Design and Fabrication 1202

Government of Newfoundland and Labrador
Department of Education

A Curriculum Guide (Interim)

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Contents

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Introduction

Background

Design and Fabrication 1202 is based conceptually, philosophically and practically on the Atlantic Canada Foundation document for Technology Education (2001). The teacher is directed to the document for specific information that forms the basis for this and other technology education curricula in the province of Newfoundland and Labrador.

This two-term course replaces the one-term technology education courses, Design Technology 1109 and Woodworking 1107. While content from these courses that addresses the General Curriculum Outcomes (GCOs) is retained, Design and Fabrication 1202 features additional topics and a delivery model that reflect the interrelation of design and fabrication in practice.

Rationale

In the production sector, design and fabrication are mutually dependent and interrelated activities. Designers must consider the capabilities of the fabricators and equipment that will be employed to produce a physical prototype of their design. Similarly, fabricators must rely on the designer's engineering drawings to determine the shape, size, form, and fit of the part that they must produce. Collaboration between the designer and the fabricator is, therefore, essential to effective design and fabrication.

While there are a variety of industry models that govern design and fabrication, the concurrent engineering approach arguably best reflects the interrelation between these two activities. In concurrent engineering, the design, manufacture, service, and ultimate disposal of a product are considered from the beginning of the design process. This is in contrast to the more traditional sequential approach in which design is completed before these other areas are considered. Concurrent engineering requires that representatives from all affected areas in an organization participate as members of the design team from the initial design concept to the finished product. This collaborative approach can help to reduce costs, minimize lead-times, and improve overall product quality.

Rationale cont.

Design and Fabrication 1202 immerses students in a student-centered problem-based learning environment that mirrors this collaborative approach between designer and fabricator. Students acquire both the technical knowledge fundamental to design and the hands-on skills needed to operate a variety of fabrication tools and equipment. They are also introduced to the economical, legal, and environmental issues relevant to the product life cycle.

Students then apply this learning during the completion of group design projects that require them to follow the design process from initial design concept to the built prototype. Students learn by doing.

Purpose of Curriculum Guide

The purpose of this curriculum guide is to provide teachers with a clear delineation of student expectations in the course. The guide includes the specific curriculum outcomes, suggested learning and teaching strategies, suggested assessment and evaluation strategies and support resources.

Context for Learning

As stated in the Atlantic Canada Foundation document for Technology Education (2001), the Technology education curriculum in Atlantic Canada adheres to certain principles that guide decisions shaping the continuous improvement of learning and teaching including the design and implementation of the curriculum. These include:

Authenticity

Technology education values and embraces the strategic links between applied learning and integrated learning.

Unity

Technology education values and embraces meaningful connections among diverse areas of study.

Constructivism

Technology education incorporates each individual's prior knowledge, skills, and attitudes in the design of authentic learning experiences.

Context for Learning cont.

Collaboration

Technology education curriculum in Atlantic Canada adheres to strategies that emphasize the unifying concepts of related disciplines, particularly science.

Autonomy

Technology education values an environment with the learner as its pivotal force.

Continuous Inquiry

Continuous inquiry is essential to technology education.

Continuous Improvement

The success of technology education initiatives is a function of informed implementation and improvement practices.

Continuous Learning

Technology education implies strategic and distinct pre-service and in-service demands on teacher education.

Design and Fabrication 1202 encourages student collaboration in solving technical problems and reflects true industry practice through the use of a problem-based learning approach. Continuous inquiry, improvement and learning are fundamental to this approach and the design project provides an authentic learning experience where students drive the learning.

Literacy through Technology Education

As noted in the Atlantic Canada Foundation document on Technology Education, in order to acquire technological "literacy", students must be given the opportunity to actively participate in the solution of technical problems. In support of this, it is recommended that delivery of Design and Fabrication 1202 be focused on the shop/lab setting with intermittent classroom instruction as required. Accordingly, the course is designed for 80% lab and 20% class delivery. This emphasis on practical experiential learning opportunities for students is consistent with instructional delivery models used in post-secondary technology education programs.

Literacy through Technology Education cont.

Trades apprentices seeking journeyperson certification, for example, are required to complete a training program that consists of 20% classroom-based instruction and 80% field experience. This mode of instructional delivery provides students with opportunities to:

- Identify, assess, and make decisions about their use of technological resources
- Assess their technological literacy/capability in the context of specific situations
- Develop personal action plans to acquire specific technical skills and capabilities
- Safely use a wide variety of technological systems, tools, and other resources
- Identify and address technological issues and situations important to them
- Design, develop, and articulate technological solutions to a wide range of problems
- Articulate ideas and take intellectual risks
- Reflect on and evaluate their learning
- Reflect on, evaluate, and express ideas and opinions on the relationship between technology and education and the role of technology education
- Assess technology as a force for change in a variety of workplaces, jobs, occupations, and careers

The design project requirement of Design and Fabrication 1202 is particularly important to providing students with each of these learning opportunities. It allows students to drive learning while the teacher's role becomes that of facilitator.

In the Atlantic Canada Foundation document on Technology Education (2001), it is suggested that in a learning community characterized by mutual trust, acceptance, and respect, student diversity is both recognized and valued. Educators should ensure that classroom practices and resources positively and accurately reflect diverse perspectives and reject prejudicial attitudes and discriminatory behaviours. It is also suggested in the document that if curriculum is to contribute to the achievement of equity and quality in education, it must:

- Reflect students' abilities, needs, interests, and learning styles
- Expect that all students will be successful regardless of gender, racial and ethno cultural background, socioeconomic status, lifestyle, or ability
- Enable students to value individual variation among members of their classroom community

Design and Fabrication 1202 considers a wide range of learners and learning styles through a problem-based learning approach that encourages experiential learning. This student-centered learning model emphasizes a group approach to problem-solving that requires students to take ownership of their own learning. As suggested in the Atlantic Canada Foundation document on Technology Education (2001), taking ownership and responsibility for their own learning is a significant element in the growth of a student's technological capability.

Effective Assessment and Evaluation Practices

The Atlantic Canada Foundation document on Technology Education (2001), recommends that in planning assessments, teachers should use a broad range of strategies in an appropriate balance to give students multiple opportunities to demonstrate their knowledge, skills, and attitudes. The document identifies many types of assessment strategies as suitable for technology education including:

- Formal and informal observations
- Work samples
- Anecdotal records
- Conferences
- Teacher-made and other tests
- Portfolios
- Learning journals
- Questioning
- Performance assessment
- Peer- and self-assessment
- Available information
- Using a high level of professional judgment in making decisions based upon information

Effective Assessment and Evaluation Practices cont.

Similarly, the document suggests that evaluation involves teachers and others in analyzing and reflecting upon information about student learning gathered in a variety of ways. The process requires:

-
- Developing clear criteria and guidelines for assigning marks or grades to student work
- Synthesizing information from multiple sources
- Weighing and balancing all available information
- Using a high level of professional judgment in making decisions based upon information

Assessment and evaluation in Design and Fabrication 1202 must consider both the problem-based learning approach used and the required General Curriculum Outcomes (GCOs) outlined in the Atlantic Canada Foundation document on Technology Education. The assessment strategies recommended in section III of this guide, reflect these requirements.

Program Design and Components

Program Components

Design and Fabrication 1202 is one of three Level I technology education courses that introduce students to a wide variety of technologies and problem-solving strategies that reflect industry practice. This course is a not a required pre-requisite for Design and Fabrication 2202, which is offered in Level II. This course also prepares students for further study in related courses such as Energy and Power 3201 and Robotics Manufacturing Technology 3202 in Level III.

Outcomes Structures

The course curriculum is structured to address outcomes as suggested in the Atlantic Canada Foundation document on technology Education (2001). These include Essential Graduation Learnings (EGLs), General Curriculum Outcomes (GCOs), Key Stage Curriculum Outcomes (KSCOs) and Specific Curriculum Outcomes (SCOs).

EGLs are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school.

GCOs are statements that identify what students are expected to know and be able to do upon completion of study in a curriculum area.

KSCOs provide additional detail for each of the GCOs and provide a means to quickly assess progress in a subject area at the end of a level of schooling. SCOs identify what students are expected to know and be able to do at a particular grade level.

Essential Graduation Learnings

The EGLs specified in the Atlantic Canada Foundation document on Technology Education include:

Asthetic Expression

Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through art.

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 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 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.

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 content.

The GCOs for technology education as defined in the Atlantic Canada Foundation document on Technology Education include:

GCO 1: Technological Problem Solving

Students will be expected to design, develop, evaluate, and articulate technological solutions.

GCO 2: Technological Systems

Students will be expected to evaluate and manage technological systems

GCO 3: History and Evolution of Technology

Students will be expected to demonstrate an understanding of the history and evolution of technology, and of its social and cultural implications.

GCO 4: Technology and Careers

Students will be expected to demonstrate an understanding of current and evolving careers and of the influence of technology on the nature of work.

GCO 5: Technological Responsibility

Students will be expected to demonstrate an understanding of the consequences of their technological choices.

Key Stage Curriculum Outcomes

GCO 1: Technological Problem Solving

The KSCOs for Design and Fabrication 1202 are based on the five previously noted GCO's and indicate what is expected of students at the end of Level III. By the end of Level III, students will be expected to:

[1.401] articulate problems that may be solved through technological means

- • assess diverse needs and opportunities
- • construct detailed design briefs that include design criteria and a work schedule
-

[1.402] conduct design studies to identify a technological solution to a problem

- • investigate related solutions
- • document a range of options to solve this problem
- • determine and justify the best option
- • determine resource requirements and availability
- • develop detailed action plans, including technical drawings and sequences of action
-
- [1.403] develop (prototype, fabricate, make) technological solutions to problems
- • match resources and technical processes for specific tasks
- • construct and test models and prototypes as needed
- • construct the solution with adherence to the design criteria
- • document activities, decisions, and milestones
-
- [1.404] critically evaluate technological solutions and report their findings
- • develop detailed evaluations of both their own and others' technological solutions, with reference to independently developed criteria
- • employ a continuous assessment methodology with the purpose of continuous improvement of the design
- • document and report their changes, the rationale for change, and conclusions
-
- [1.405] communicate ideas and information about technological solutions through appropriate technical means
- • accurately present technical information by using a representative sample of analog and digital tools, including, for example, two- and three-dimensional, computer-assisted drafting and modeling tools
- • create accurately scaled models and prototypes
-

GCO 2: Technological Systems

- [2.401] operate, monitor, and adjust technological systems of increasing complexity
- [2.402] manage technological systems of increasing complexity
- [2.403] modify programming logic and control systems to optimize the behaviour of systems
- [2.404] deconstruct complex technological systems into their simpler systems and components
- [2.405] troubleshoot and maintain systems

GCO 3: History and Evolution of Technology

- [3.401] evaluate technological systems in the context of convergence where one system has multiple functions, or divergence where multiple systems have the same function
- [3.402] evaluate the symbiotic roles of technology and science in modern society
- [3.403] analyse the symbiotic relationship between technology and education, including factors that influence standards for technological literacy and capability, and ways that the community responds
- [3.404] critically evaluate the effects of accelerating rates of technological change on self and society
- [3.405] account for effects of cultural diversity on technological solutions
- • critically examine the effects of cultural diversity on market forces and technological products, and vice versa
- • incorporate knowledge of cultural diversity into development of technological solutions

GCO 4: Technology and Careers

- [4.401] assess and evaluate employability profiles for a variety of workplaces and careers and determine the level of technological literacy and capability they would need to achieve for job entry
-
- [4.402] employ design and invention as tools to create entrepreneurial activity
-
- [4.403] envision their short- and longer-term future and develop a plan for acquiring the technological literacy/capability required to achieve their vision
-

GCO 5: Technological Responsibility

- [5.401] demonstrate responsible leadership in employing legal and ethical rules and principles
-
- [5.402] demonstrate responsible leadership in employing health and safety rules and standards
-
- [5.403] demonstrate responsible leadership in taking proper measures to manage current and future technological risk
-

Specific Curriculum Outcomes

Overview

The Specific Curriculum Outcomes (SCOs) for Design and Fabrication 1202 Curriculum Guide are derived from Stage 4 (Grade 10-12) of the Key Stage Curriculum Outcomes (KSCOs) outlined in the Atlantic Canada Foundation document for Technology Education (2001). The SCOs are organized into six units delivered over two terms:

Unit 1: Introduction to Design

- Unit 2: Fabrication Techniques
- Unit 3: Introduction to Shop Practices
- Unit 4: Graphical Communications
- Unit 5: Introduction to CAD/CAM
- Unit 6: The Design Project

It is recommended that units 1 through 4 be covered in the first term with Unit 5 extending into term 2. This will provide students with the knowledge and skills considered pre-requisite to successful completion of Unit 6, the Design Project, in term 2.

Term 2 incorporates a problem-based learning approach in which students experience the actual process used in the field to move from design concept to finished product. Working in groups of 2 or 4 on one of several pre-defined projects, students are required to develop the working drawings and build a physical prototype of their chosen design. Evaluation of the design is based on adherence to design objectives, project time/cost management, and actual performance of the prototype in a class demonstration.

Each unit consists of several topics that address the General Curriculum Outcomes (GCOs) detailed in the Atlantic Canada Foundation document for Technology Education (2001). Units are sequenced to progressively challenge students.

The EGLs specified in the Atlantic Canada Foundation document on Technology Education include:

Overview cont.

The six units that comprise Design and Fabrication 1202 include the following key topics for a total of 110 hours instructional time:

Unit 1: Introduction to Design (10 hours)
- Topic 1: History of Design (1 hour)
- Topic 2: The Design Process (4 hours)
- Topic 3: Social/Environmental Considerations (2 hours)
- Topic 4: Design for Fabrication (2 hours)
- Topic 5: Careers in Design (1 hour)

Unit 2: Fabrication Techniques (11 hours)
- Topic 1: Shop Safety (10 hours)
- Topic 2: Metrology (2 hours)
- Topic 3: Machine Operation (4 hours)
- Topic 4: Environmental Protection (2 hours)
- Topic 5: Shop Related Careers (1 hour)

Unit 3: Introduction to Shop Practices (17 hours)
- Topic 1: Material Types and Properties (4 hours)
- Topic 2: The Production Environment (4 hours)
- Topic 3: Processing of Materials (8 hours)
- Topic 4: Careers in Production (1 hour)

Unit 4: Graphical Communications (10 hours)
- Topic 1: Lettering and Sketching (2 hours)
- Topic 2: 2D Orthographic Views (4 hours)
- Topic 3: 3D Pictorial Drawings (1 hour)
- Topic 4: Working Drawings (2 hours)
- Topic 5: Drafting Related Careers (1 hour)

Overview cont.

