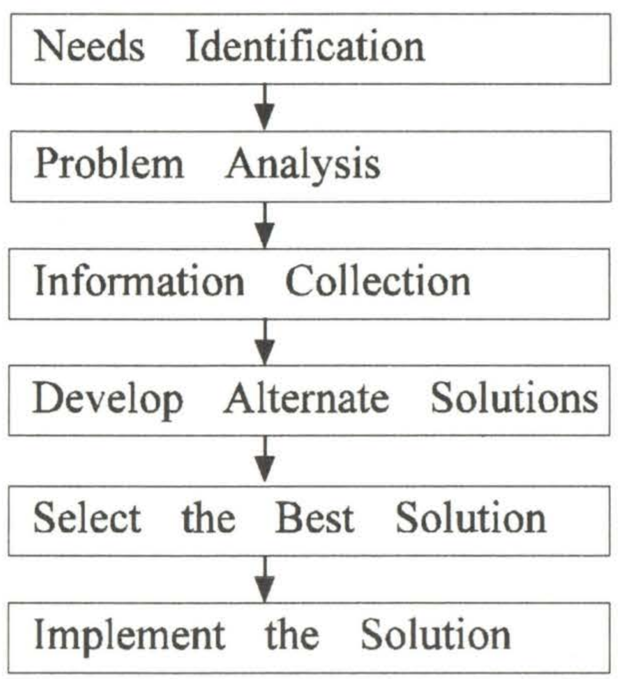

Figure 15 Linear Design Model

The second model (Figure 16) appears linear, but it provides ample opportunity for open-ended thinking within the context of the problem. As shown by the number of feedback loops, one is directed at almost every stage to review decisions and information from previous stages in the process. This model is suited to a single problem or situation. It is especially suited when it is desirable to focus on an issue to the exclusion of other issues. One should remain aware, however, that consideration needs to be paid to issues outside the particular problem. This model is suitable for use by elementary students. They should be made aware of the cyclical nature of technology identified in models below (see Figures 17 & 18).

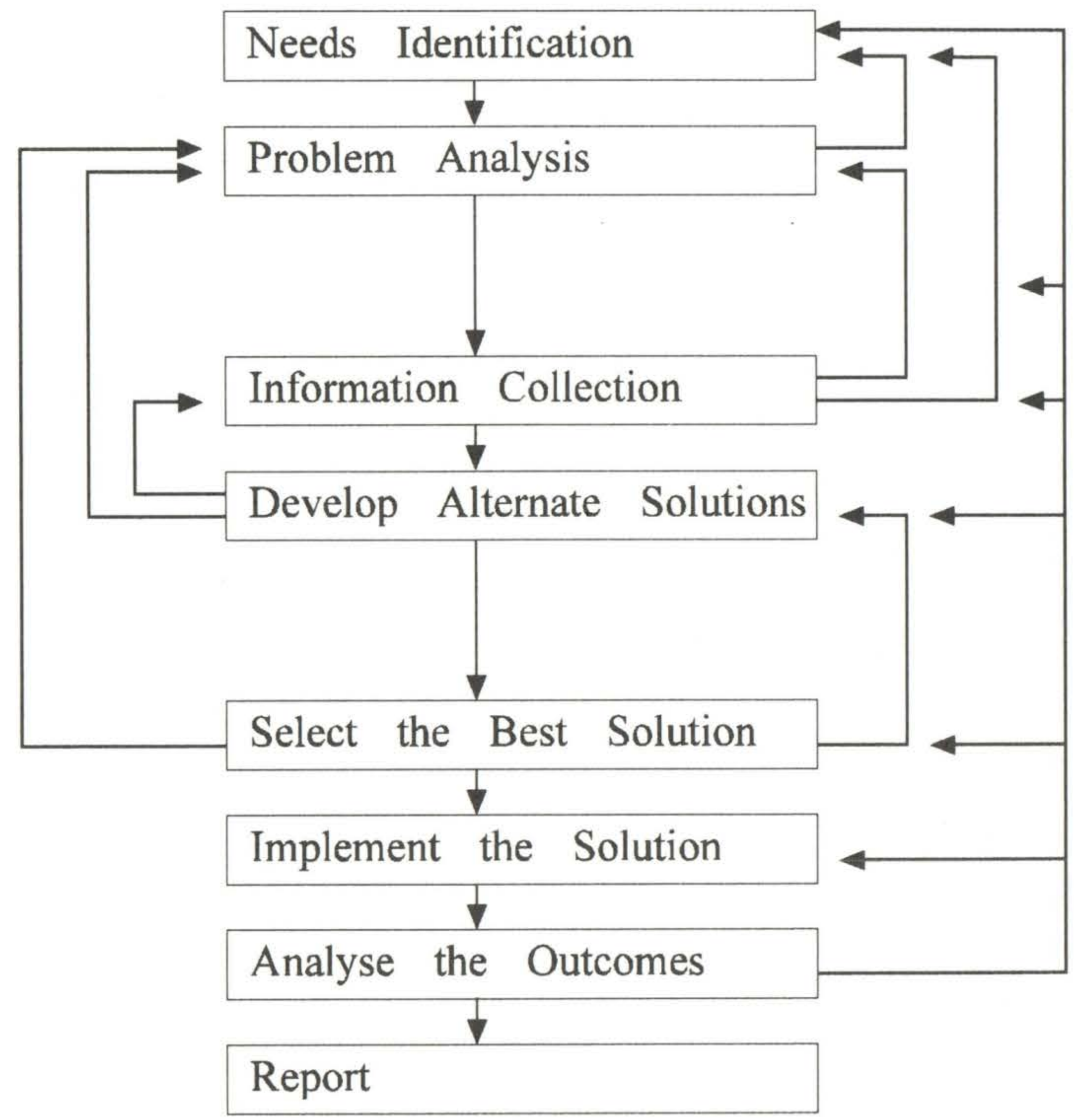

Figure 16 Design Model with Feedback Loops

Design and technological problem-solving are not usually such clearly delineated start-stop processes. Solving one problem often creates another. Meeting one opportunity often leads to the identification of others. This is best illustrated by a continuous loop model. Figure 17 demonstrates the cyclical nature of technological problem-solving.

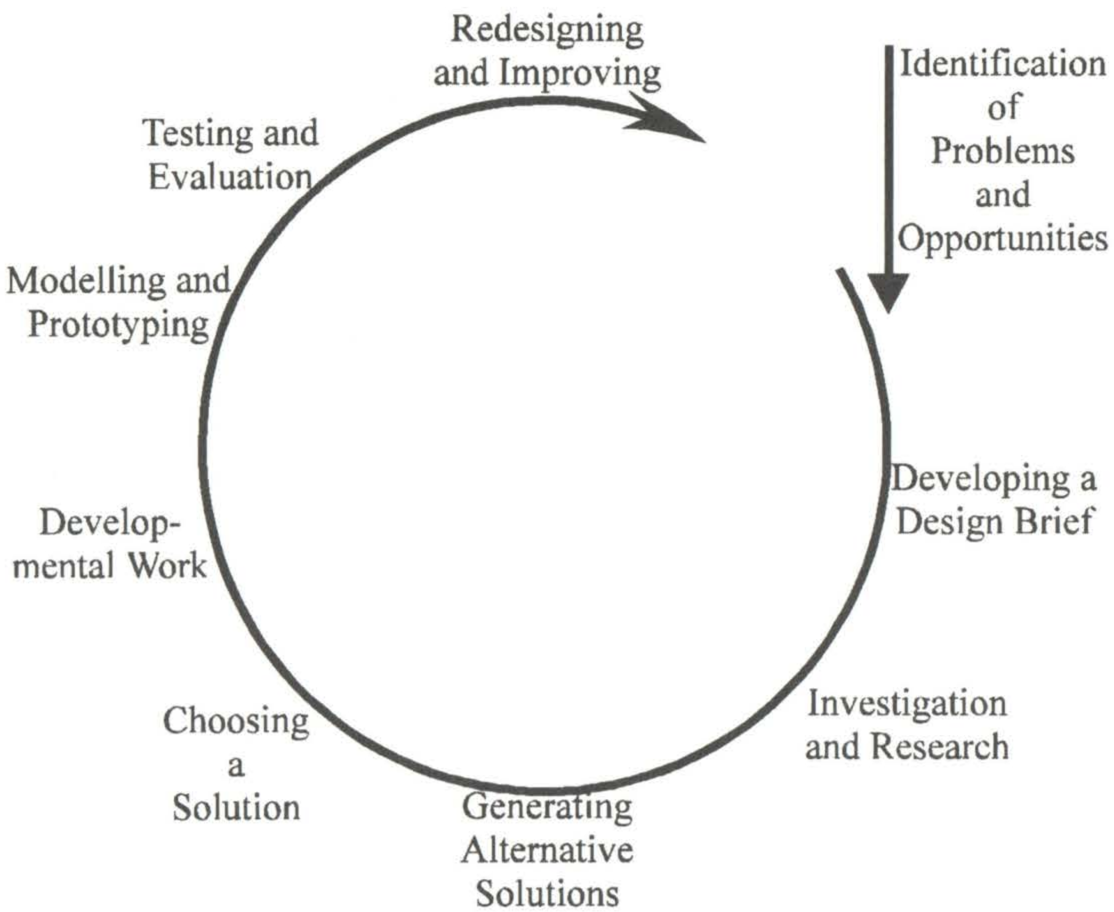

Figure 17 Cyclical Technological Problem Solving Model

In practice, the model above is seldom implemented in the linear (step by step) fashion implied by the diagram. Rather than a linear progression from one stage to the other, it is often necessary to refer to previous stages to confirm the accuracy of assumptions and information. Sometimes conditions which gave rise to the problem or opportunity change and adjustments need to be made in the problem-solving strategy. Information and resources identified during initial design brief development and during the investigation and research are constantly referenced during subsequent stages of design. Sometimes additional research is necessary. The next model (Figure 18) illustrates the interactive nature of design. At any point in the process, one can move to any other point. This model should be employed by students before they complete the intermediate progam.

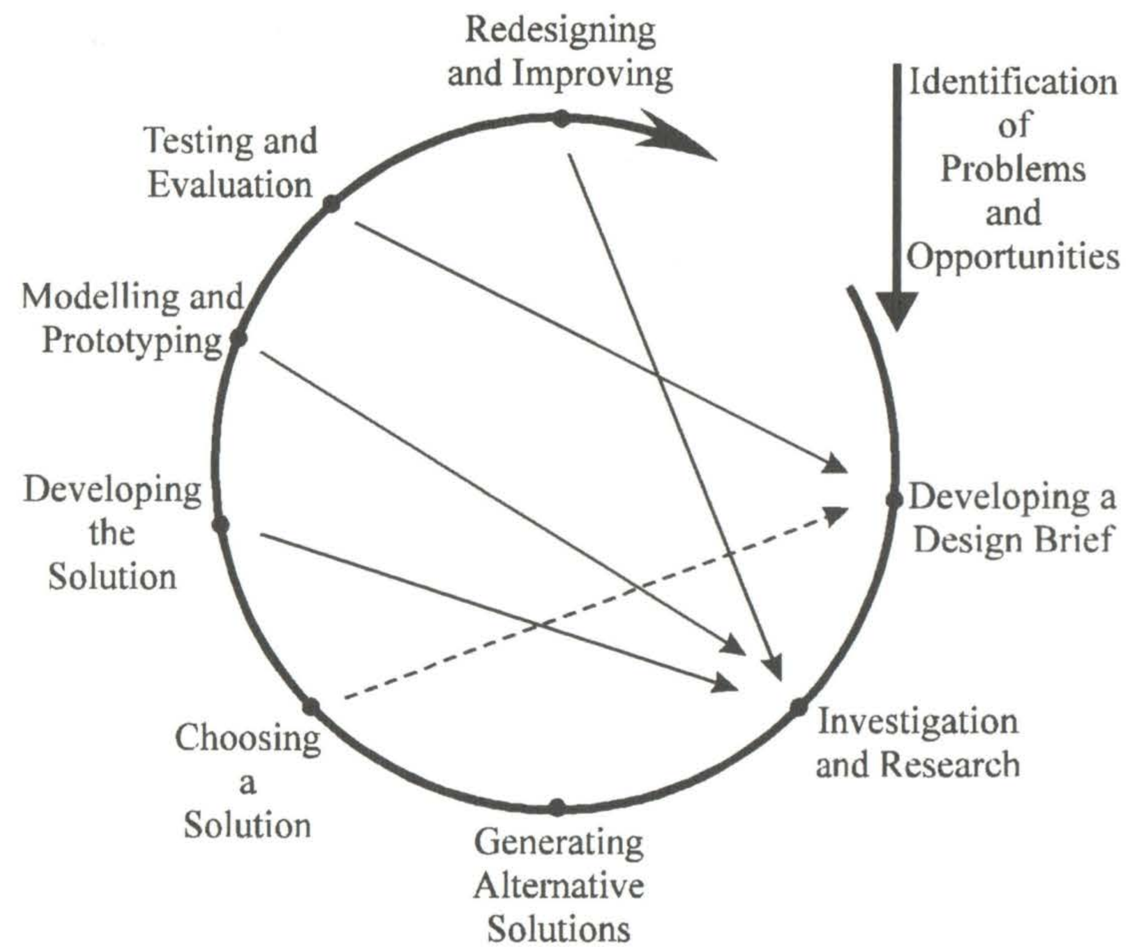

Figure 18 Cyclical Design Model

Student Capability with Design Practise

Design practice requires development of particular skills and aptitudes. Experiences need to be provided for students which enable them to develop skills with:

- Visualizing and representing objects in 2 dimensional and 3 dimensional forms. This includes representation methods such as isometrics and orthographics as well as drawing modes like sketching, computer assisted drafting, and 3-D rendering. It also includes development and production of 2 and 3 dimensional physical models.
- Identifying and clarifying human and environmental interactions with technology. Issues such as what is the consequence of using this material, these tools, or this technological process to solve a problem are critical.
- Human considerations such as fitting things to a human scale; peoples abilities to see, hear, and lift for example; and the mental and emotional capability of people to adapt.

Design has a significant aesthetic component. Making things look right requires attention to visual elements of an object, report, or graphic. Dots, lines, shapes (planes, solids), value, tone, texture, color, and space have significant impact to the visual presentation of a design. When combined with design principles such as balance, proportion, rhythm, and harmony they provide for variety and innovation in the visual presentation of things ranging from written information to sophisticated technological products such as vehicles and clothes.