Unit 5: Introduction to CAD/CAM (16 hours)

- Topic 1: Creating Entities (4 hours)
- Topic 2: Display Manipulation (2 hours)
- Topic 3: Modifying Entities (2 hours)
- Topic 4: Dimensioning (3 hours)
- Topic 5: Plotting (1 hour)
- Topic 6: Computer Aided Manufacture (CAM) (4 hours)

Unit 6: The Design Project (46 hours)

- Topic 1: The Design Portfolio (2 hours)
- Topic 2: Defining the Problem (2 hours)
- Topic 3: Generating Options (2 hours)
- Topic 4: Selecting the Best Option (2 hours)
- Topic 5: Developing the Solution (16 hours)
- Topic 6: Prototyping and Testing (20 hours)
- Topic 7: Evaluation and Redesign (2 hours)

Note that the times allocated to each topic are recommendations only.

The 4-column Layout

The 4-column layout in the curriculum guide spans across two pages and presents the necessary information to the teacher to deliver a particular course topic to the student. The 4-column layout consists of:

I Specific Curriculum Outcomes.

The set is one or more SCO's from the course that will be addressed by the organizer. Each SCO also contains a listing of the KSCO's to which it directly relates (the relative KSCO's are included in brackets). The KSCO would be those for the subject area the course fits.

II Suggested Teaching and Learning Strategies.

Suggested Teaching and Learning Strategies are recommendations for implementing the curriculum. This section could include Organization and Preparation and Sample Student Projects and Activities sections.

III Suggested Assessment Strategies.

Suggested Assessment and Evaluation Strategies are recommendations for determining student achievement. Suggestions are provided to assist the teacher with the evaluation and assessment of student activity.

IV Resources.

This column provides additional information that may be of help to the teacher in lesson planning. References to teacher and student texts and other resources are included here. The teacher is encouraged to expand and elaborate upon the information presented in columns II, III and IV, as the information provided in those columns is meant to be suggestions.

The Design and Fabrication 1202 Teacher Resource Guide, which accompanies this curriculum guide, provides additional resources to support course delivery. The concepts, strategies, and resources identified in the curriculum guide are elaborated on in the Teacher's Resource Guide.

Unit 1
Introduction to Design

Purpose

The purpose of this unit is to provide students with an introduction to design, which forms the foundation of the Design and Fabrication 1202 course. Students develop both knowledge of the design process and an appreciation for the design philosophy through completion of the following unit topics:

- **Topic 1:** History of Design (1 hour)
- **Topic 2:** The Design Process (4 hours)
- **Topic 3:** Social/Environmental Considerations (2 hours)
- **Topic 4:** Design for Fabrication (2 hours)
- **Topic 5:** Careers in Design and Fabrication (1 hour)

Profile

Students will be exposed to the evolution of technological design methodology and its relationship to the fabrication of products and systems. Students will also discover the impact of technological designs on society and the environment. An exploration of career opportunities available in design and fabrication will make students aware of possible career options in technology.

Implementation

Unit 1 sets the groundwork for the remainder of the course by introducing the method of technical design and the philosophy of design. Teachers provide knowledge but more importantly help develop critical thinking and analytical skills in the students. This unit will provide the teacher the opportunity for active group and individual discussions on product and systems design. It will also provide for an investigation of the effects of design on society and the environment.

Evaluation

Unit 1 consists of 10 hrs of instruction, which represents approximately 9% of the total course teaching time.

Evaluation particulars are provided in the Teacher Resource Guide.

Suggested Timeline

The timeline indicated below is a guideline for the teacher.

Topic 1: Design and Technology (1 hour)

- SCO 1.1.1
- SCO 1.1.2

Topic 2: The Design Process (4 hours)

- SCO 1.2.1
- SCO 1.2.2

Topic 3: Social/Environmental Considerations (2 hours)

- SCO 1.3.1
- SCO 1.3.2

Topic 4: Design for Fabrication (2 hours)

- SCO 1.4.1
- SCO 1.4.2

Topic 5: Careers in Design and Fabrication (1 hour)

- SCO 1.5.1

Topic 1: Design and Technology

Outcomes

Students will be expected to

1.1.1 define technology as it relates to design and fabrication. [3.404, 3.405]

Focus for Learning

Teacher Preparation

Technology is the use of knowledge, tools and skills to solve problems. Its is not a thing, as it is frequently defined, but rather a process by which needs, wants and opportunities are met.

The intermediate technology program includes outcomes that reference technology but do not deal specifically with this definition. Using the references to technology as a part of building the definition would be a useful strategy. Integrated Systems 1205 defines technology in the first outcome, and this can also be referenced.

An effective method of introducing this topic would be to engage students in a discussion of what they think technology is. They will most likely give examples of technology as products, so you can guide them to the idea that it is a process.

This is not the first time that students would have been engaged in this conversation, but it is expected that the depth of treatment for this will be greater at this level.

Sample Performance Indicator

- Create a journal entry in the course portfolio where students should be able to describe and defend, in their own words, the definition of technology.

Topic 1: Design and Technology

Sample Teaching and Assessment Strategies

Activation

- Students could give examples of each and describe technology in terms of:
  - Technology as knowledge
  - Technology as process
  - Technology as product

Consolidation

- Using the notes and examples given by the instructor, along with the reference materials provided to the student, students could write a one sentence definition of the term technology in their portfolio.

Resources and Notes

- Unit 1, Section 1, Lesson 1 of Communications Technology 2-3104 - http://www.cdli.ca/courses/ctecx104/
- Unit 1, Section 1, Lesson 1 of Integrated Systems 1205 - http://www.cdli.ca/courses/isys1205/)
- Foundation for the Atlantic Canada Technology Education Curriculum, The Nature of Technology Section - http://www.ed.gov.nl.ca/edu/sp/foundations/tech_edu/te_found_nf-lab_full.pdf

Topic 1: Design and Technology

Outcomes

Students will be expected to

1.1.2 explain the historical development of design. [3.404, 3.405]

Focus for Learning

Teacher Preparation

This is a good foundation for presenting the design process to follow in the next outcome. Students may have encountered this in other technology education courses in junior high. Building on that previous knowledge will be important.

To begin, a discussion on the historical development of design and how it has evolved from an informal approach to a formal one with defined steps and procedures could be used. From this an explanation of how the design process has expanded from simple trial and error into a multidiscipline approach that relies on people with varied disciplines and backgrounds could occur.

A chronology of historically noteworthy designs, presented to the class, may direct a class discussion aimed at stimulating student interest in the field. Also a review of the continuing emergence of environmental, legal and ethical concerns and their effect on the design process would be beneficial.

Sample Performance Indicator

Students could construct a timeline, wherein they provide their own examples of historical design achievements, to outline the historical development of the design process.

Topic 1: Design and Technology

Sample Teaching and Assessment Strategies

Activation

- Students could brainstorm on the chronology of design. This discussion could involve students hypothesizing when the first design may have occurred.

- Students could debate or present their arguments of what the first design may have been. Criteria for the debate could be based on why it was first, what it was and how the design process was used.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Web Resources Site - http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/skilledtrades/df1202links.html

Topic 2: The Design Process

Outcomes

Students will be expected to

1.2.1 identify the steps in the design process. [1.401]

Delineation

The discussion should focus on:

- Needs identification
- Defining the Problem
- Generating Options
- Selecting the Best Option
- Developing the Solution
- Prototyping and Testing
- Evaluation and Redesign

Focus for Learning

Teacher Preparation

Building on the learning that has taken place in the previous outcome, the concept of design can be expanded to the process identified in the delineation. It is essential in any design that the student be familiar with the steps in the design process and their relation to the fabrication of the system or product. This will not be their first look at this process as all intermediate modules present it in some form.

The process is similar to other models of problem solving, and linking these in the discussion will further solidify students' understanding of this concept. Examples include: the writing process, the scientific method or decision making techniques.

An introduction of the concept of problem solving in both individual and group environments and the related advantages/disadvantages in each case would be beneficial.

Sample Performance Indicator

Using a case study example, students could discuss the product life cycle or how a product or system starts as an identified need that evolves through the design process to a built prototype.

1.2.2 apply the design process in the design of a simple project [1.402, 1.403]

Teacher Preparation

Once the student knows the steps used in the design process the process needs to be reinforced through application. In this section review the design of the product discussed in the previous class and the steps followed in the design process.

Emphasize to the students the importance of developing a problem definition including objectives, criteria and constraints.

Sample Performance Indicator

In groups of 2, students will, under the guidance of the teacher, develop a design document in which they detail the process for design and fabrication of a simple product. A sample of these designs will be presented to the class. Students will be required to summarize the process followed in generating their design.

Topic 2: The Design Process

Sample Teaching and Assessment Strategies

Activation

- Students could debate and discuss the order of the steps of the design process. Links to the scientific method and other problem-solving approaches should be introduced here

Connection

- Students could develop a poster outlining the steps of the design process. This poster could be decorated with examples of the various stages of a product in design.
- Students could present to the class their interpretation (based on student vernacular) of the design process.

Consolidation

- Students could outline and explain the steps of the design process. This outline should include language such that a student in grade 4 or 5 would understand what was being explained.

Activation

- Students could create a design portfolio at this point. This portfolio will contain all of the designs, design elements, meeting notes and drawings that students will have undertaken in this course. The portfolio could be paper-based, digital or some other media that students will feel comfortable reporting in.

Practical activity

- Students could design their first project in small groups at this stage. It is suggested that the design be very simple and be significantly facilitated by the instructor.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Web Resources Site - http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/skilledtrades/df1202links.html

Design and Fabrication 1202 Teacher's Resource Guide

Topic 3: Social/Environmental Considerations

Outcomes

Students will be expected to

1.3.1 explain the relationship between design and related social/environmental impacts. [5.403]

Focus for Learning

Teacher Preparation
With the increasing emphasis on protection of the environment and the wise use of non renewable resources, designers now have to consider the impact that the selection of particular materials and processes have on the environment.

Points to emphasize:

- the effect that the disposal of the product, at the end of its life cycle, will have on the environment,
- any legal consequences associated with product use and misuse,
- the exposure of workers and the general public during production, and
- the effect of depletion of resources and pollution on future generations.

This outcome has some cross-curricular links with Environmental Science and opportunities for intra-class projects may exist. Students could discuss these points and related environmental standards. An illustration using an everyday product will be most effective. Simple examples such as tires and plastic bottles have specific meaning for this province.

1.3.2 describe the ethical and legal responsibilities of designers. [5.401, 5.402, 5.403]

This outcome is directly linked to the previous outcome. Environmental/social impacts of design are directly related to the ethical and legal responsibilities of designers.

Further points to emphasize

- designs have implications beyond their use, disposal is the newest consideration.
- safe use has always been important, but in the past few years it has taken on a new significance.

Sample Performance Indicator
Students, in groups of 2 could be assigned a product. The group will examine the product and develop a list of the possible environmental and legal implications of making, operating and disposing of the product. Within this, a discussion of what could have been done to lessen the impact in the design could ensue.

Topic 3: Social/Environmental Considerations

Sample Teaching and Assessment Strategies

Connection
- Students could present to the class how some designs in history have had negative societal and environmental impacts.

- Students could debate a series of products, how they were designed, including their packaging, and how the design has a societal or environmental impact.

Activation
- Students could write a simple paragraph outlining the perils of design, and how designs will have impacts to both society and the environment.

Consolidation
- Students could identify one product in history that did what the designer intended but had negative impacts on society and the environment. This research could include why the product was designed in the way it was, what risk factors were ignored,

Activation
- Students could debate what legal and ethical are as concepts for designers. This debate could result in a list of "ethics" and "legalities" that should be taken into account when designing something.

Connection
- Students could develop a poster outlining ethics and legalities to be considered when designing. Examples of ethical issues and illegalities should be included.
- Students could place a listed overview of the ethical and legal implications of designs in their design portfolio.

Consolidation
- Students could present to the class their interpretation of the ethics and legal implications of designing products. This presentation should include the new reality of designing products,

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Sample Products

Web Resources Site - http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/skilledtrades/df1202links.html

Topic 4: Design for Fabrication

Outcomes

Students will be expected to

1.4.1 explain the relationship between product design and fabrication. [1.403]

Focus for Learning

Teacher Preparation

During the design process the designer has to consider the available manufacturing processes in view of cost and time constraints. The principles governing Design for Manufacture (DFM) and Design for Assembly (DFA) should be incorporated to facilitate manufacture.

This is the first time students would have been introduced to this topic. It is not part of the curriculum in junior high.

The primary aim of Design for Manufacturing (DFM) is to minimize the cost of production and/or time to market for a product, while maintaining an appropriate level of quality. This typically involves minimizing the number of parts in a product.

Similarly, Design For Assembly (DFA) involves making attachment directions and methods simpler. There are several fundamental principles governing DFM and DFA that are outlined in the appendix.Review the DFM/DFA principles and discuss these with the students, using some common products to illustrate.

Sample Performance Indicator

The students working in groups of 2 or 4 will review a set of working drawings for a simple project. The project design will incorporate wood, metal and plastic to give the students the opportunity to work with each of these materials later in Unit 2 when they will fabricate the design. Based on review of the detail and assembly drawings, the students will develop a list identifying the processing method needed to make each part. Each group will recommend design changes that will facilitate fabrication.

Topic 4: Design for Fabrication

Sample Teaching and Assessment Strategies

Activation

- Students could discuss what they consider to be the primary principles of design for manufacturing and design for assembly and how they may come into conflict.

Connection

- Students could present to the class how design for assembly is an integral part of design for manufacturing.