Design often involves different modes of ideation, or means of generating ideas and cultivating imagination. Different modes include association of ideas or chains of thought and laws of association (vertical thinking, lateral thinking, analogies), brainstorming, synectics (a brainstorming process to view the familiar in strange ways and the strange in familiar ways), morphological charts (a highly structured process based on charting relationships), attribute listing, finding a new point of view, sketching and doodling, and incubation (Hubel and Lussow, 1984). Each involves becoming familiar with the issue or problem, preparing all relevant information, analysing (taking apart), theorizing on the possibilities, taking time to let ideas form, synthesizing (putting it together in different combinations), and verifying the conclusions by testing and evaluating them.

Students need to adopt an open-minded attitude, one of questioning assumptions about the way things are done and why. Adopting a design strategy means looking beyond the obvious. Students need to ask questions like:

- *What are the most important factors in this situation?*
- *What is least important?*
- *What resources are available (how much time?, what materials?, what do I know about this? who can I ask?)?*
- *If a product is created from this process, how will it be used?*

The challenges of designing can be small or they can be large. Students need to develop attributes such as the following in order to be effective technological problem solvers and designers:

- awareness of people and their habits;
- tolerance for different cultures and ways of life;
- awareness of cultural impact on change and on the development of ideas and products;
- creative ideation skills through visualizing, sketching, and drawing;
- knowledge and skill with the design problem-solving process;
- familiarity with basic materials, tools and methods;
- understanding that technology is designed to serve the person;
- ability to work within limited resources;
- ability to work with others
- enhanced aesthetic perception through the use of good design principles and elements;
- skills in effective communication of designs and ideas.

Design in the Classroom - The Design Brief

The design brief is a common procedure for developing solutions to technological problems. It is employed in the workplace as well as the classroom. It provides a means of focusing on issues relevant to the problem situation and ensuring that an appropriate solution is developed. Its purpose is problem clarification and specification.

The design brief details exactly what is to be done, what specifications apply to the process, what the limitations are (often in terms of resources), and the requirements for the solution. Development of the design brief requires careful consideration. It will specify the exact problem to be resolved, what the designer (the student) will do, and what the successful design will do. Students should be involved in development of design briefs as early as possible. The last phase, *what the design will do*, often requires research and considerable thought before it can be properly written. Specifications need careful consideration as well. Developing them often involves asking questions about functional things such as:

- guidelines for similar solutions,
- human factors such as safety and fit,
- environmental questions such as waste and pollution disposal,
- aesthetic questions such as appropriate use of materials and pleasing style, and
- production questions such as what is the demand for this product.

Design briefs can be applied to a broad range of problem types and result in an even broader range of products. This can include computer based products such as drawings, illustrations and multimedia (which incorporates sound, video, text, animations, and computer graphics). Printed documents, displays, models, and working prototypes of physical objects can all be generated from a design exercise.

Teaching and Learning Strategies

Fostering in students the kind of individual observation and perception skills, and the inclination to be open-minded in thinking and doing, requires a particular type of approach to teaching and to management of the learning environment. This approach is characterized by a treatment of the student as a technological problem solver. A variety of teaching and learning strategies are required. At diverse times these strategies employ transmission (teacher instructs, informs), transaction (enquiry, activity, design and problem solving), and transformation (uses problems and structures content based on the students needs and experiences) orientations. Each is chosen carefully, depending on the situation and the learners needs.

Transmission techniques may be required for cases such as providing information essential to a task or for demonstrating procedures. Care should be taken to restrict this to essential use and to ensure that the sequencing makes sense to the student. Transmission techniques are often interspersed throughout other modes.

Transaction techniques tend to be a natural approach for technological problem-solving. This is a constructivist approach which assumes that knowledge is constructed in the mind of the learner. It is based on teacher as facilitator, student as performer and learner. By engaging in design experiences which draw on connections across the disciplines and on connections with life experiences outside the school, students construct new knowledge. Design strategies guide students through a process which encourages them to find, select, and assess information sources and information; critically evaluate divergent points of view; make informed choices about resource selection and usage; develop best possible solutions; construct and test their solutions, and determine the effectiveness of their solutions. Solutions usually have physical, concrete manifestations.

Transformation techniques are also enabled in a technological problem-solving mode. Identification of appropriate problem situations, or of needs and opportunities from which problems can be solved, should be made in the context of the students world. This may mean a level of sensitivity on the part of the teacher to choose appropriately for younger students, or to guide them in their choice of problems to solve. Students in higher grades will always have ample opportunity to identify and/or choose problem settings which have relevance to them. Technological issues and problems always have social and environmental connections. These should be drawn on to help contextualize the experience for the student.

Both the transactional and the transformational modes employ a variety of strategies to engage the learner. These include:

- ***Individual and Group skills***. Independent student work develops skills in independence of thinking and doing and higher levels of self confidence. Cooperative/collaborative group work can lead to higher achievement and longer retention, more positive attitudes about the subject matter, higher self esteem, more effective social skills, and more positive feelings about each other. A balance of individual and group activity is required.
- ***Developing applied skills.*** Students need to see technology activity and problem-solving as relevant. The program allows students to make connections between the rest of the curriculum and everyday living. Students access, interpret, apply, and synthesize information while developing knowledge in the context of using technical skills.
- ***Fostering research and critical thinking skills.*** Students apply critical thinking skills to access, read, assess, and develop information in the context of developing technical solutions to problem.
- ***Using technological tools and products.*** Development of knowledge, skills and attitudes to adapt to new tools, and to adapt tools to new situations is an essential skill. This is an important component of technological problem-solving, particularly as it involves the use of information and communications tools across the full spectrum of human endeavour.
- ***Solving technological problems using design.*** Students identify needs and problem situations, pose solutions, and implement them. Decision making and critical thinking strategies are essential to this process. Students need challenging, worthwhile problems which may be resolved by the development of new products, systems or environments.

Organizational Issues

Individual versus Group Activity

Careful attention needs to be paid to which components of technological problem-solving are conducted as individual student activities and which are done as group activities. A balance of individual and small group is important. Design activities need to emulate real world design practices. Design teams may be organized to share responsibility for the entire project. Individual team members can have specialized roles or responsibility for certain components of the exercise.. Students should be encouraged to take individual responsibilities and demonstrate accountability for their actions while operating as members of a cooperative team.

Course/Class Management

Issues of safety and a safe working environment need to be recognized and planned for. Students will use a variety of resources, some of which pose safety hazards if used incorrectly. Establishing proper rules of conduct and procedures for safe handling of materials and equipment needs to be done at the beginning of each module or course. Students need to develop a sense of what they are capable of doing on their own.

They also need to be able to determine what requires assistance.

Students need to understand that technological activity is gender neutral. Issues of male and female roles and capabilities are societal constraints. An approach which fosters gender equality is essential. Some approaches and some problem situations may favour boys more than girls, or girls more than boys, in terms of students' predispositions and interests. Teachers should structure the learning experience to appeal to the interests of boys and girls. Practical activities, emphasis on who uses technology and in what ways, demonstration of the relevance of technology to the student's life, and providing instruction which acknowledges the differences in boys and girls are important elements of a program designed to promote personal interest in technology.

Adaptations in delivery may be necessary for students with special needs. Changes may be required in classroom/technology laboratory arrangements, methods of interacting with the student, instructional approaches, types and range of resources, and in assessing achievement.