- Students could place an overview of these concepts into their design portfolio

Consolidation

- Students could create a diagram that illustrates how the principles of Design for Manufacturing are integrated into the design process. Design for Assembly is also a part of this process and should be included.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Working Drawings

Web Resources Site - http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/skilledtrades/df1202links.html

Topic 4: Design for Fabrication

Outcomes

Students will be expected to

1.4.2 demonstrate recognition of the importance of a team approach in design and fabrication. (4.401)

Focus for Learning

Teacher Preparation

As indicated in Topic 1, design and fabrication of a product has gone from the traditional one-person operation to a team approach. The design and fabrication of a product or system now involves a multidiscipline team of technical specialists, accountants, purchasers, marketers and legal experts. All of these individuals have input on different areas of the design. A common example would be the design of a car. Historically students can also relate this concept to the creation of the assembly line.

Points to emphasize

- design of some products involve design of their component parts and then assembly. This can be related to the solids design software used later in this course.
- assembly can also be done in components as in an assembly line.
- the adage "sometimes the whole is greater than the sum of its parts" has specific relevance in this section, as working together can create something greater than each group working in isolation.

Sample Performance Indicator

The students working in groups of 2 or 4 will review a set of working drawings for a simple project. The project design will incorporate wood, metal and plastic to give the students the opportunity to work with each of these materials later in Unit 2 when they will fabricate the design. Based on review of the detail and assembly drawings, the students will develop a list identifying the processing method needed to make each part. Each group will recommend design changes that will facilitate fabrication.

Topic 4: Design for Fabrication

Sample Teaching and Assessment Strategies

Activation

- Students could discuss what the meaning of the adage “the whole sometimes exceeds the sum of its parts”. This discussion could include how this relates to the design and fabrication process.

Connection

- Students could itemize the benefits of team work in the process of design and fabrication. Examples from history of designs that were not carried through to fruition should be included in this assignment.
- Students could place an overview of these concepts into their design portfolio.

Consolidation

- Students could present to the class how teamwork is important to the design and fabrication process.

Resources and Notes

Design and Fabrication 1202

Teacher’s Resource Guide

Working Drawings

Web Resources Site - http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/skilledtrades/df1202links.html

Topic 5: Careers in Design

Outcomes

Students will be expected to

1.5.1 identify the various job roles required to support both design and fabrication in industry. (4.401)

Focus for Learning

Teacher Preparation
In SCO 1.2.2, students were engaged in the design process for a simple project supplied to them. At this point this can be reintroduced to form the basis of a discussion with students involving the specific role that each member of the design group had in the design of the product. Students could outline specifically what role they took on and what was involved in that role.
The discussion could then move to what the roles of the members of the fabrication team in the production of the product would have to be. Once again the specific project introduced in SCO 1.2.2 would be used. Students could itemize what had to be done, how the tasks could be broken down and who may or may not be responsible for each task. A common example such as the design and production of a small fiberglass boat can be used. A list the skill set for each member of the design and fabrication team can then be generated.

A field trip to a small manufacturing centre could be undertaken at this point. While at such a site, students should be shown the various positions held by people all working together to fulfill a single purpose.

Sample Performance Indicator
The students working in groups of two or four will review the birdhouse design introduced in Topic 1 and list the job roles required for the design and fabrication of the product assuming mass production.

Topic 5: Careers in Design

Sample Teaching and Assessment Strategies

Discussion

- Students could discuss the various roles and jobs to support Design and Fabrication in industry. This discussion could use a brainstorming technique, with students being evaluated on their participation in the exercise.

Paper and Pencil/Role Play

- Students could take on one of the roles used to support Design and Fabrication in Industry. In taking on this role and interacting with others in similar roles they could create a list of the skills required and how they interact with other jobs in the process.

Research/Presentation

- Students could research one of the jobs in industry involved in Design and Fabrication. Such things as work type, education, pay expected and general job satisfaction could be some of the things they focus on. This research should be presented to the class as a whole in some fashion be in poster or in class presentations.

Design portfolio

- Students could place an overview of these concepts into their design protfolio.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Working Drawings

Web Resources Site - http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/skilledtrades/df1202links.html

Unit 2
Fabrication Techniques

Purpose

The purpose of this unit is to provide students with an introduction to the operation and environment of an industrial shop. Students will learn how to operate power and hand tools and fabricate simple projects. They will also study the impact of shop operation on the environment. The following unit topics will provide these experiences:

- **Topic 1:** Shop Safety (10 hours)
- **Topic 2:** Metrology (2 hours)
- **Topic 3:** Machine Operation (4 hours)
- **Topic 4:** Environmental Protection (2 hours)
- **Topic 5:** Shop Related Careers (1 hour)

Profile

Students will be exposed to a simulated production environment in the fabrication lab accompanied by supporting activities in the classroom. This unit will give students the hands on experience that is required to relate their design to fabrication. The students will also learn how to deal with the pollution problems that arise out of the fabrication or processing of a product. After the practical exposure the students will have an opportunity to investigate some of the careers related to shop work.

Implementation

Unit 2 sets the groundwork for the hands-on component of the remainder of the course by familiarizing the students with the shop equipment that will be used to complete related projects and the prototype for the design project.

Evaluation

Unit 2 consists of 17 hours of instruction which represents 15% of the total course teaching time.

Evaluation particulars are provided in the Teacher Resource Guide.

Suggested Timeline

The timeline indicated below is a guideline for the teacher.

Topic 1: Shop Safety (10 hours)
- SCO 2.1.1
- SCO 2.1.2
- SCO 2.1.3
- SCO 2.1.4
- SCO 2.1.5
- SCO 2.1.6
- SCO 2.1.7

Topic 2: Metrology (2 hours)
- SCO 2.2.1
- SCO 2.2.2

Topic 3: Machine Operation (4 hours)
- SCO 2.3.1
- SCO 2.3.2

Topic 4: Environmental Protection (2 hours)
- SCO 2.4.1
- SCO 2.4.2

Topic 5: Shop Related Careers (1 hour)
- SCO 2.5.1

Outcomes

Students will be expected to

2.1.1 develop personal rules of conduct based on standard practice. [5.401, 5.402, 5.403]

Focus for Learning

Occupational Heath and Safety rules clearly state that employees and employers have rights and responsibilities. It is the responsibility of employers to provide a safe work environment, and the responsibility of employees to maintain that environment. Establishing a personal code of conduct will allow students to take ownership of their OH&S rights and responsibilities, and will also serve to establish the baseline for safety within the lab.

This outcome also involves the project management topic within Unit 3. One of the duties of the project manager in that section is to ensure that all students are working in a safe manner. It is important that this does not become a case of one student "telling" on another, but rather the students working together to keep the fabrication lab safe. It is suggested that if an unsafe practice is identified that the first step would be to talk to the worker in question, the second step would be to make an informal report, and the third step would be to put a "stop work" order on the module in question. This could easily become a whole class learning experience, addressing aspects of the fabrication lab safety section, the Occupational Health and Safety section and the project management section.

Sample Performance Indicator

Students will create a contract concerning their behaviour in the fabrication lab. This contract will provide details of appropriate behaviour and consequences. In the development of the contract, students should include the prior learning from the previous section on Occupational Health and Safety.

At this stage a parental permission form, signed and returned, would be advisable.

Suggested Teaching and Assessment Strategies

Although in most assessments the activities are suggested, in the case of the safety sections most are prescribed. Wording for these specific activities will be indicative.

Activation

- During a tour of the Fabrication Lab, students could discuss behaviours that would be safe and appropriate in each area. This could be done as a guided tour, a scavenger hunt, or in small groups.

Connection

- Students could do research on what standard practice entails with regards to personal safety. Commentary on the origins of Occupational Health and Safety could also be included here.

Consolidation

- Students could develop a short description of why codes of conduct are needed in the fabrication lab. This description would then be used as an adjunct to the parental permission form for information to take home.

Resources and Notes

Skilled Trades 1201
Curriculum Guide

Design and Fabrication 1202
Teacher's Guide

Topic 1: Shop Safety

Outcomes

Students will be expected to

2.1.2 identify common hazards within the fabrication lab. [5.402, 5.403]

Focus for Learning

Safety rules within the fabrication lab should be clearly and prominently displayed. One of the first activities for students in this course or any of the other skilled trades and technology courses should be to design and implement a safety information program within the lab site. This will enable students to become aware of the common hazards in the fabrication lab, while taking personal responsibility for identification and awareness for others using the space.

This outcome and the previous can be taught together as they tie in directly with the preceding topic on OH&S and specifically the SAFE work program. The first steps in that program are:

- Spot the hazard.
- Assess the risk.

All students should walk through their fabrication space and identify and assess the hazards.

A cautionary note is that most of the student work completed will have to be checked carefully as it deals with safety. If student work is to be used for safety in the fabrication lab, an important motivator, then this should be a heavily guided activity.

Sample Performance Indicator

- Students could audit the fabrication lab themselves for hazards. Each group could do an assessment of the space and then compare notes with the other groups.

Topic 1: Shop Safety

Suggested Teaching and Assessment Strategies

Activation

- This activity can be done in concert with the previous outcome. During the tour of the fabrication lab, students could also identify common hazards along with their proper deportment.

Connection

- Each group of students could be given a piece of equipment or situation that they can then address with rules, messaging, clear zones and floor plans. This is something that can be done in every course on a yearly basis, and it can also form the basis of a design project with the inclusion of OH&S and safe work principles.

Consolidation

- Students could develop a general fabrication room safety project that encompasses all of the common elements developed in the previous activity. This could be done in the form of a poster, video, presentation, manual, etc.

Resources and Notes

Skilled Trades 1201 Curriculum Guide

Design and Fabrication 1202 Teacher's Resource Guide

Related Document
Workplace Safety Text Book

Topic 1: Shop Safety

Outcomes

Students will be expected to

2.1.3 demonstrate safe practice for use of standard hand, portable power, and stationary power tools, for design and fabrication. [5.402]

Delineation

Students must

- complete the safety program for each tool that requires it, and that is intended for use;
- state and describe the safe operating procedure for using a tool at 100% accuracy; and
- demonstrate safe use of a tool with 100% accuracy.

Focus for Learning

Working with a wide variety of tools is at the heart of design and fabrication. For power tools in particular, ensuring students are properly certified to use them is essential. Normal practice is to use a combination of written and performance testing for each student for each tool. It is a good idea to maintain a chart of who is qualified for what tools. You may wish to provide class wide instruction on tools, followed by individual testing.

Include:

- function of the tool:
- parts of the tool:
- adjustments that can be made and the correct procedure for completing them;
- safe usage of the tool for performing the common tasks; and
- procedures to follow in instances where the tool is not functioning or functioning outside the specs.

It is to be expected that not all students will qualify for all tools. It is also expected that students who qualify for different tools may wish to trade tasks.

Points to emphasize

- Safety is not just a set of rules. Safety is a way of life. It is a set of ideas, attitudes, behaviours and practices that are essential to the workplace. Safe practice does not eliminate risk, but it reduces risk. Safe practice is risk management.
- Safe use of tools is primarily using them in the prescribed manner, with the proper adjustments and usage procedures. It is also avoidance of clearly understood unsafe practices. In particular shortcuts and quick work-arounds often increase risk.

Cautionary notes:

- Only students who are qualified will be allowed to use a particular tool. It is not necessary for all students to use all tools. It is perfectly acceptable for a group to divide the tasks so that each member can qualify for a different group of tools.
- Tool qualification can occur on an as-needed basis.
- Tool qualification has no margin of error. Only 100% on written/verbal/performance tests are acceptable for qualification.
- Each tool is different but all tools have commonalities. Point out the commonalities with other tools when demonstrating a tool's function, adjustments and operating procedures.

Topic 1: Shop Safety

Suggested Teaching and Assessment Strategies

Activation

- This entire section can be activated through the tour of the fabrication room. Students could be introduced to the tools and their general position in the fabrication room.

Connection

- Students could report in their portfolio each tool they are qualified to use, and the date and time of the qualification. These should be checked or verified by the teacher in each case.

Consolidation

- Students are expected to complete a written/oral safety test (passing grade is 100%) and complete a practical safety demonstration for each of the hand, portable power, and stationary power tools to be used in the fabrication laboratory. These tests are available online.

Resources and Notes

Skilled Trades 1201 Curriculum Guide

Design and Fabrication 1202 Teacher's Resource Guide

Sample MSDS Sheet

Topic 1: Shop Safety

Outcomes

Students will be expected to

2.1.4 demonstrate safe practices within the fabrication area, including proper procedure for handling shop emergencies. [5.402, 5.403]

Focus for Learning

The purpose of this outcome is to formalize the normal safety procedures established in classrooms and laboratories. Teachers should outline the various contingencies and the proper safe response by students. These should include but are not limited to:

- fire extinguishers;
- eye wash station;
- fire exits;
- emergency shut-off; and
- first aid kit.

As before, the entire topic to this point could be taught together. Specific activities that deal with shop emergencies and the processes students have to follow would need to be included.

2.1.5 describe the importance of WHMIS and demonstrate knowledge of its key features. [5.402, 5.403]

WHMIS is an acronym for Workplace Hazardous Materials Information System. It involves a series of national regulations concerning the communication of information about the use and storage of hazardous material in the workplace.
Students should have been introduced to this in grade 9 science, Science 1206 and the locally developed Workplace Safety 3220 as both present a short course in WHMIS.
In this course we will touch on the basics of the system and what has to be looked for in the fabrication lab.

Points to emphasize:
Students should review the details of WHMIS, specifically:

- supplier label;
- workplace label;
- material safety data sheets (MSDS); and
- employee education.

Sample Performance Indicator
Students could produce a poster outlining the elements and the importance of WHMIS in the workplace.

Topic 1: Shop Safety

Suggested Teaching and Assessment Strategies

Consolidation

- Students could participate in a mock emergency within the fabrication lab. This simulation should involve injury, fire, electrical situations and chemical spills.

Activation

- During their tour of the fabrication lab, students could itemize the number of chemicals in use. Specific reference to those which are controlled substances could be made to show the importance of WHMIS.

Connection

- Students could role play a situation on the job for when an MSDS sheet is needed and should be supplied. A mock MSDS sheet can be used and in the role play discussions of what important information is contained within it could occur.

Consolidation

- Students could develop a presentation for new students coming into the course, on the elements of WHMIS and how they are applied in the fabrication lab.

Resources and Notes

Design and Fabrication 1212
Student Text

Design and Fabrication 1212
Teacher's Resource Guide

Outcomes

Students will be expected to

2.1.6 recognize the need to consult Material Safety Data Sheets (MSDS) when dealing with chemicals on the jobsite. [5.402]

Focus for Learning

The material safety data sheets are provided with all hazardous materials defined as those having the potential to cause a physical or health hazard.
Points to emphasize:
The different classes of such material are:

- Class A - compressed gas;
- Class B - flammable and combustible material;
- Class C - oxidizing material;
- Class D - poisonous and infectious material;
- Class E - corrosive material; and
- Class F - dangerously reactive material.

This material has been presented in grade 9 science and Science 1206. Practical use of the knowledge is what is important in this course. Teachers should emphasize the importance of this information when dealing with safety in the Fabrication lab and on the jobsite for young workers.
Young workers disproportionately have the most accidents on the job, and some of this is due to a lack of knowing their rights and what information they should be looking for when working with chemicals.

Sample Performance Indicator
Students could create a fact sheet on MSDS, including the essential elements and purpose.

2.1.7 revise personal rules of conduct based on standard practice. [5.401, 5.402, 5.403]

This is the last outcome in this topic, and as such provides the basis for students to reconsider their rules of conduct. The rules of conduct were established at the beginning of this unit, and should be reinforced through practice during the remainder of the course. Students should strive to develop a culture of safety when it comes to working in the fabrication lab.

Sample Performance Indicator

Students should take some time to revisit their safety projects created earlier in the unit and revise as necessary in accordance with their newly acquired safety knowledge.

Suggested Teaching and Assessment Strategies

Activation

- Students could choose a common hazardous material in the Fabrication Lab and research the relevant Material Safety Data Sheet. A report to the instructor should be prepared on this material, its use and storage in the Fabrication Lab.

Connection

- Students could present to the class on the importance of MSDS. In this presentation specific examples of where such a system may have saved a life or saved someone from an injury should be used

Consolidation

- Students could record in their portfolio the completion of the section on WHMIS and what it entails.

Consolidation

- Students could create their finalized code of conduct, revised from the previous version, and note specifically the changes they made due to the learning that has taken place.

Resources and Notes

Sample MSDS Sheet

Skilled Trades 1201 Curriculum Guide

Design and Fabrication 1202 Teacher's Resource Guide

Topic 2: Metrology

Outcomes

Students will be expected to

2.2.1 discriminate between common metrology tools and their specific uses. (1.403)

Focus for Learning

Teacher Preparation

Fabrication is engaged in the creation of parts and assembly. Assembly is contingent upon the method and accuracy of the measurements used to make the parts. The cost of the product is dependant on the degree of accuracy or tolerance of the dimensions. Excessive tolerance can result in the product being too expensive to produce. It should also be noted that the type of metrology tool used depends on its accuracy and the fabrication method. For example, specifying the angle of the roof for a house in degrees would be unusable for the carpenter building the house.

The concept of metrology may not be familiar to students and the types of measuring devices used beyond the simple ones, will also be new.

The teacher should identify and briefly describe the common metrology tools for metal and wood fabrication including:

- steel rule,
- steel tape,
- micrometers,
- calipers,
- scriber,
- center punch,
- feeler gauge and
- rafter square.

Each of these tools has a specific and most appropriate use. Some of these are immediately obvious given the shape and type of scale on the tool itself. For example using a micrometer to measure an interior diameter is not possible.

Sample Performance Indicator

Students could outline the most appropriate use for each of the metrology tools listed above. This could be recorded in their portfolio.

Topic 2: Metrology

Suggested Teaching and Assessment Strategies

Activation

- Students, in groups of the two, could research the origins and history of the metrology tools listed. In each case they would be expected to present to the class on their tool.

Connection

- Students could measure a variety of samples given them by the teacher. In each case they will be expected to use the most appropriate metrology tool for the sample in question. Student measurements could be compared against teacher prepared standards.

Consolidation

- Students could research some of the most recent changes in the world of metrology. Specific attention should be placed on how the new technologies used will make measurement easier, more precise or more accurate.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Metrology Tools

Part Samples

Slide show display of metrology tools

Topic 2: Metrology

Outcomes

Students will be expected to

2.2.2 state the relationship between tolerance and production cost. (1.403)

Focus for Learning

Teacher Preparation
Every different part produced from the same fabrication process will be different physically, because nothing can be made to an exact size. This variation or tolerance will depend on factors such as machine capability and operator skill. The cost of production and its production method will depend on the tolerance which is specified for the design.

The teacher should explain that the cost and accuracy for a piece of lumber cut with a chainsaw will be much less than that done by a table saw. The choice of which method to use will depend on the function of the product. For instance, the tolerance on the axle for a tricycle will be much higher than the tolerance on the shaft for a jet engine.

As part of the tolerance, there is also the effect of accuracy and precision when measuring materials. Between the two, tool tolerance and measurement variations, the size of variance could be quite substantial. This is a good place to emphasize the importance of accuracy and precision when measuring and when using tools.
Points to emphasize:

- Good resource usage is a keystone to an effective and cost efficient fabrication.
- Tools used to obtain accuracy when laying out on material: Ruler, scribe, protractor, templates, etc.
- “Measure twice, cut once” policy

Sample Performance Indicator
Students could use the metrology tools provided by the teacher to measure various part samples. Variation in the size of common features on similar parts should be noted.

Topic 2: Metrology

Suggested Teaching and Assessment Strategies

Activation

- Students could research a variety of technologies used in measurement and production that reduce the amount of deviation between parts. In this discussion robotics and CNC should be introduced as concepts.

Connection

- Students could discuss the variety of tools and measurement devices they have been introduced to, concerning how to reduce the amount of variation in production. Some of the ideas could include: using the same operator on a tool, measuring a number of pieces before cutting and comparing them, etc.

- Students could make their own definition of accuracy and precision. Discussion of how the two will have issues in production.

Consolidation

- Students could interpret a variety of technical drawings and blueprints showing measurements. They could then transfer the dimensions indicated to a piece of stock and measure the stock for fabrication. These measurements should be compared to others and against a standard.

Resources and Notes

Design and Fabrication 1202
Teacher's Resource Guide

Part Samples

Metrology Tools

Topic 3: Machine Operation

Outcomes

Students will be expected to

2.3.1 demonstrate appropriate use of hand tools in the fabrication of a simple project. (1.403, 2.401)

Focus for Learning

Teacher Preparation

This activity is designed to give students the opportunity to use various hand tools. The teacher can have the students fabricate different components of a project that must then be assembled. This will not only demonstrate tool use but also the idea of interchangeability of parts.

This will be the first time in school that students have been engaged in a practical project involving tools in the fabrication lab. As such, the practical application of the safety they have learned to this point should be paramount in all instruction.

This outcome links directly with the design of a small project from the first unit. It is expected that the project designed in that outcome will be the one used for this activity.

It may be useful to take one class and do a review demonstration of all the hand tools to be used in the fabrication. Include:

- function of the tool;
- parts of the tool;
- adjustments that can be made and the correct procedure for completing them;
- safe usage of the tool for performing the common tasks; and
- procedures to follow in instances where the tool is not functioning or functioning outside the specs.

Points to emphasize

- Each tool is different but all tools have commonalities. Point out the commonalities with other tools when demonstrating a tool's function, adjustments and operating procedures.
- The right tool for the job is central, keeping in mind that some tools have multiple applications, and some jobs can be completed with multiple tools.
- Not all tools will be used for this project, but the most common ones should be encompassed.

Sample Performance Indicator

- Students could undertake a fabrication activity using hand tools. This fabrication activity would see a each group of students responsible for a certain part of the fabrication as a whole. While doing the fabrication students could insure they are using the hand tools in a safe manner. Final assembly could be undertaken as a whole group activity. This activity could be carried on into the next outcome as well.

Topic 3: Machine Operation

Suggested Teaching and Assessment Strategies

Activation

- Students could research the evolution of one of the hand tools they are using. In this research they could look for how the tool has evolved/not evolved and how it has been replaced by a power equivalent. A short presentation to the class on the tool would be a good wrap-up.

Connection

- Students could report in their portfolio each tool they are qualified to use, and the date and time of the qualification.

- Students could develop a set of safety rules for a hand tool they have been working on. Unlike power tools, hand tools rarely have a set of rules for safety. After checking with the instructor, these rules could be posted in a area of the fabrication lab dealing with hand tools.

Consolidation

- In groups of 2 or 4 students will use hand tools in the fabrication of the various components of a simple assembly project. Each group will be responsible for repeated production of a single component. After groups exchange completed components, each student will assemble a single unit.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Metrology Tools

Hand Tools

Project Drawing

Topic 3: Machine Operation

Outcomes

Students will be expected to

2.3.2 demonstrate the proper selection of power tools used for cutting, turning and milling (2.401)

Focus for Learning

Teacher Preparation

While all tools can be dangerous, power tools have a special propensity for hazards. This is mainly due to their power and speed of operation. A power tool can quickly become uncontrollable if used incorrectly or for the wrong application. The purpose of this activity is for the teacher to demonstrate to the students the safety procedures in selection and operation of common power tools. The teacher should also indicate potential hazards for each tool.

This outcome is not intended to engage students in specific activities with these tools at this point, but make students familiar with them. A useful instructional strategy could be to make comparisons between the activities engaged in during the fabrication of the small project and how it could be done differently (not necessarily better) by using power tools.

It may be useful to take one class and do a review demonstration of all the hand tools to be used in the fabrication. Include:

- function of the tool;
- parts of the tool;
- adjustments that can be made and the correct procedure for completing them;
- safe usage of the tool for performing the common tasks; and
- procedures to follow in instances where the tool is not functioning or functioning outside the specs.

Points to emphasize

- Each tool is different but all tools have commonalities. Point out the commonalities with other tools when demonstrating a tool's function, adjustments and operating procedures.
- The right tool for the job is central, keeping in mind that some tools have multiple applications, and some jobs can be completed with multiple tools.
- Not all tools will be used for this project, but the most common ones should be encompassed.

Sample Performance Indicator

Students could itemize, in their portfolio, the power tools they could have used to create their fabrication project from the previous outcome. This list should include accessories and or changes that the tools may have required.

Topic 3: Machine Operation

Suggested Teaching and Assessment Strategies

Activation

- Students could research a particular power tool and how it has evolved from the hand tool it replaced. The research could include the various iterations of the change and how the final product evolved. A short presentation to the class on this research could also be done by the student.

Connection

- Students could compare and contrast the various types of general maintenance required for power tools to those required for non-powered hand tools. This could be completed as a chart or entered in their portfolio.

- Students could make a notation in their portfolio indicating the power tools they have qualified to use.

Consolidation

- Students could itemize the various changes that can be made to a power tool to achieve different results. This could include but not be limited to:
    - changing bits,
    - changing blades,
    - adjusting guards,
    - adjusting bevels, etc.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Skilled Trades 1201 Curriculum Guide Appendices

Metrology Tools

Drill Press, Planer, Lathe, Table Saw, Scroll Saw, and Band Saw

Wood

Topic 4: Environmental Protection

Outcomes

Students will be expected to

2.4.1 explain the proper disposal methods for waste material from the fabrication lab. (5.402, 5.403)

Focus for Learning

Teacher Preparation

Waste disposal is becoming a pressing environmental problem. The remaining capacity of many of the domestic landfill sites in Newfoundland and Labrador is not adequate to handle expected future volumes of waste. In addition, the traditional use of incinerators is no longer a viable option given the toxic fumes generated during burning of waste products. This has resulted in an increased emphasis on recycling of paper, cardboard, beverage containers and other products such as tires.

The teacher should discuss with the student the general concern with pollution from processing material and the processing machinery itself. An application to the disposal of the waste from shop operations can be used.

A misconception of most people is that because wood is a natural product, disposing of it in the landfill is not a bad thing. Wood will decompose over time, but still takes a significant amount of space to do so. As well, some of the woods used in fabrication, such as plywood, have resins and glues within them that delay decomposition. Wood preservatives, which are used in wood fabrication, also have issues with disposal. Everything from the wood stain used on a project up to an including pressure treated materials have varying degrees of impact on the environment. Finding a way to reduce this waste will not only save the environment but save cost in the fabrication process as well. Reference to the previous section on tolerancing will help make this point clear.

Sample Performance Indicator

The students could identify the waste products produced in either the shop or the school cafeteria and identify current disposal methods. This list should include not only the waste from the material but pollution caused by operation and service of the processing machinery.

Topic 4: Environmental Protection

Suggested Teaching and Assessment Strategies

Activation/Connection

- Students could research the state of the land fills in their area, and the programs in place to reduce the amount of waste going into them. During discussion they could develop some ideas as to how to divert more waste and how individuals could do so in their own houses. A presentation on this topic could be made to the class as a whole. Research/Paper and pencil

Consolidation

- Students could make a list of the materials that are waste products in the fabrication lab. Alternate methods of disposal rather than simply discarding it should be discussed and developed. An extension of this activity could be to send the students to other parts of the school involved in fabrication (the art room, the cafeteria), assess their amount of waste and help to develop programs that will reduce this as well.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 4: Environmental Protection

Outcomes

Students will be expected to

2.4.2 identify recycling and reuse opportunities for production waste from the fabrication lab. (5.401, 5.402, 5.403]

Focus for Learning

Teacher Preparation

One way to lower disposal costs of waste products and to minimize environmental impacts is to recycle and re–use. The most obvious example of recycling is in the beverage container industry where containers are collected, cleaned, relabeled and re-used. Rubber products such as tires can be reused as blasting mats or shredded and used as an ingredient in roof shingles.

Reducing the amount of waste produced is also significant in reducing environmental impacts. In many cases, this involves finding a market for byproducts formed during product processing that would otherwise be sent to the landfill. For example, the offal produced during the processing of ground-fish can be used to produce fertilizer for gardens. Sawdust from sawmills that was traditionally dumped into landfills can be used to fire boilers.

The teacher should discuss with the students the recycling and re–use of some common products such as beverage containers, tires, batteries and used oil. A list of the recycling companies in the province should be provided to the students.