Often the implementation of modules or activities works differently than intended. Teachers may wish to keep track of a number of things which may be modified in subsequent implementation. These include:

- children's experiences with the activity,
- outcomes and performance expectations actually achieved,
- how well the activities matched the outcomes and performance expectations,
- design briefs developed and how they worked,
- materials and equipment used,
- time required,
- problems encountered and suggestions for improvement.

Scheduling Technology Education Modules

Flexible scheduling is required. Block scheduling is an efficient means of delivery for technology education modules. Block scheduling will ensure that the module is delivered in contiguous time. For example, a grade 2 theme may require a 15 day block, while a grade 7 module may require a five day block. Within the block, flexibility is required to allow different patterns of student-teacher and student-student interactions, and to allow variable patterns of task completion. At any given time, different groups of students may be engaged in work related to different subjects. This activity may be in small or large groups, in independent or class work. Block scheduling is important to maintain the integrity of the exercise. It allows students to become fully immersed in the technological problem-solving experience, while providing many opportunities for them to link technological activity to the rest of the curriculum.

Scheduling Technology Education Courses

Courses will follow similar patterns for scheduling as any other course at that level. Consideration should be given to blocking double periods for many courses since the activities often require a sustained period of activity longer than the typical class period.

Resources Management

Technological problem-solving is resource based. Learning in a technology education program is resource based learning. Students employ a broad range of resources. Often they are required to identify resources based on the development of the particular design exercise. Research and open-ended thinking are essential.

Resources for technological exercises go beyond textbooks and computers. They include the materials required to construct models and test them. They are identified in technological problem-solving as information, time, materials, people, tools, machines, and money. Resource identification is an essential skills for technological problem-solving.

As teachers and students identify appropriate problem situations and develop design briefs, the need for particular resources may become apparent. Teachers need to ensure that resources can be obtained appropriate to the problems chosen. In most instances resources need to be made available, or at least identified, by the time the design brief is being developed. In some instances teachers will be responsible for obtaining the resources, at other times the students will be responsible. Student responsibilities should be clearly identified in the problem situation and design brief.

Most courses and modules have clearly identified resources. These are usually the minimum requirement and should be in place prior to commencement.

A learning centers approach is the preferred method of resourcing the technology education modules, particularly at the primary and elementary levels. Resources for the learning centers are identified with each module and need to be in place prior to commencement of the module. Learning centers are designed for flexibility. They can be easily set up and dismantled. All the resources for a learning center are containerized and packaged with an inventory control list. Consumables are clearly identified and need to be replenished after each usage.

Resources for technology education modules will be identified for all relevant learning centers related to other curriculum areas. In addition, each technology education module will employ a technology learning center. The primary purpose of the technology learning center is development of technological solutions to problems. Resources for the center will therefore facilitate this process. Examples of learning centers resourced for technology education modules are described in each of the curriculum guides

Technology Education Facilities

Technology education is multi-faceted and requires a variety of resources for implementation. The physical learning environment can significantly affect the nature, and even the outcome, of the learning activity. The facility must be able to accomodate a variety of activities with a variety of technological resources and do so in a manner which promotes learning. Technology is integrative in the sense that in the world at large it rarely is an activity in and of itself, but is usually a component of some other purpose. Technology activities, particularly those related to information, in primary, elementary, intermediate, and senior high programs can and should be integrated into the curriculum and therefore should be done in the regular class setting. Often, however, the subject of the activity in school is the technology itself and its interaction with, and impact on, other components of the students activity and environment. In each case access to appropriate technological resources is required. The key to a succesful program is adaptable, flexible work areas and technologies.

One option is to use mobile workstations (not necessarily related to the computer workstation) which can be wheeled out for use and docked in a storage bench along the wall after use. These are modular, can be outfitted for a variety of purposes and are suited to the classroom as well as to the technology laboratory. They are ideal for the primary, elementary, and intermediate programs which are operating without a dedicated space. Additional details are provided in curriculum guides.

Primary Program Facilities

The primary program should be implemented in the classroom. Technology activities, like other activities, can be configured as learning centers. Learning centers are portable and reconfigurable. Learning center resource kits should be transportable and easily stored. An inventory control system needs to be employed which clearly identifies consumables required at the beginning of the module or activity.

A storage cabinet should be provided for those resources which are not permanent components of learning centers, and for learning centers which are out of the duty cycle.

Elementary Program Facilities

The elementary program is also suitable for classroom implementation. Due to the problem-solving nature of these activities, a greater range of resources is required. This increases the need for adequate storage and for space for technology activities. It is expected that some activities will result in students constructing models and working with materials and tools which create some debris. These activities will need to be conducted in an area which can be readily cleaned, such as a learning center. Finally, students will need work surfaces which are sturdy and which are flexible enough in design to accomodate a wide variety of activities. Some activities may be suited to a multi-purpose room or area in the school.

Intermediate Program Facilities

The intermediate technology program has needs which can be met by integrating the technology activities into the curriculum in the regular classroom and needs which can best be met by a technology laboratory. Options for this laboratory would depend on the size of the school and the number of students, and include a spare classroom, sharing facilities with the science program, sharing facilities with the art program, and a separate dedicated facilty. The ideal technology laboratory from a program perspective would be at least as large as two classrooms.

Much of the technology program is multi-activity in nature. Students move from one type of activity to another, often in the same class period. Different students may be working at different things. The technology laboratory must accomodate activities in information technology, in design and systems modeling, in basic robotics, in simulations of integrated systems, and in construction of prototypes using a variety of materials and simple tools. Work surfaces must be sturdy and adaptable to a variety of activities. Adequate storage for resources and project materials is essential.

Schools which have existing industrial education facilities are in an ideal position to offer all courses in this program. These facilities can be readily modified to accomodate the multi-activity, multi-technology nature of the program. A possible technology lab is shown in the appendix to this document. The learning center approach may also be suited for some intermediate situations.

Senior High Program Facilities

The senior high program has a number of course requirements which mandate the use of technologies ranging from computers to robotics, and from simple material handling tools to computer integrated manufacturing simulations. A properly designed technology laboratory is highly desirable for delivery of this program. It is expected that a single multi-purpose laboratory can accomodate all courses in each of the five technology strands. Doing so requires well designed teacher and student resources. It should be noted that a computer lab is not generally well suited to technology education courses. The resource and working space needs of communication, production, design, integrated systems and computer technology courses cannot be accomodated in a computer lab.

The Technology Laboratory

A sample technology education laboratory is included in the Appendix. A number of alternate arrangements are shown. The key concept of this design is flexibility. It accomodates activities in design and the requistite modelling and prototyping, information technology, communications, and integrated technologies. Work surfaces should be modular and mobile, technologies are portable and interchangable. If a student identifies a solution that requires CAD, CIM, and traditional tools to model the solution, this laboratory is accomodating of that range of activities.

Chapter 5 Assessment of Student Achievement

> ***Evaluation needs to determine students knowledge and understanding of materials, people, technical and production matters, and aesthetics. It needs to account for both active and reflective modes.*** *(Farrell and Patterson, 1993)*

Assessment of Student Achievement

The technology education paradigm suggested by this document implies particular modes of assessment Student knowledge of concepts and process, abilities to develop and use technology, ability to transfer knowledge and skills to new situations, and understanding of the consequences of technology activity is fundamental. Assessment must accurately measure student performance in many types of technology activities.

Assessment of student development, progress and achievement is one of the most important functions performed by schools and teachers. It is fundamental to the teaching-learning process. Many irreversible decisions result from various forms of assessment reports. Careful attention must be given and every effort must be made to ensure fair, appropriate and adequate student assessment. Student assessment must be based upon thorough understanding of the nature and the purpose of the program and the particular course. The required learning outcomes must have reasonable expectations for student knowledge and performance. The process of student assessment must be wisely applied reflecting a genuine concern for the interests of the individual.

Students are expected to exhibit evidence of progress and achievement. Four areas are of particular interest: factual knowledge, conceptual understanding of systems, problem-solving skill, and practical performance of a variety of technological activities. Various measurement and assessment techniques are developed and used to provide continuous assessment throughout the course with the goal of overall total growth. Emphasis or weighting is given to problem-solving and practical activities with only limited use of testing of factual information. Problem solutions and practical experiences will usually be reliable indicators of growth in student knowledge and conceptual understanding.

Assessment in a technology program has broad contexts that need to address the following:

- Student performance must be evaluated relative to outcomes and performance expectations to determine progress and to determine the next course of action in teaching and student activity;
- Assessment must reflect the activity based nature of technology education in the cognitive (knowledge), affective (attitudes and values), and psychomotor (skills) domains;
- Assessment must assess students' understanding of the technological and strategic changes taking place in industry and the

workplace; and
- Assessment must be continuous (formative and summative).

The Department of Education handbook and policy guide, *The Evaluation of Students in the Classroom*, outlines in detail the purpose and proper use of student assessment and provides coverage of assessment methods and procedures. Particular reference is made to Chapter III and the Appendices of this guide. It is recommended that teachers make use of that document in designing their own assessment techniques. The Handbook provides a detailed explanation of both formative and summative assessment. It is expected that teachers will follow these guidelines closely. Provincial and local school board policies must also be incorporated in the assessment process.

The following are examples of procedures, activities, and projects which may be utilized to accomplish a more complete assessment of the student's achievement:
- observation;
- written test;
- model construction;
- prototypes;
- equipment design/construction;
- system design/construction;
- illustrations;
- presentations;
- assignments;
- research;
- class participation;
- sketches/illustrations;
- technical drawings;
- design portfolios;
- interviews;
- student self assessment;
- peer assessment.

Curriculum and Teaching Guides for each course will provide additional details. Assessment weighting is specified for each course.

Assessment Focus

Assessment needs to reflect the nature of technological problem solving. It needs to ask questions like:
- was the problem or need understood?
- was there evidence of creative thinking?
- was there collaboration with others? what form did it take? what issues were involved?
- what information gathering occurred?
- what research skills were involved?
- how were the results recorded?
- what ideas were developed? how were they developed? how were they articulated?
- what evidence of planning? techniques? types of drawings?
- what materials and tools were chosen? how were they used? skill level shown?
- what evidence of assessment throughout the process? any modifications made? type? why made?
- what evidence of communications with others on findings? how done? consequence?
- what evidence of troubleshooting ability? coping ability if things went wrong?

Care should be taken to focus assessment on curricula content. It has to reflect design and technology problem solving issues. It has to determine evidence of progression in capability. The design practise of having students record and communicate ideas, and explore and develop them is a means of confronting and exploring hazy ideas in order to develop and clarify them. It is a means of demonstrating why and in what ways they are being active and reflective, thinking and reasoning. Assessment has to include these components.

Emphasis should be placed on quality rather than quantity. Good research and information is better than a lot of irrelevant information. Knowing what is appropriate action and taking it is more important than just taking action and doing a lot of things.

Summary

Design and technological problem-solving offers a natural group activity. It can easily link and give relevance to many subjects. It shifts attitudes and values away from a focus on only academics towards inclusion of social and problem solving skills. It offers the student a real opportunity to make decisions and to discuss meaningful problems with their peers. It provides immediate feedback and gives responsibility for actions and consequences to the student.

Design activities develop students capability in a technological society. Being capable means having the ability to combine practical action with deepening understanding. It is more than a collection of separate abilities. It also means the ability to transfer knowledge and skills to new situations and to simultaneously consider multiple options and issues and respond correctly to new situations. Design and technological problem solving require, and develop, the processes of perception (ability to see), generation (learning to create and confront) and critical thought (learning to question and challenge).

Design and technological problem solving requires students to be active and reflective in balance. It means confronting and clarifying not just what they are doing and how they are doing it, but why they are doing it. Students need to be taught how to focus on both active and reflective modes and how to use them interactively. The ideal is to have action and reflection working iteratively. Too much focus on active ability will result in doing things without pausing to appraise, show judgements, or recognize the implications of decisions. Students need to review, modify and consider alternatives. Too much focus on reflective ability results in a lot of work on issues and theoretical proposals. Students need to examine and develop the technical and production issues of making the ideas work and need to make as well as imagine. They also need to understand and make their own magic.

Assessment needs to determine students knowledge and understanding of materials, people, technical and production matters, and aesthetics. It needs to account for both active and reflective modes.

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Appendix A

Some contributions of technology education to the development of skills and concepts related to other subject areas are illustrated below.

Language

Technology education activities enhance the development of the following specific skills which are also necessary for, and common to, language programs:

a. talking, listening and discussing,
b. reading and writing,
c. locating and retrieving information efficiently,
d. selecting, analysing, interpreting, creating, organizing and presenting information in graphic and written reports,
e. comprehension and coping strategies with multi-step oral and written instructions.

Mathematics

Technology education promotes understanding of the following mathematical concepts and tools by applying them to the solution of technological problems:

a. measuring accurately,
b. understanding shape and space,
c. creating models and comparing properties,
d. interpreting pictures and identifing patterns,
e. presenting information in chart and graphical form,
f. creating scale drawings (similarity, ratio, proportion, fractions),
g. creating 2 dimensional representations of 3 dimensional objects (similarity, congruence, parallelism, symmetry including rotational),
h. using linear models to investigate and analyse the best use of limited resources,
i. analysing and priorizing the tasks in the solution of technological problems.

Science

Technology education contributes to the goals of science education in the following ways:

a. exploring the relationship between science and technology by drawing on scientific knowledge to develop and enhance technology;
b. applying scientific principles and processes to the solution of technological problems reinforces the students understanding of these concepts;
c. knowledge and understanding in science assists in predicting the outcomes during the design stage of a technological problem and helps in defining the constraints that are imposed on the solution of the problem;
d. requiring students to identify, assess the value of, and use real world instances of many scientific principles and processes including energy, materials (types, properties, uses), and forces (including electricity and magnetism),
e. development of cooperative, collaborative participatory skills,
f. first-hand experience with technology-environmental interactions and issues.

Social Studies

A number of concepts and processes central to technology education activities are also important to many areas of the social studies. These include:

a. using communication techniques, especially representation of ideas by drawings, charts, graphs and symbols;
b. increasing awareness of environmental and resource issues by solving technological problems within the constraints of limited resources, and by predicting the outcomes of the solution;
c. understanding of the role of technology in positive and negative impacts on the human and physical environment including the role of technology in ecological issues;
d. developing knowledge of, and skill in, the use of simulation and modelling techniques which can be used to study geographic and environmental phenomena;
e. providing first hand experiences with the interaction of people and technological products, processes, and environments.