Discussion of how individuals can have an impact in this area should also take place. Students should be referred to the sections dealing with planning and tolerancing so that they can now see that one of the other reasons for accuracy and precision in planning is to insure the least of amount of material is wasted. Also the multiple use of smaller stock is projects will allow for smaller pieces to be used effectively reusing a single piece of stock. This not only saves funds during fabrication but also will have an environmental impact as well.

The depth of treatment could include actually implementing suggestions from students on how to reduce, reuse and recycle within the fabrication room.

Sample Performance Indicator

Students will identify possible recycle/reuse opportunities for the waste generated in a local fabrication enterprise.

Topic 4: Environmental Protection

Suggested Teaching and Assessment Strategies

Activation/Connection

- Students could research the state of the land fills in their area, and the programs in place to reduce the amount of waste going into them. During discussion they could develop some ideas as to how to recycle and reuse to divert more waste and how individuals could do so in their own houses. A presentation on this topic could be made to the class as a whole.

Consolidation

- Students could make a list of the materials that are waste products in the fabrication lab. Products that can be reused and or recycled should be identified and methods of diversion should be discussed and developed. An extension of this activity could be to send the students to other parts of the school involved in fabrication (the art room, the cafeteria), assess their amount of waste and help to develop programs that will divert some of this as well. This can be presented as a report, a poster to engage students in the activity or a presentation to school staff on the possibilities.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

List of recycling facilities in Newfoundland and Labrador.

Topic 5: Shop Related Careers

Outcomes

Students will be expected to

2.5.1 identify the various job roles and educational requirements to support design and fabrication in industry. [4.401]

Focus for Learning

Teacher Preparation

In any processing facility there are people who are directly involved in the processing operation and those that support those operations. In a typical industrial plant this could include:

- millwrights,
- plumbers,
- electricians,
- carpenters,
- production technicians,
- technologists,
- safety officers, and
- engineers.

The teacher should take a local industry and get a list of the human resources used in the production of the product. The teacher can then take this list and discuss the function of various trades and other technical people who support the processing of the product. A guest speaker who works at the local plant could be invited to speak to the students.

Similarly, a job advertisement for a plant occupation could provide information that can be used to meet this outcome. Students could compare the activities and job descriptions with their own interests and see if a job in design and fabrication would be right for them.

Sample Performance Indicator

Students will interview a guest speaker/individual from industry. Ideally, this person should be a tradesperson, draftsperson, technician, technologist or engineer who deals daily with design and fabrication. The interview should be recorded in their portfolio.

Topic 5: Shop Related Careers

Suggested Teaching and Assessment Strategies

Activation

- Students could research the college system in Newfoundland and Labrador. When doing so they should consider the programs and locations offered through the public system and the programs and locations offered through the private system.

Connection

- Students could research the educational requirements for all the shop positions listed. When listing the educational requirements, special attention should be paid to those programs that are offered in or near the hometown of the student.

Consolidation

- Students could research the educational and training requirements for one of the positions listed. They should then create a career profile for this position which could be presented to the class or posted in the fabrication lab in some manner. The profile should include:

    educational requirements;

    type of work;

    expected training costs;

    expected salary;

    hiring outlook.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Guest Speaker

Career Education Resources

Skilled Trades a Career you Can Build on

Design and Fabrication 1202

Teacher's Resource Guide

Guest Speaker

Unit 3
Introduction to Fabrication Lab Practices

Purpose

This unit introduces students to shop practices and their interrelation to design. Students explore the physical properties of common metals, wood and plastics and the role that these play in material selection, production and disposal of products. This is presented through the following unit topics:

- **Topic 1:** Material Types and Properties (4 hours)
- **Topic 2:** The Production Environment (4 hours)
- **Topic 3:** Processing of Materials (8 hours)

Generally, the purpose of doing a product design is to eventually fabricate a physical product for the end user. The transition from design blueprint to the final product often requires that various materials be selected, processed and then fabricated. The student has to be aware of selection criteria, processing methods and fabrication techniques in choosing materials for product manufacture.

Profile

In this unit the student will be introduced to the physical/mechanical properties of wood, common metals and plastic. The student will explore how these properties affect the cost, function and the required manufacturing processes. They will also see the effect of proper material selection and processing on quality assurance and costing of the final product. The use of work standards, production planning and production related careers are also overviewed.

Implementation

Unit 3 applies the information from Unit 1 to connect the theory to practice. The teacher will have to apply the design principles covered in Unit 1 and demonstrate the processing tools and equipment available to students to construct a prototype. This unit contains material that will require outside resources such as guest speakers and/or field trips. These should be arranged prior to starting the unit.
Unit 1 consists of 10 hrs of instruction, which represents approximately 9% of the total course teaching time.

Evaluation

Unit 3 includes 17 hours of instruction and represents approximately 15 % of the total course time.

Evaluation particulars are provided in the Teacher Resource Guide.

Suggested Timeline

The timeline indicated below is a guideline for the teacher.

Topic 1: Material Types and Properties (4 hours)

- SCO 3.1.1
- SCO 3.1.2
- SCO 3.1.3
- SCO 3.1.4

T opic 2: The Production Environment (4 hours)

- SCO 3.2.1
- SCO 3.2.2

Topic 3: Processing of Materials (8 hours)

- SCO 3.3.1
- SCO 3.3.2
- SCO 3.3.3
- SCO 3.3.4
- SCO 3.3.5

Topic 1: Material Types and Properties

Outcomes

Students will be expected to

3.1.1 identify the common materials available for fabrication. [1.403]

Delineation:

Materials should include:

- Wood
- Sheet Metal
- Plastic

Focus for Learning

Teacher Preparation
This outcome is designed to provide students with an opportunity to physically examine common types of wood, metals and plastics. A quick brainstorm with the class should create a list of what materials are available commonly for fabrication. The teacher could prepare samples of local wood species including fir, spruce and larch along with common building species from other parts of Canada. A sample of exotic woods used in decorative engineering applications will also be prepared by the teacher. The teacher could also conduct simple demonstrations to illustrate physical properties.

This is purely a demonstrative activity, depth of treatment should only include materials that are readily available for use in fabrication.

Within the fabrication lab, aluminum and sheet metal would be the more common, and readily accessible with regards to metals, while common thermo-setting and thermo-plastic samples including ABS and polypropylene would be most likely to be used in some regards within fabrication.

Demonstrations of other materials can occur but would be more of an extension than a set activity.

Performance Indicator
Students will examine simple products composed of wood, metal, and/or plastic and suggest why a particular material was used in each case.

Topic 1: Material Types and Properties

Sample Teaching and Assessment Strategies

Activation

- Students could discuss and examines the various material types. In groups they should determine what sorts of products could be made from each material, and how some materials could be substituted for others having the same basic qualities.

Connection

- Students could research and prepare a presentation on one of the common materials available for fabrication. It is suggested that this be done in groups and that each group take a different material for presentation. Each presentation could include:
- Type of material
- Uses in Fabrication
- Costs of use
- Pros and cons

- Students could put the information they gather on the various materials in their design portfolio

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Samples of wood, metal, and plastic

Topic 1: Material Types and Properties

Outcomes

Students will be expected to

3.1.2 define the key physical/mechanical properties of materials. [1.403]

Materials should include:

- Wood
- Sheet Metal
- Plastic

Focus for Learning

Teacher Preparation

Physical/mechanical properties of material should be differentiated from chemical properties. Physical properties include but are not limited to density, boiling point, melting point, hardness, conductivity, and magnetic properties. Mechanical properties include but are not limited to rigidity (malleability), strength (stress) and elongation. When discussing or researching materials these are the properties that should be looked at.

The physical/mechanical properties of materials are essential considerations in the selection of materials for product design and application. The teacher should define these properties and then relate them to product application. This can be accomplished through demonstrations using the materials in the previous topic. Students should be directed to reference sources for determining physical properties of materials. The teacher could discuss the relationship of material cost, supply and workability to the physical/mechanical properties.

In the previous section the students were introduced to a variety of different materials and their uses. The basic physical and mechanical properties of each of those materials determine what they are best for in fabrication and are a key element in the design of products. In some instances the physical properties may make the material perfect and inappropriate at the same time. In later outcomes we will discuss the properties and the environmental considerations.

Suggested Student Activity

Students could perform simple lab tests on wood, metal and plastic stock to compare mechanical properties. The simple tests, qualitative in nature, could include bending, stretching, impact and marring. Students could document lab results, analysis and conclusions for review by the teacher.

Topic 1: Material Types and Properties

Sample Teaching and Assessment Strategies

Activation

- Students could identify certain of the physical and mechanical properties and present on them to the class. Each presentation should include an explanation of the property and what effect it could have in a fabrication.

Consolidation

- Students could perform tests on the materials discussed in the first outcome and determine for the most part the physical properties of that material. These should be listed in a table within their portfolios.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Samples of wood, metal, and plastic

Topic 1: Material Types and Properties

Outcomes

Students will be expected to

3.1.3 explain the relationship between material properties and end-product specifications and limitations. [1.403]

Focus for Learning

Teacher Preparation
The method used to process a material into a finished shape depends on the properties of the material. Iron, for example, is easily cast and can hold heat with very little distortion. Aluminum, on the other hand, is not generally suitable for high heat applications. Because aluminum is more ductile then steel, it can be fabricated much easier and into more intricate shapes. The lower weight of aluminum allows for its application to situations that require low weight to strength ratios.

The teacher should discuss general processing methods for wood, metals and plastics with students. Examples of common products such as engines or snow shovels can be used to illustrate the application of material to the products. At this stage the teacher can relate the material choice back to the design process covered in Unit 1.

Application and property should be put into a single table. This table then could have the application listed next to the property. For example for high heat applications as listed above each physical property that applies to that application would be listed next to it.

Common product properties for example are:
- lightweight/heavy
- rigid/malleable
- retains heat/dissipates heat
- conductive/insulative
- magnetic/non-magnetic

This outcome should also be discussed with the next and the previous outcome in mind. The four outcomes can be taught concurrently in a series of lessons.

Performance Indicator
Students will review existing product designs and suggest improvements related to material selection. Students will share findings in a class discussion.

Topic 1: Material Types and Properties

Sample Teaching and Assessment Strategies

Activation

- Students could research a single product from a list supplied by the teacher. This research will look at the various materials used in the product, the physical properties and why the materials were probably used. Suggestions for different materials with similar properties should be made. A class presentation of some sort (presentation, poster, model) could be made.

Consolidation

- Students could create a chart that lists each of the material types they have been looking at. The chart would include the physical properties and the possible applications that the material would be most appropriate for. This could be placed in their portfolio.

Resources and Notes

Design and Fabrication 1202
Teacher's Resource Guide

Topic 1: Material Types and Properties

Outcomes

Students will be expected to

3.1.4 explain the relationship of material type and properties to environmental impact. [5.402, 5.403]

Focus for Learning

Teacher Preparation

The production, processing and disposal of every material has an environmental impact. The production of wood, for example, can have a serious impact on the environment depending on the harvesting method. The student must be aware that the choice of material used in the design can cause severe environmental impact during production, fabrication and ultimate disposal of the product at the end of its life cycle.

A useful introduction for this outcome is a brainstorm or class discussion activity. The use of common products such as computer hardware to illustrate the rate of consumption of product and the problem associated with disposal of computer components. Students could bring in other examples which can include products that are recyclable. Rubber tires, for example, can be shredded and used to produce roofing shingles. Products used in processing operations such as vegetable oils can be used to power diesel engines. The economics of using environmentally friendly materials and their effect on health should be discussed.

This is primarily a design issue so discussions of ethical design can take place here. As well discussions of how physical properties can sometimes have environmental impacts should occur. For example the use of pesticides cut down on noxious insects. That same property was one of the problems; as pesticides were injurious to other species such as birds, small mammals and fish. Many municipalities have banned them for home use as a result.

Performance Indicator

Students could analyze a process chart that illustrates the various operations involved in production and identify possible environmental impacts throughout. Group lists could then be reviewed in a class discussion.

Topic 1: Material Types and Properties

Sample Teaching and Assessment Strategies

Activation

- Students should identify and research a material used in fabrication in the past that has lead to environmental issues. In this research emphasis should be placed in the physical property that made the material so attractive for its use and the property that made it an environmental issue. The results of this research should be presented to the class as a whole in some manner

Consolidation

- Using the chart created in the previous outcome, students could list which physical properties could have environmental impacts in the future or even in present situations. This information could be placed in their portfolios.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Sample Products

Topic 2: The Production Environment

Outcomes

Students will be expected to

3.2.1 discuss a production process observed within a manufacturing setting. [1.404, 3.405, 4.401, 4.403]

This observation should occur

- during a field trip,
- during a demonstration of the process by an industry representative, or
- via a narrated video.

Focus for Learning

Teacher Preparation

Within the Skilled Trades and Technology program the emphasis on learning has been for real-work applications. Relating school-based learning to industry is a focus of the program. It is vital that students appreciate the relationship between theory learned in the classroom and real life applications. An industry field trip provides the opportunity to see this connection.

Field trips would be the best method for meeting this outcome but may not be possible given financial or time constraints. In those instances, a guest speaker, a narrated video or a visit to a college may provide an overview of the process in question. Validation that what students are studying is actually happening in the industrial world is important.

The teacher should discuss with the students the process that they observed during the field trip with particular emphasis on identifying each of the operations, inspections, storages and delays that comprise it.

The teacher should discuss with students the role of tradespersons, technicians, technologists and engineers and their required education. The teacher should also indicate the relationship between these groups and how an individual can move through the different job roles. Ideally, a video of the process should be made during the field trip for later review in the class.

Performance Indicator

Each student can complete a field log outlining the various production operations observed during the field trip and share their findings through classroom discussion. This field log should include: tools used, safety protocol followed, materials used, waste produced, possible environmental impact, and fabrication processes.

Topic 2: The Production Environment

Sample Teaching and Assessment Strategies

Activation/Connection

- Students could research a local industry, by contacting the business in question. They should then make a presentation to the class discussing what the business fabricates, what sorts of people and skills are involved in the process and how it relates to what they are learning. Job options in the future in that industry could also be discussed.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Video made of plant visit

Personal safety equipment for plant visit

Topic 2: The Production Environment

Outcomes

Students will be expected to

3.2.2 state the principles governing methods of measurement, time standards, production costing and production planning. [2.402, 2.404]

Focus for Learning

Teacher Preparation

This outcome is designed to make students aware of what is involved in the planning and production costing for a product. Generally, the approach begins with development of a standard method and cycle time. The student will also be made aware of the basics of planning a production schedule.

The teacher could refer to the field trip/video/college and discuss how there are standards in methods and cycle times. The teacher can relate this to determination of production cost, safety and quality control.

A brainstorming activity may lead students to some of the more common aspects of production planning. These should include:

- lead times
- cycle times
- production capacity,
- production bottlenecks.
- standardization
- tooling
- just in time material delivery

Where possible these should result from interaction with the students and their own ideas and experiences.

Performance Indicator

Students will discuss the production methods that they observed during the plant/college visit. They should also discuss the impact of standardization on cost and product planning.

Topic 2: The Production Environment

Sample Teaching and Assessment Strategies

Activation

- Students could present on the importance of production planning on the fabrication process in industry. During the presentation emphasis should be placed on the common problems in production planning, and how to fix them over time.

Consolidation

- Students could define each of the common terms and relate how they would have an effect in product fabrication. Emphasis should be placed on how decreasing lead and cycle time, reducing bottlenecks and making sure that standardization is in place will reduce production costs.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Video made of plant visit

Topic 3: Processing of Materials

Outcomes

Students will be expected to

3.3.1 demonstrate how differences in material properties affect fabrication during the machining process. (2.401)

Delineation:

Materials should include:

- Wood
- Sheet Metal
- Plastic

Focus for Learning

Teacher Preparation

As indicated earlier in the course the physical/mechanical properties of a material determine its fabrication method. Stainless steel because of its work hardening property (hardens as it deforms) for example, should not be cut using a tubing cutter whereas this is the accepted method for copper.

The same power tool can be used on a variety of materials to demonstrate the effect that the material has on feed, speed, tool wear and production time. These demonstrations will also provide the student with an opportunity to see the physical changes in the material due to heat and deformation. This will reinforce the earlier discussion on physical/mechanical properties.

A discussion with students can take place here around the idea of tools that have specific uses for materials. Certain types of tools have materials restrictions that make them unsuitable for multi-materials use. In the fabrication lab environment certain tools, such as the table saw, are not able to be used with light metals. Few of the tools in the lab can be used with heavier metals.

As well this is a chance to introduce the concept of minor changes to tools to make them suitable for multi-material use. Reversing the blade on a table saw will make it better for cutting rigid plastics, a blade change is also necessary in the bandsaw to make it cut metals and so on.

Performance Indicator

- Students could drill a hole in different materials using the drill press. This will indicate how a tooling change will be necessary for different material types as well as show how one tool can be used for such types. Students could record the information concerning materials processing into their design portfolios.

Topic 3: Processing of Materials

Sample Teaching and Assessment Strategies

Activation

- From a manufacturers website or packaging on the outside of a package of bits/blades students will record the types of material that each bit/blade is designed for. An example is a package of assorted jigsaw blades.

Connection

- Considering the materials being used in the fabrication lab, students could hypothesize which materials would require different tooling and what physical property this results from.

Consolidation

- Students could research the three main types of material used for fabrication in the course, and establish what tools/bits/blades are appropriate for each. This can be recorded in a chart or poster to be displayed in class.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Drill Press

Wood, metal, and plastic samples

Topic 3: Processing of Materials

Outcomes

Students will be expected to

3.3.2 perform basic machine operations for the processing of wood. (1.403, 2.401)

Processes will include:

- boring,
- cutting,
- planing,
- jointing,
- turning, and
- fastening.

Focus for Learning

Teacher Preparation

It is not intended that the student become proficient with the use of power tools to process wood products. What is intended is for them to become familiar with the capability of the equipment and then relate that capability to the design process.

The teacher should demonstrate some basic operations on:

- table saw,
- band saw,
- jointer,
- miter saw and
- hand held power tools,

to demonstrate their use and capability. The teacher should discuss with the students the advantages and disadvantages of each of the tools for different operations. Each of the tools has a specific purpose and their use for other than that purpose should be strictly limited. For example, table saws can rip of cross-cut dimensional lumber, but a miter saw can only cross-cut. Bandsaws and scroll saws should only be used for intricate "scroll" work rather than the heavier ripping and cutting.

It should be noted that before the student can operate this machinery they must qualify in its use. The shop safety section and tool qualification and safety procedures must be completed before students are permitted to use standard hand, portable power, and stationary power tools.

Performance Indicator

Students could perform basic operations using a variety of power tools in the fabrication of the simple design project studied earlier in Topic 4, Unit 1. Each group will be responsible for repeated production of one component and then assemble a single unit after groups exchange components.

Topic 3: Processing of Materials

Sample Teaching and Assessment Strategies

Activation

- Students could research the basic operations of each of the standard hand, portable power, and stationary power tools found in the fabrication lab. In small groups they could present to the class on one tool, its specific uses for wood and the other material it could process.

Connection

- In small groups, students could research the processes used in wood fabrication. Each group could take a process and create a poster on what the process entails.

Consolidation

- Students could make a chart on the different processes of wood fabrication, the different tools that are used, and the basic operations that are necessary for fabrication. In this chart, there will be instance where there are multiple tools for the same process.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Power Tools

Metrology Tools

Wood

Topic 3: Processing of Materials

Outcomes

Students will be expected to

3.3.3 perform basic machine operations for the processing of metal. (1.403, 2.401)

Processes will include:

- shaping,
- boring,
- cutting, and
- fastening.

Focus for Learning

Teacher Preparation
It is not intended that the student become proficient with the use of power tools to process metal products. What is intended is for them to become familiar with the capability of the equipment and then relate that capability to the design process.

The teacher should demonstrate some basic operations on the:

- 3 in 1 metal forming machine,
- metal working hand tools,
- drill press, and
- hand held power tools,

to demonstrate their use and capability. The teacher should discuss with the students the advantages and disadvantages of each of the tools for different operations. Each of the tools has a specific purpose and their use for other than that purpose should be strictly limited.

It should be noted that before the student can operate this machinery they must qualify in its use. The shop safety section and tool qualification and safety procedures must be completed before students are permitted to use standard hand, portable power, and stationary power tools.

Performance Indicator
Students will perform basic operations using a variety of power tools in the fabrication of the simple design project studied earlier in Topic 4, Unit 1. Each group will be responsible for repeated production of one component and then each student will assemble a single bird-house after groups exchange components.

Topic 3: Processing of Materials

Sample Teaching and Assessment Strategies

Activation

- Students could research the basic operations of each of the standard hand, portable power, and stationary power tools found in the fabrication lab. In small groups they could present to the class on one tool, its specific uses for metal and the other material it could process.

Connection

- In small groups, students could research the processes used in metal fabrication. Each group could take a process and create a poster on what the process entails.

Consolidation

- Students could make a chart on the different processes of metal fabrication, the different tools that are used, and the basic operations that are necessary for fabrication. In this chart, there will be instance where there are multiple tools for the same process.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Samples of iron, steel and aluminum

Topic 3: Processing of Materials

Outcomes

Students will be expected to

3.3.4 perform basic machine operations for the processing of plastic. (1.403, 2.401)

Processes will include:

- shaping,
- boring,
- cutting/scoring, and
- fastening.

Focus for Learning

Teacher Preparation

It is not intended that the students become proficient with the use of power tools to process plastic products. What is intended is for them to become familiar with the capability of the equipment and then relate that capability to the design process.

The teacher should demonstrate some basic operations on the:

- plastic strip heater,
- table saw,
- scroll saw,
- band saw,
- drill press,
- miter saw and
- hand held power tools,

to demonstrate their use and capability. The teacher should discuss with the students the advantages and disadvantages of each of the tools for different operations. As well the changes to tooling for each of the power tools should be discussed along with the reasons for such changes. The special requirements caused by heat due to friction should be explained to the student. Each of the tools has a specific purpose and their use for other than that purpose should be strictly limited.

It should be noted that before the student can operate this machinery they must qualify in its use. The shop safety section and tool qualification and safety procedures must be completed before students are permitted to use standard hand, portable power, and stationary power tools.

Performance Indicator

Students will perform basic operations using a variety of power tools in the fabrication of the simple design project studied earlier in Topic 4, Unit 1. Each group will be responsible for repeated production of one component and then assemble a single unit after groups exchange components.

Topic 3: Processing of Materials

Sample Teaching and Assessment Strategies

Activation

- Students could research the basic operations of each of the standard hand, portable power, and stationary power tools found in the fabrication lab. In small groups they could present to the class on one tool, its specific uses for plastic and the other material it could process.

Connection

- In small groups, students could research the processes used in plastic fabrication. Each group could take a process and create a poster on what the process entails.

Consolidation

- Students could make a chart on the different processes of plastic fabrication, the different tools that are used, and the basic operations that are necessary for fabrication. In this chart, there will be instance where there are multiple tools for the same process.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Samples of thermosetting plastics and thermo-plastics

Topic 3: Processing of Materials

Outcomes

Students will be expected to

3.3.5 explain the potential impact of material processing methods on the environment. (5.402, 5.403)

Focus for Learning

Teacher Preparation

The processing or fabrication method has an environmental impact. The amount and type of impact depends on the material itself and how it is processed. One of the more obvious negative environmental impacts is caused by the disposal of spent uranium, that is the by-product of producing electricity with nuclear power. While less dramatic, such an impact also applies to everyday products. Oil, produced from a variety of sources, has impacts from oil spills off shore, improper disposal at home and at work, and by-products produced at the oil sands.

The teacher should discuss the environmental impact from supposedly benign operations such as drilling holes in metal. The cutting oil used when the students drilled holes in the metal samples, for example, must be collected and eventually disposed. The teacher can also use a simple product such as a plastic phone receiver and discuss the emission of plasticizers from the receiver into the air.

Material choice for a product also has an environmental impact. In some instances the use of light metal or plastics is done to reduce costs and or weight. Disposal of excess materials during processing, and disposal of the product after its useful life time is spent will have an effect on the environment. The use of biodegradable alternatives is one way to reduce this waste and has sparked a series of new industries in Canada and around the world.

Performance Indicator

Students could, as an aspect of their design process used in an earlier outcome, identify ways they can reduce wastage in the fabrication of their simple design product, and lessen the impact to the environment at every step.

Topic 3: Processing of Materials

Sample Teaching and Assessment Strategies

Activation/Connection

- Students could develop a process chart for their simple design project, outlining each of the steps of the process, the materials used, the tools required and the by-products and waste products at each stage.

Consolidation

- Students could research a product in common use. The fabrication process for that product should be identified, along with the materials used in its production. A presentation could be made to the class on alternate methods of production and different materials that could be used to make the process and the product more environmentally friendly.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Process chart

Unit 4
Graphical Communications

Purpose

Graphical communications is the interdisciplinary communications method for design and fabrication in industry. This unit is intended to provide students with a basic introduction to technical drawing and the related drafting conventions and standards. Students will learn how to sketch simple engineering drawings and review industrial blueprints required to produce a simple product. The unit includes the following topics:

- **Topic 1:** Lettering and Sketching (2 hours)
- **Topic 2:** 2D Orthographic Views (4 hours)
- **Topic 3:** 3D Pictorial Drawings (1 hour)
- **Topic 4:** Working Drawings (2 hours)
- **Topic 5:** Drafting Related Careers (1 hour)

Profile

The focus will be on hands on work with supporting theory where required. The students will acquire an appreciation for the relationship between working drawings and production.

Implementation

This unit lays the foundation for the following units that concentrate on the application of engineering drawing to the design and fabrication of the design project in Unit 6. Graphical communications, like any written or oral language, is more than a collection of symbols or words. The student has to learn to "think" in that language in order to effectively communicate with other technical personnel who possess the same knowledge and skills.

Evaluation

Unit 4 consists of 10 hours of instruction which represents approximately 9% of the total course teaching time.

Evaluation particulars are provided in the Teacher Resource Guide.

Suggested Timeline

The timeline indicated below is a guideline for the teacher.

Topic 1: Lettering and Sketching (2 hours)
- SCO 4.1.1
- SCO 4.1.2

Topic 2: 2D Orthographic Views (4 hours)
- SCO 4.2.1
- SCO 4.2.2
- SCO 4.2.3
- SCO 4.2.4

Topic 3: 3D Pictorial Drawings (1 hour)
- SCO 4.3.1
- SCO 4.3.2

Topic 4: Working Drawings (2 hours)
- SCO 4.4.1
- SCO 4.4.2
- SCO 4.4.3

Topic 5: Drafting Related Careers (1 hour)
- SCO 4.5.1

Topic 1: Lettering and Sketching

Outcomes

Students will be expected to

4.1.1 print gothic lettering in accordance with drafting standards. (1.403, 1.405)

Focus for Learning

Teacher Preparation
The standard lettering style used by technical people in the engineering disciplines is the vertical gothic style of lettering. This style is used for all written communications and on drawings. Vertical gothic is so named because the longest lines are in the vertical direction. There is a set of instructions used to make these letters with specific start points and end points found in the text *Basic Blueprint Reading and Sketching*.

Points to emphasize
- letters are drawn as a series of lines that should be drawn in a specific order
- characters should be uniform and of consistent size
- characters have specific spacing

The teacher will review the novelty and technical styles for lettering and their differences and applications.

Examples of this style of lettering are available online and in most word processing programs. Emphasis should be on having the students draw the lines to start but then identifying where samples can be found.

Performance Indicator
Each student will complete a single page lettering assignment given by the teacher. From this point forward the student will be required to submit any handwritten assignments using gothic style of lettering.

Topic 1: Lettering and Sketching

Suggested Teaching and Assessment Strategies

Activation

- Students could research the origins of the vertical gothic style of lettering and why it is used in engineering and technical drawings. Once the origins are determined a presentation to the class as a whole can be undertaken.