The Arts

Technology education contributes to the skills and knowledge developed in the fine arts (music and art) by:

a. developing a level of understanding and skill with the use of some of the technologies used in the arts;
b. developing a level of understanding and skill with the elements of design, in particular, form and shape, pattern, rhythm, and texture;
c. Enhancing the creative abilities of the student.

Enterprise Education

Technology education helps the student to develop a number of attributes and skills which are essential to the aims of enterprise education. These include:

a. developing creativity, initiative, analytical ability, autonomy, independent thinking, good work habits, and good communication skills;
b. developing a level of technological understanding essential to an entrepreneurial venture;
c. development of a core of transferrable, broad-based life and work skills.

CO-OP Education

Technology education is an ideal focus for many CO-OP programs since one of the goals of technology education and the primary goal of CO-OP education is to provide students with experiences which bridge the gap between the world of academe and the world of work. Common elements include:

a. exploring career opportunities;
b. applying academic knowledge and skills to practical problems;
c. developing good work habits and increasing confidence;
d. working effectively with others;
e. exploring an area of interest in greater depth;
f. giving relevance to the importance of education in the workplace.

Appendix B:

Glossary of general technology terms

For purposes of this document the following definitions hold. They are consistent with definitions used in other parts of Canada and in other countries.

Computer Integration

Computer integration into the curriculum is the appropriate use of computer-based information technology as a tool in a wide range of curriculum based student activity in all subject areas.

Cybernetic Technology

Cybernetic technology is the integration of information technologies with other technologies to assess the state of real world events and to manipulate real world events. Examples would be computer control of video editing, robotics, computer assisted manufacturing, and a broad range of more common devices such as microwave ovens, computer control modules in cars, and supermarket barcode scanners.

Education Technology

Education technology is the use of technology in a teaching-learning situation to enable the learner to understand curriculum content and to attain educational aims and objectives. These technologies have traditionally included information delivery systems ranging from books to overhead projectors to video. Increasingly, educational technologies are information technology based and are student-centered, interactive systems.

Information Technology

Information technology is a term used to lump together a range of technologies and technology based processes which are used to gather, assess, create, modify, disseminate, and otherwise manipulate information. Typically, but not always, information technologies are computer based. They include stand-alone computers, local area networks, wide area networks, broadcast systems, print based systems, databases (including CD-ROMs and networked databases), video, and interactive computer systems.

Science

Science is the study of the natural world in order to understand the nature of life, matter and natural forces.

Science Education

Science education is a program which is designed to develop students understanding of the nature of science, of scientific activity, and of important scientific findings and principles in a manner which shows their relevance to the individual and to society.

Resource-based Learning

Resource-based learning is a philosophy and methodology of learning which focuses on the student centered use of a variety of resources, learning strategies, and activities to encourage development of the individuals ability to assess situations, solve problems, and accept responsibility for the outcomes of decisions.

Technology

Technology is the use by people of resources to create solutions to human needs and problems. It has a product component and a process component.

Technology Integration

The use of technology as a resource-based learning tool across the curriculum. Computer integration is one aspect of technology integration.

Technology Education

Technology Education is an activity based program aimed at developing an understanding of technology, its products, its processes, the outcomes of technological activity, and the effects of technological activity on society and the environment.

Design and Technological Problem-solving Terms

The following operational definitions are used, or are implied, in this document.

Analysing
Examining in detail in order to discover relationships or values.

Appraising
Estimating quality, worth or condition.

Artifact
A functional human-made object.

Assembling
Putting or fitting together the parts of, for example, a mechanism.

Component
A simple finished item ready for assembly into a product.

Constructing
Building using components and sub-systems.

Control
Regulate and direct a process or sequence of events.

Design
Utilisation of intellectual and physical skills leading to the complete description of a product to satisfy a human need or want, or market opportunity. Design includes the management of though-action processes and the generation of the necessary written and graphic material for product manufacture, maintenance and use.

Device
A sub-system capable of performing work.

Developing
Bringing to a more advanced or effective state.

Devising
Working out, contriving or planning in one's mind.

Discussing
Considering issues by means of speech and/or writing.

Drawing
Accurately depicting a product essentially in 2D or 3D line form.

Evaluating
Judging or assessing quality, worth or condition.

Generating
Producing or creating ideas.

Identifying
Recognising through exploration.

Investigating
Inquiring into a situation or problem.

Making
Bringing into being by shaping, changing or combining materials.

Manufacturing
Processing or making a product especially by machines and powered tools.

Materials
The range of substances of which a product is made - typically metals, wood, plastics and textiles.

Modelling
Representing a product with a view to improvement.

Modifying
Changing an idea or product with a view to improvement.

Observing
Looking with the aim of gathering information.

Planning
Detailing a scheme or method of obtaining an objective.

Predicting
Foretelling; making a declaration on a reasoned basis, in advance.

Product
The outcome from an activity in technology in the form of an artifact or system.

Prototype
A full-size model suitable for use in complete evaluation of form, design and performance.

Recording
Setting down in some permanent form.

Reporting
Presenting an account of product development.

Researching
Systematically investigating a situation or problem.

Sketching
Free-hand drawing, often for subsequent elaborations.

Symbol
A sign letter or abbreviation used on a diagram or equation to represent a quantity, component or object.

Sub-System
An assembly of components which may form part of a larger system.

System
A combination of several sub-systems or items of equipment integrated to perform a specific function.

Testing
Determining the quality or effectiveness of an idea or product.

Appendix C

The Technology Laboratory

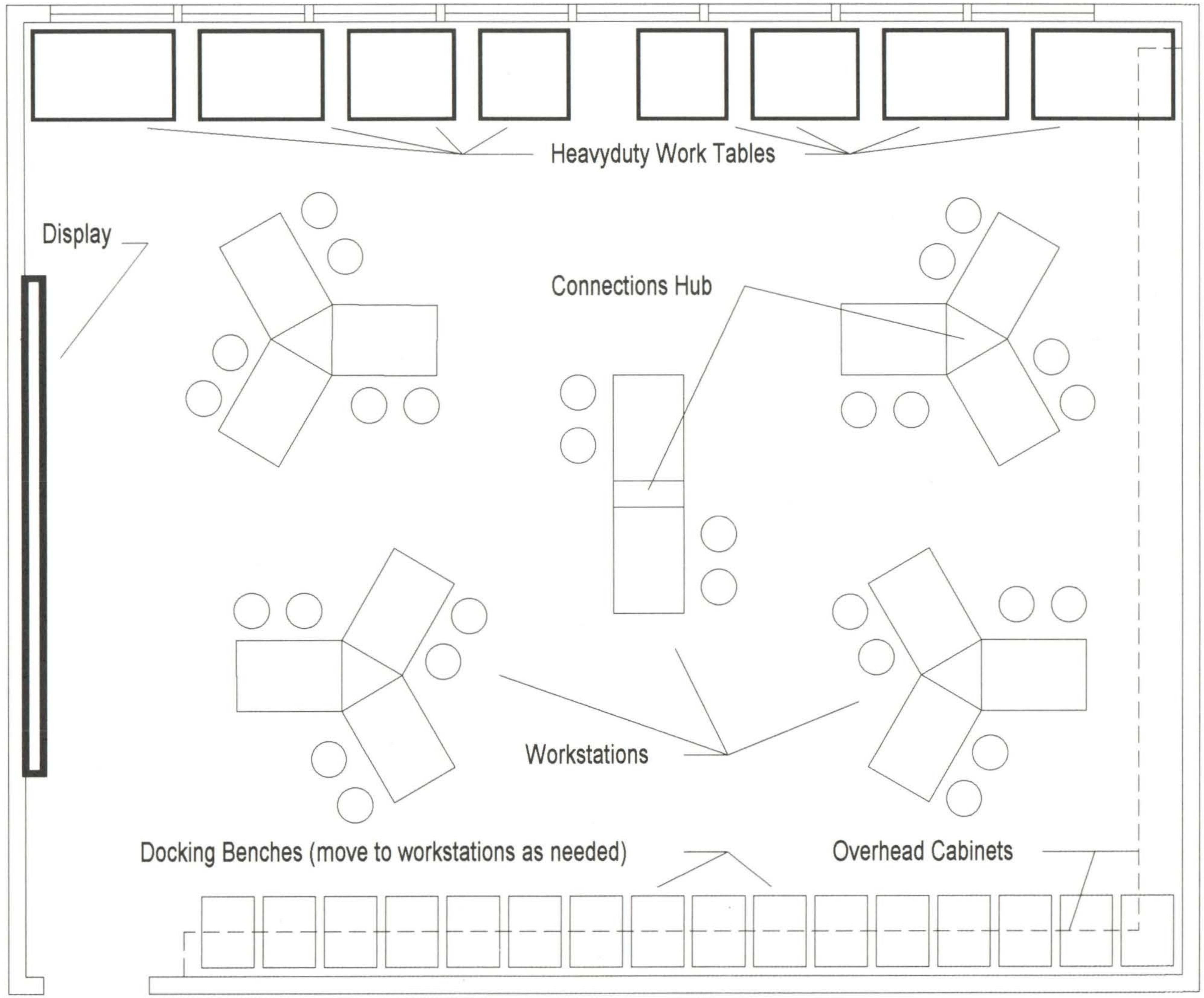
A number of configurations are possible for a technology lab. The most important consideration is flexibility. The diagrams on the next several pages are meant to serve as a starting point for planning a technology laboratory. They do not provide the level of detail needed to construct a lab, but provide ideas for planning. Each is designed to accomodate a wide variety of activities within a single class setting. In addition, the room can be quickly reconfigured for a quite different range of activities between classes. The room is a standard sized classroom. For most technology classes this can accomodate up to 28 students working in teams of 2.

The main feature is a series of 14 workstations, each of which includes a networked computer system capable of handling any task the student needs to accomplish. Workstations can accomodate a team of 2 students. The workstation tables, which are mobile, connect to docking hubs with electrical and network connections. The hubs may be permanently fixed or movable, connected from above or below. The tables are 2' by 3' 9". The keyboard tray pulls out to provide keyboard and mouse space. Although this may seem small at first, the pull out tray and docking carts provides a effective worksurface which is much larger.

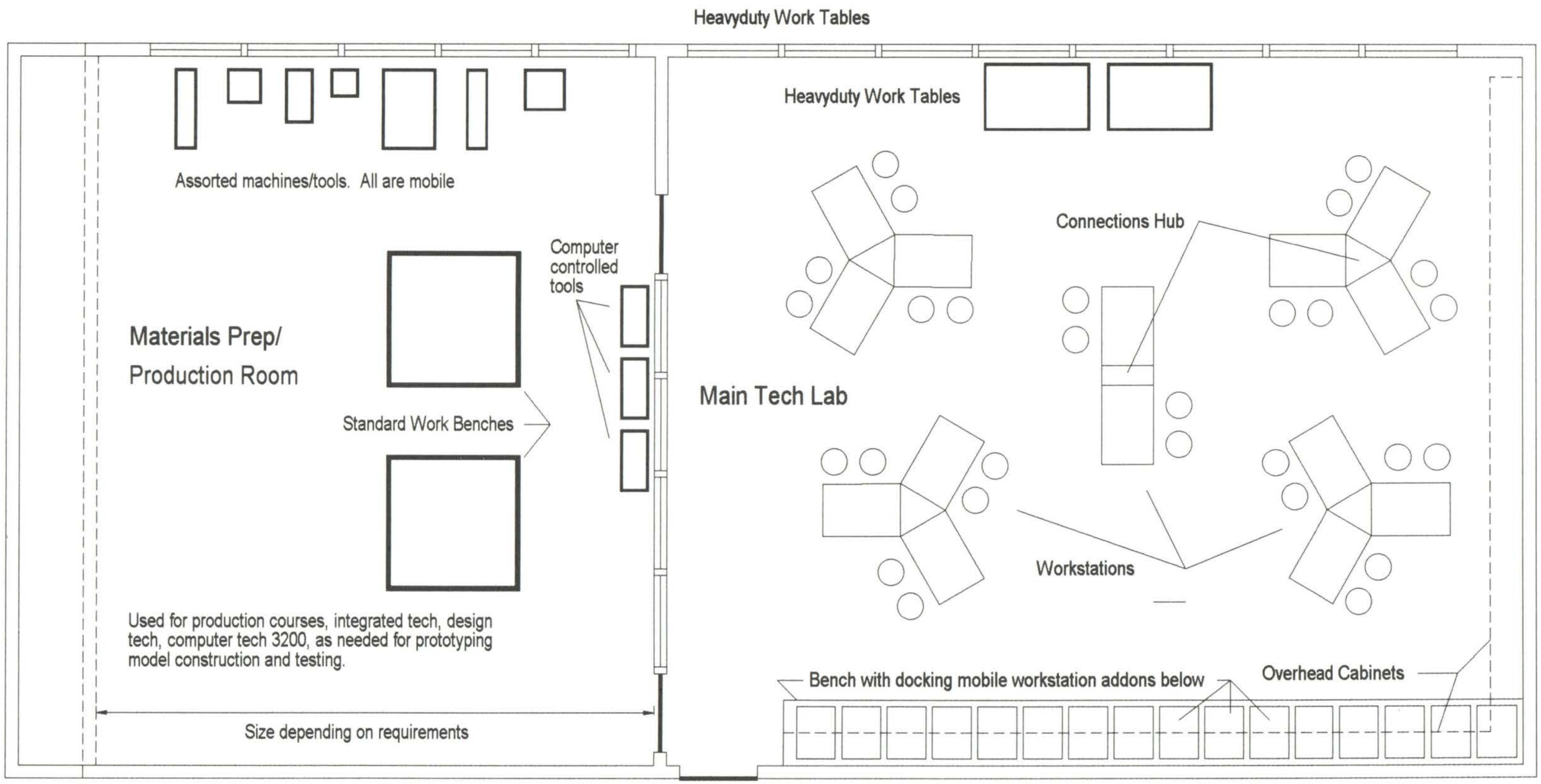
All specialzed equipment is stored, ready for use, on a series of mobile carts. Carts are nominally 2' by 1' 6". Other sizes are possible. Carts may have tops that extend or tip up from the back to provide larger surface area. All carts have lockable storage. Carts can be custom designed to accomodate equipment for communications, production, energy and power, control, and biotechnology. Carts can also be designed to accomodate light duty materials processing, especially for intermediate students.

The intermediate lab is intended to accomodate all activities in the same space. The senior high lab is separated in this design into 2 areas. This may be necessary for schools that adopt the production technology courses. With effective dust control and more computer controlled equipment, a single larger room may be sufficient.