Consolidation

- Students could do a series of lettering assignments using the vertical gothic style of lettering. In these assignments attention should be paid to
    - keeping letters to a 3mm height
    - capitalizing letters so that copies of the drawings will still be legible
    - consistent spacing between letters must be maintained

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Lettering assignment

Unit 35, *Basic Blueprint Reading and Sketching*, Thomas C. Olivo

Topic 1: Lettering and Sketching

Outcomes

Students will be expected to

4.1.2 produce simple single view sketches. (1.403, 1.405)

Focus for Learning

Teacher Preparation

Most technical personnel will have to produce or interpret simple sketches as part of their job requirements. These sketches are used to communicate with others in a variety of departments including maintenance, installation, fabrication, and design. These sketches are often refined using computer aided drafting (CAD) software as finished detail and assembly drawings. It is, therefore, essential that students have the skill to produce simple sketches that are accurate and complete.

Points to emphasize

- mark end points of the lines and draw between them
- draw long lines as a series of short ones
- use grid paper when available
- do not use a straight edge
- do not shade the drawing
- draw neat circles, changing page orientation if needed
- title information (in proper lettering) is required

A demonstration for the students on the basic rules governing free-hand sketching will be required here.

Performance Indicator

Each student will complete a single view sketching assignment using quad paper.

Topic 1: Lettering and Sketching

Suggested Teaching and Assessment Strategies

Activation

- Students could research various methods of sketching in industry. Each student should take a different method, outlining its distinct features, and presenting their results to the class as a whole.

Connection

- Students could copy a drawing in class, using the sketch techniques listed. Once finished they could compare the size, shape and details of their drawing to the original.

- Students could sketch their proposed small fabrication project using free-hand sketching techniques. Once completed it could form the basis of their design.

Consolidation

- Students could sketch a series of objects within the fabrication lab. These objects should only be sketched in 2 dimensions, or on a face. This will lead into the next lesson on orthographics.

Resources and Notes

Design and Fabrication 1202
Teacher's Resource Guide

Quad paper (1/2")
Pencil
Eraser

Basic Blueprint Reading and Sketching, Thomas C. Olivo

Topic 2: 2D Orthographic Views

Outcomes

Students will be expected to

4.2.1 sketch 2D orthographic views of common objects. (1.403, 1.405)

Focus for Learning

Teacher Preparation
Understanding orthographic views and being able to draw them forms the very foundation of technical drawing. Describing a shape accurately so that it can be made or designed is still generally done using orthographic views. There are six orthographic views of an object but the vast majority of objects can be described accurately using less than three views.

Using common objects from the classroom, students could be asked to describe the shape and size of them from their perspective. Following this a review of the theory of orthographic projection and a drawing of the orthographic view of one of the objects on the whiteboard or SMART Board could be demonstrated. Some simple shapes made from styrofoam could be circulated and drawings of the orthographic views required to describe the object could be demonstrated on the whiteboard or SMART Board.

Points to emphasize

- orthographic projections are a collection of 2D drawings
- meant to accurately represent the object
- should contain front, top and side view
- contains three types of lines:
    - object lines - visible features
    - hidden lines - features not visible in current view
    - center lines - to represent symmetry and the center of circles

A demonstration for the students on how to do a simple freehand sketch of orthographic views on quad paper will be required here.

Performance Indicator
Each student will complete a 2D orthographic view sketch of an object shown in a 3D pictorial provided.

Topic 2: 2D Orthographic Views

Suggested Teaching and Assessment Strategies

Activation

- Students could find examples of orthographic projection for engineering, and document how they are used. This could be placed in their portfolio.

Connection

- Students could research the other common projected views used in engineering and fabrication and do a brief presentation on how they are used and their salient features. Two of the views are:
  - oblique
  - perspective

Consolidation

- Students could do an orthographic projection of an object in the fabrication lab. This drawing does not need to include scales or measurements as this is part of the next outcome

Resources and Notes

Design and Fabrication 1202
Teacher's Resource Guide

Quad paper (1/2")
Pencil
Eraser

Styrofoam objects

3D Pictorial Samples

Topic 2: 2D Orthographic Views

Outcomes

Students will be expected to

4.2.2 dimension simple 2D orthographic views. (1.405)

Focus for Learning

Teacher Preparation

The two essentials required to reproduce an object are the necessary orthographic views of the object and the related dimensions. Once the orthographic views are drawn the dimensions have to be applied. Two classes of dimensions, location and size, are used on a technical drawing. There are general rules for the technique and placement of dimensions. As with orthographic projection, you can encounter some very difficult dimension problems on complicated drawings. At this introductory level the drawings are relatively simple and so is the dimensioning.

We will be using unidirectional dimensioning and will use a typical two-view drawing to illustrate and explain the placement of dimensions. We must also explain the relationship of dimension precision to the metrology instruments and the production process. The basic concept of tolerancing will be part of this explanation.

One of the important aspects of dimensioning is the application of a scale. Scale drawings and scale conversions should be explained to the class. It is obvious that scales are used to allow us to draw larger objects in smaller spaces, but in orthographic projections, properly representing the object being drawn require dimensioning and scales.

In some CAD programs this is a feature that must be considered before starting the drawing. In Solid works and similar solid modeling software, dimensions can be added throughout the process and are not a guide or hindrance to the design process.

Suggested Student Activity

The student will dimension their 2D sketch of the object shown in the 3D pictorial from the previous exercise.

Topic 2: 2D Orthographic Views

Suggested Teaching and Assessment Strategies

Activation

- Students should research the proper way to indicate dimensions on an orthographic engineer drawing.

Connection

- Students could prepare a poster for their class indicating and demonstration the proper way to dimension an orthographic drawing. This could be posted in the fabrication or design lab.

Consolidation

- Students could dimension their orthographic views. In doing so they should establish a scale and measure the object accurately and precisely so that their dimensions are useful. This will be good practice for the fabrication section of this course.

Resources and Notes

Design and Fabrication 1202
Teacher's Resource Guide

Quad paper (1/2")
Pencil
Eraser

3D Pictorial Samples

Topic 2: 2D Orthographic Views

Outcomes

Students will be expected to

4.2.3 differentiate between 1st angle and 3rd angle projection. (1.403 1.405)

Focus for Learning

Teacher Preparation
There are two basic systems of orthographic projection used in the world; 1st angle and 3rd angle. Once a person understands one system the other one is easily understood. The analogy is that in Canada we drive on the right hand side of the road while in England they drive on the left hand side. The remainder of the driving rules and required skills are the same. The 3rd angle system is used in most of the world with the exception of England and some Commonwealth countries. The vast majority of drawings that we produce and use in the western hemisphere are 3rd angle.

The only difference between first and third angle projection is the position of the front, side and top views. In Third angle projection the front view lines up with the top view with the side view to its left. In first angle projection the front view is to the left of the side view and the top view found below it. From one perspective it is a more accurate representation of what is being drawn, but not useful for assembly.

A demonstration for the student of a two view drawing using 3rd angle projection and 1st angle drawing would be useful here. A direct comparison between the two would logically follow.

Students could practice drawing both types of projection, and compare what is available in the design software for their use.

Performance Indicator
Each student will complete a blueprint reading exercise on a simple 2D drawing with orthographic views based on 1st angle projection.

Topic 2: 2D Orthographic Views

Suggested Teaching and Assessment Strategies

Activation

- Students could find example 1st and 3rd angle projections and distinguish between the two visually.

Connection

- Students could research the reasons behind the popularity of the third angle projection, and why it has achieved preeminence in most of the world. At the same time, some information could be gathered as to why first angle has not gained such widespread use.

Consolidation

- Students could draw their orthographic view in both the third angle and first angle view. A discussion of which is the more accurate representation of the object could take place at this point. Examples of their first and third angle projections should be placed in their portfolio.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Blueprint Reading 1st and 3rd Angle Projection

http://www.technologystudent.com/index.htm

Topic 2: 2D Orthographic Views

Outcomes

Students will be expected to

4.2.4 determine the required orthographic views for part production. (1.403 1.405)

Focus for Learning

Teacher Preparation

The number of orthographic views required to describe a product so that it can be made depends on the complexity and shape of the product. The vast majority of products can be described in three or fewer views. When drawing the object the first thing that the drafter has to determine is the correct number and orientation of views. This activity is designed to give the student some practice in doing this.

Start with styrofoam shapes from the previous activity for this purpose by asking the students for the views required to draw each object. Following this the a discussion on the criteria used for the proper selection could ensue.

Using more than three views is rare for most products but there are cases when more are required. An example of such a case could be used as a demonstration in class. A variety of styrofoam shapes that may involve more than three views will help to do so. Students could draw the views and discuss why the extra view was necessary.

A variety of metrology tools could be used in this section, such as

- ruler,
- caliper,
- micrometer, and
- measuring tape.

Performance Indicator

Each student will measure the critical dimensions of one of the styrofoam shapes provided by the teacher and then sketch the required orthographic views.

Topic 2: 2D Orthographic Views

Suggested Teaching and Assessment Strategies

Activation

- Students could research the use of orthographic views in engineering and attempt to discover those areas where more than three views for fabrication are often used. This could be presented to the class or put on a poster for placement in the class.

Connection

- Students could explore aspect of Solid Works, specifically determining how many orthographic views are possible within the drawing section of the software.

Consolidation

- Students could draw the orthographic views necessary to re-create a styrofoam shape. This could be done in small groups with one person drawing the shape from the model and others trying to reproduce it without access or seeing the model. In this way, students will experience the reality of the engineering fabrication world.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Styrofoam Shapes

Metrology Tools

SolidWorks 3D Design Software

Topic 3: 3D Pictorial Drawings

Outcomes

Students will be expected to

4.3.1 explain the engineering applications of oblique and isometric 3D views. (1.403 1.405, 2.404)

Focus for Learning

Teacher Preparation

While pictorial drawings are generally not used for the production of parts or products, they are effective for relaying product information to non-technical personnel. 3D exploded assemblies are often used to display products in parts catalogs and instruction manuals. A barbeque assembly manual, for example, will usually contain pictorial drawings that show the relationship of the various parts and the sequence of assembly. Any number of examples should be available and students should be able to find some , snowblower manual, computer desk assembly instructions, any number of Some orthographic drawings such as piping drawings can be complicated and the drafter will include a pictorial to aid with visualization.

- Some views are used to help visualize how products will come together from their component parts.
- 3D views and the ability to manipulate them put significant power into the hands of the designer. Solid Works actually creates 3D views and then develops an isometric, oblique and orthographic view from that 3D drawing.

A demonstration from a parts catalog for a product such as the steering system on a car could be used to illustrate one use of a pictorial drawing.

Performance Indicator

Each student will complete a blueprint reading exercise on 3D oblique and isometric drawings.

Topic 3: 3D Pictorial Drawings

Suggested Teaching and Assessment Strategies

Activation

- Students could research the historical development of oblique and isometric views in engineering and fabrication. A presentation could be made to the class on how the views were developed and the historical use they have had.

Connection

- Students could review the use of oblique and isometric views in engineering and fabrication. Identifying one specific use, students could then research how that use evolved and present to the class where it came from and how it is important within fabrication.

Consolidation

- Within the SolidWorks design software, students could switch between the oblique and isometric views of a sample drawing. A discussion of what they feel such views could be used for in fabrication and engineering could also be a part of this assessment.

Resources and Notes

Design and Fabrication 1202
Teacher's Resource Guide

Blueprint Reading Exercise

SolidWorks 3D Design Software

Topic 3: 3D Pictorial Drawings

Outcomes

Students will be expected to

4.3.2 Sketch a simple oblique and isometric drawing. (1.403 1.405)

Focus for Learning

Teacher Preparation

Drawing a pictorial of an object can be complicated and require a degree of artistic skill, thus in engineering drawing a system of simplified pictorials is used. The most common of these are the oblique and isometric drawings. Both types approximate a visual image while at the same time keeping visual distortion to a minimum. These drawings are also relatively easy to draw needing very little artistic ability.

For assembly, drawings are needed to give:

- the shape of each part,
- the dimensions of each part.
- specifications of material,
- a title on each drawing.
- the relationships of each part, and
- a part list.

Oblique and isometric drawings have a specific use in engineering, helping to accurately represent what the product will look like after assembly. In most cases orthographic views are used in technical drawings, but usually an oblique or isometric drawing is present as well. Also in assembly drawings such views are useful indications of how things will look when all the parts are put together.

An explanation of the differences and applications of the isometric and oblique drawing is required here. As well, a sketch using the proper grid paper for an isometric and oblique drawing of a shop project would be of value.

Performance Indicator

The students will prepare freehand pictorial sketches in isometric and oblique on graph paper supplied by the instructor.

Topic 3: 3D Pictorial Drawings

Suggested Teaching and Assessment Strategies

Activation

- Students could discuss the importance of sketching something by hand versus using a computer program. In this discussion, specific examples of when drawing by hand is called for and when more time can be spent doing a computer rendering. A poster or short presentation board could be made up by each group on this subject.

Connection

- Students could draw an oblique and isometric sketch of an object in the classroom. It is suggested that the object be somewhat simple and the both sketches be drawn of the same object. Review of the sketching points cover in a previous section would be advantageous.

Consolidation

- Students could draw a sketch of the same simple object above in Solid Works. This sketch could then be compared, using the view changes in the program, with the oblique and isometric views drawn by hand.

Resources and Notes

Design and Fabrication 1212 Teacher's Resource Guide

Isometric Grid Paper

SolidWorks 3D Design Software

Topic 4: Working Drawings

Outcomes

Students will be expected to

4.4.1 explain the relationship between working drawings and part production. (1.403, 1.405, 2.404)

Focus for Learning

Teacher Preparation

Before an engineered part can be made, the necessary shape, form and dimension information needed to manufacture it must be known. In the case of assemblies that consist of multiple parts, information regarding part identity and how the various parts fit together is also required. Working drawings provide this information. A "set" of working drawings includes detail drawings, which provide the shape, form and dimension information for each part, and the assembly drawing, which identifies each part and illustrates how parts should fit together.

The drawing produced by the drafter is checked and approved by the project leader before a blueprint is produced and sent to the fabrication personnel. Errors in the blueprint may have drastic implications for cost, production and function. It is essential that all blueprints be carefully reviewed and checked before production begins.

To illustrate this, take the example of the school building. Different contractors completed the construction in stages. The point here is, for instance, that if the bases for the columns were not located correctly then the prefabricated columns, beams and trusses would not have aligned properly.