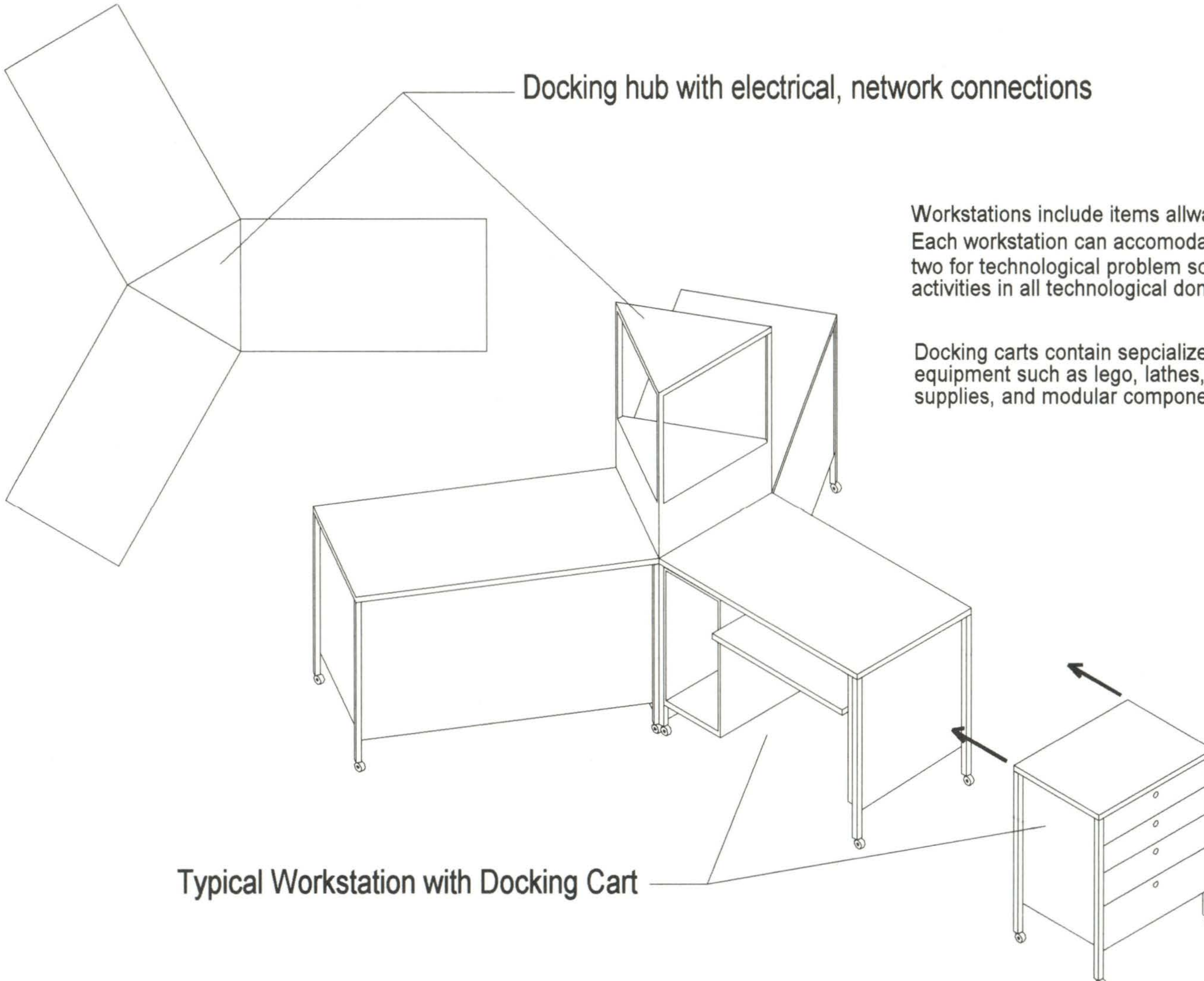
An Intermediate Technology Lab



A Senior High Technology Lab



A Typical Workstation



Workstations include items allways required
Each workstation can accomodate a team of two for technological problem solving activities in all technological domains.

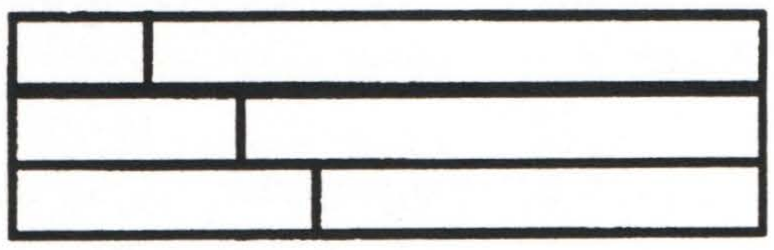
Docking carts contain sepcialized equipment such as lego, lathes, printers, supplies, and modular components.

GCO C: Students will explore, recognize, represent and apply patterns and relationships, both informally and formally.

Sample Assessment Items/Strategies

Performance

✔ Suggest to the student that she/he use Cuisenaire rods (or another suitable manipulative material) to show the pattern for all of the facts for 8.



1 + 7 = 8
2 + 6 = 8
3 + 5 = 8

Paper and pencil

✔ Ask the student to continue the pattern.

4+3=7
5+3=8
[]+3=[]
[]+3=[]

✔Allow the student to list all the pairs of numbers that can be added for a total of 4. Have the student repeat for a total of 5 and then of 6. Ask what the pattern is.

Interview

✔ Ask the student to describe the "pattern" of a fact family.

Resources

GCO D: Students will demonstrate an understanding of and apply concepts and skills associated with measurement.

Suggested Assessment Items/Strategies

Performance

✓ Provide the student with 3 containers (of various shapes) and filling material (beans, styrofoam packing material, etc.). Ask the student to order the containers according to capacity.

✓Provide students with trains of various lengths made from interlocking cubes. Ask the student to order the trains from shortest to longest.

✓Provide a jar half-full of beans and several other containers of various sizes and shapes. Ask the student to predict, then check, to find a container which would be a better fit for the beans.

✓Ask two children to perform a standing jump. Encourage them to find a way to determine who jumped farthest.

Interview

✓Place a longer, curved piece of string beside a shorter, straight piece.

Ask the student which is longer and why.

✓Ask the student to show, without using a ruler, how he/she could find out which is wider, the door or the window.

✓Ask the student how he/she would decide whether his/her thumb is shorter than the other fingers.

✓Ask what "holds more" means.

Presentation

✓Have students prepare a set of ribbons for first, second and third place in a race, so that the faster runner gets a longer ribbon.

✓Ask students to decide whether a coffee mug usually holds more or less liquid than a drinking glass.

Resources

GCO D: Students will demonstrate an understanding of and apply concepts and skills associated with measurement.

Sample Assessment Items/Strategies

Performance

✓ Provide a small jar with 10 marbles in it; indicate how many there are. Ask the student to estimate how many marbles it would take to fill the jar and then check the estimate.

✓ Ask a student to use joining cubes to measure the distance toy cars travel when rolled down a ramp.

Paper and Pencil

✓ Ask students to write or draw something that would explain why a book is not a good length unit.

✓ Have the students fill a small box with pattern blocks to find its volume.

Interview

✓ Ask the student to explain how he/she could find out who is the fastest runner in the class.

Portfolio

✓ Students can first discover items with various masses, for example, 10 pennies, 20 pennies, 30 pennies, etc. They could then organize their data and present it (drawings or cut-out pictures) for inclusion in their portfolio.

Resources