Performance Indicator

Students will review a set of sample working drawings from industry and identify the fabrication processes required.

Topic 4: Working Drawings

Suggested Teaching and Assessment Strategies

Activation

- Students could research the origins of working drawings and their relationship with part productions. A presentation dealing with how working drawings evolved could be made to the class as a whole.

Connection

- Students could create working drawings of their smaller design project. These working drawings should be used to create at least one aspect of the fabrication project.

Consolidation

- Students could create working drawings as a demonstration of their purpose. Footnotes indicating what they are and why they have been used could be included. These drawings could be put on a poster and displayed on the walls of the fabrication lab or the design lab.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Sample Working Drawings

Topic 4: Working Drawings

Outcomes

Students will be expected to

4.4.2 differentiate between detail and assembly drawings. (1.403, 1.405)

Focus for Learning

Teacher Preparation

Before an engineered part can be made, the necessary shape, form and dimension information needed to manufacture it must be known. In the case of assemblies that consist of multiple parts, information regarding part identity and how the various parts fit together is also required. Working drawings provide this information. A "set" of working drawings includes detail drawings, which provide the shape, form and dimension information for each part, and the assembly drawing, which identifies each part and illustrates how parts should fit together.

Essentially the detail drawing describes in significant detail (hence the name) a part. A set of working drawings for fabrication will usually have a set of these. The assembly drawing shows all parts put together in their operational positions. It is usually, but not always, done in an oblique with each part labelled. For assembly a set of drawings is necessary, usually consisting of:

- a set of detail drawings outlining each part,
- an assembly drawing showing how each part fits together and how the final product looks,
- parts list, and
- other information such as oiling diagrams.

There should be a set of fabrication drawings demonstrating how the detail and assembly drawings interact available at this point.

Performance Indicator

Students will review a set of sample working drawings from industry and identify the fabrication processes required.

Topic 4: Working Drawings

Suggested Teaching and Assessment Strategies

Activation

- Students could research the origins of the detail and assembly drawings. A presentation on these origins and why they were developed could be made to the class as a whole.

Connection

- Students could create detail and assembly drawings of their smaller design project. The assembly drawing could be used in the fabrication of the design project.

Consolidation

- Students could create detail and assembly drawings as examples of what they are used for. With accompanying explanations they could be developed into a poster that could be posted in the lab.

Resources and Notes

Design and Fabrication 1202
Teacher's Resource Guide

Sample Working Drawings

Topic 4: Working Drawings

Outcomes

Students will be expected to

4.4.3 find and select technical information from detail and assembly drawings. (1.403, 1.405)

Focus for Learning

Teacher Preparation

Technical personnel may have to both prepare drawings and work from drawings prepared by others. As with any language, it is important to be able to read and write technical communications. During their careers, technical personnel may be frequently required to read blueprints to retrieve design and fabrication information. It is, therefore, essential that students be able to read and interpret basic technical drawings.

A detail drawing should contain but is not limited to the following information for a specific part:

- shape,
- size,
- type of material,
- surface finish,
- fabrication requirements, and
- the tolerance of the piece (accuracy needed)

All this information should be ascertained from a detail drawing.

Assembly drawings usually indicate which part is where within the assembly and may include some machining operations necessary to complete it. There are also different sub-types of assembly drawings dealing just with sections of the whole assembly, which may require fabrication, or a drawing containing installation instructions.

Students need to be aware of these different types and uses when they are working through a set of drawings to get the information.

Performance Indicator

The student will complete a blueprint reading exercise on working drawings. From this they will need to gather the relevant information, including but not limited to the list itemized above.

Topic 4: Working Drawings

Suggested Teaching and Assessment Strategies

Activation

- Students could list technical information found on detail and assembly drawings. This list could be compared to a standard for the drawings in question to test the veracity of what the students have done.

Connection

- Students could add technical information to their own detail and assembly drawings and edit the drawings they have already created for their smaller design project.

Consolidation

- Students could add technical information to the detail and assembly drawings they have created in poster format. When added the notes on the poster should be updated to show why the various pieces of information are present and how they should be presented.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Blueprint Reading Exercise

Topic 5: Drafting Related Careers

Outcomes

Students will be expected to

4.5.1 identify the various job roles and educational requirements to support engineering drawing production. (4.401)

Focus for Learning

Teacher Preparation

The job roles for technical people involved in engineering drawing can range from a junior drafter to senior engineer. At the entry level the junior drafter is responsible for doing basic level engineering work that is of a repetitive nature and with limited responsibility for decision-making. This individual will copy drawings and make simple detail drawings. The next level would be an intermediate drafter who would be a technologist or junior engineer. This person would be involved in some minor design elements and incorporate these into detail and assembly drawings. The third level would be the senior engineer level where major design and production methods are decided and decisions made on modifications. This level would require that the individual be a professional engineer with associated work experience.

Professional qualifications are required to obtain these levels. Some people in the drawing area stay at the same level throughout their careers while other progress through the levels. A combination of education and experience is required for this progression. Senior technologists and engineers generally enhance their education by taking advantage of industrial education programs in specialized areas. They then enhance that education by working on related projects.

This needs to emphasize to the students that education and experience in industry is a continuous process throughout the career of the individual.

Performance Indicator

Students will interview a guest speaker/individual from industry. Ideally, this person should be a tradesperson, draftsperson, technician, technologist or engineer who deals daily with engineering drawings. The interview should be recorded in their portfolio.

Topic 5: Drafting Related Careers

Suggested Teaching and Assessment Strategies

Activation/Connection

- Students could research one of the job roles required to support engineering drawing production with the focus on what college and or university programs in this province would be able to be taken to gain training in this area. Students could then examine the requirements for entry into these programs and compare them to their own academic standing.

Consolidation

- Students could identify one of the job roles required to support engineering drawing production and develop a career profile. The profile should include but would not be limited to:
  - Education required
  - Training programs
  - Earnings expected
  - Job type
  - Expected duties.

Students could then present these findings to the class as a whole.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Guest Speaker

Unit 5
Introduction to CAD/CAM

Purpose

CAD or Computer Aided Drawing extends on the traditional manual technical drawing method by taking advantage of the advanced capabilities of the computer environment. It allows the drafter to be more productive and accurate in producing and modifying technical drawings. While the performance of the available software packages is very impressive, CAD is still only a tool. The quality of the work done using a CAD system still depends on the knowledge of the drafter in the use of graphics communication.

In industry the CAD system is sometimes linked to a CAM or computer aided manufacturing software system. This combination makes for a complete system from design drawings to actual manufacture of the product. This increases efficiency and gives industry the ability to respond quickly to product changes. It also allows industry to perform low volume and custom production that would otherwise not be cost effective. Operators of these combined systems have to be proficient in both engineering drawing production and manufacturing methods.

This unit introduces students to the basic drawing, modify, and display tools available in conventional CAD software. Students are also given the opportunity to observe the CAD/CAM process including CAD file export, CAM file generation, CNC machine set-up and part production through a teacher demonstration. Several topics are addressed in this unit including:

- Topic 1: Creating Entities (4 hours)
- Topic 2: Display Manipulation (2 hours)
- Topic 3: Modifying Entities (2 hours)
- Topic 4: Dimensioning (3 hours)
- Topic 5: Plotting (1 hour)
- Topic 6: Computer Aided Manufacture (CAM) (4 hours)

Profile

Students will use CAD software to make a simple detail drawing on the computer. They will then dimension the drawing and plot a hardcopy. The drawing for a simple project with then be transferred to CAM software fro eventual part production on a computer numerical control (CNC) machine.

Implementation

This unit is allows the student to progress from a design drawing through to a built prototype. Students develop basic skills in CAD and CAM that are later further developed during completion of the design project in Unit 6. An introduction to the draw, modify and display tools used in conventional CAD software to create engineering drawings is first provided. This is followed by an introduction to CAM which overviews the procedure needed to transfer CAD files to CAM software for eventual production on a Computer Numerical Control (CNC) machine.

Evaluation

Unit 5 consists of 16 hours of instruction which represents approximately 14% of the total course teaching time.

Evaluation particulars are provided in the Teacher Resource Guide.

Suggested Timeline

The timeline indicated below is a guideline for the teacher.

Topic 1: Creating Entities (4 hours)
- SCO 5.1.1
- SCO 5.1.2
- SCO 5.1.3

Topic 2: Display Manipulation (2 hours)
- SCO 5.2.1

Topic 3: Modifying Entities (2 hours)
- SCO 5.3.1

Topic 4: Dimensioning (3 hours)
- SCO 5.4.1
- SCO 5.4.2

Topic 5: Plotting (1 hour)
- SCO 5.5.1
- SCO 5.5.2

Topic 6: Computer Aided Manufacture (CAM) (4 hours)
- SCO 5.6.1
- SCO 5.6.2
- SCO 5.6.3
- SCO 5.6.4

Topic 1: Creating Entities

Outcomes

Students will be expected to

5.1.1 identify the key areas of the CAD interface. (1.403, 1.405)

Focus for Learning

Teacher Preparation

The CAD operator has to be familiar with the CAD interface before learning the methods to create and modify drawings. An overview of the CAD interface should be provided to students including the drawing area, menu areas, status areas, and so on. Key identifiers and related terminology should be introduced at this stage. The optional methods available to execute commands should also be reviewed including the mouse, keyboard, and menus.

The various areas of the CAD interface will be identified for students and they will be introduced to key terminology that will be used throughout the unit. These should include but are not limited to:

- model display window
- contextual menu items
- Feature Manager Design Tree
- Property Manager
- Configuration Manager
- Resources Window
- Design Library Window
- Tool box
- File Explorer

Some of the terms used in this area are:

- axis
- plane
- origin
- face
- edge
- vertex
- extrusion

Performance Indicator

Students should orient themselves to the SolidWorks interfaces by working through a self-directed tutorial. The SolidWorks teacher guide has a series of tutorials for students. As well SolidWorks the program has an interactive tutorial within it. It is suggested to start that students work through the interactive tutorial found in SolidWorks and then work through the teacher guide tutorials.

Topic 1: Creating Entities

Suggested Teaching and Assessment Strategies

Activation

- Students could compare and contrast the various CAD software and how the differ from 3 D modelling software.

Connection

- Students could do a short presentation to the class on one aspect of SolidWorks for the class. In this manner students could become more familiar with the interface.

- Students could work through the first series of tutorials within SolidWorks. These could be either the interactive tutorials or the self-directed tutorials.

Consolidation

- Students could do a quick overview of the tutorials and create a short guide to SolidWorks for new users. This guide could be in print or web format, and should include steps and hints to use these more specifically.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Solid Works - CAD Software

Solid Works Teacher Resource Guide, Unit 1

Topic 1: Creating Entities

Outcomes

Students will be expected to

5.1.2 create basic 2D entities (1.403, 1.405)

Focus for Learning

Teacher Preparation
In CAD, technical drawings are generally developed by drawing and modifying a number of basic elements or entities including lines, circles, arcs, and points. The drafter's first requirement in order to use CAD is the ability to accurately create these basic entities.

SolidWorks is more than a CAD program, although it has CAD elements. SolidWorks is design automation software that creates 3D solids. The solids or models are made up of parts, assemblies and drawings. Using the interface students begin the process by creating the base feature.
Points to emphasize:

- The base feature is a two dimensional drawing that will inevitably become the 3D model through extrusion. It is the first part of the drawing.
- A boss feature adds material to the part and is also created from a 2D drawing.
- A cut feature removes material form a part and is created from a 2D drawing.

In all of these cases the 3 dimensional rendering is created from a 2D entity. Students must be aware of this if they are to be successful in this topic.

A demonstration to the student on how to create these basic entities using the keyboard, mouse and menus is useful here.

Performance Indicator
Each student will complete a tutorial that overviews the CAD tools used to create basic entities. Each student will then develop the CAD drawing for the freehand sketch previously produced in topic 2, Unit 4.

Topic 1: Creating Entities

Suggested Teaching and Assessment Strategies

Activation

- Students could compare and contrast 2 dimensional CAD programs with 3 dimensional CAD products. In this comparison important features such as ease of use, compatibility with systems and cost should be factors.

Connection

- Students could do a quick demonstration of how each of these features occur from a 2 dimensional drawing. In this demonstration each of the three features should be included.

- Students should complete the first set of tutorials assigned by the teacher.

Consolidation

- Students should take the drawing they completed in their simple design project and develop a 3 dimensional feature from it.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Solid Works - CAD Software

Solid Works Teacher Resource Guide, Unit 1

Topic 1: Creating Entities

Outcomes

Students will be expected to

5.1.3 use file management tools for CAD drawings. (1.403, 1.405)

Focus for Learning

Teacher Preparation
When drawings are created in industry they have to be stored, cataloged and retrieved to make changes and copies. The same applies to drawings that are generated using CAD. The student needs to know the importance of keeping control of the original drawing, filing of drawings for easy access, and the retrieval of drawings to make modifications and copies.

An overview of the filing systems of the CAD software is needed to demonstrate how to store a drawing and make a backup. The file management must also include how to create folders and sub folders. The use of the various storage media will also need to be discussed.

Within Solid Works there is a powerful file and folder search option. Files can be found and recovered even if haphazardly saved. This does take time though, and to more parsimoniously use their time, students should set up a distinct folder, sub-folder system along with an intuitive naming convention.

All Solid Works files save in a particular format. For example:

- Parts save as *.sldprt
- Assemblies save as *.sldasm
- Drawings save as *.slddrw

These are the extensions found at the end of the file and introduce a new concept for students, each of these extensions has more than three letters. You can also see the commonalities of the files in question. Each extension starts with the three letters sld (solid) and then three letters logically mated to the file type they are representing (prt for part, asm for assembly, drw for a drawing)

Performance Indicator
Students will complete a self-directed tutorial on file management using Windows Explorer. They will then be required to set up the necessary folders for their design project.

Topic 1: Creating Entities

Suggested Teaching and Assessment Strategies

Activation

- Students should complete the set of tutorials dealing with searches and folder creation available in all version of Windows.

Connection

- Students could compare and contrast the way Windows Explorer and SolidWorks Explorer find, store and report files. This could be done in a tabular form.

Consolidation

- Students could create a series of folders to be used in the remainder of this course. The folders should have a logical structure, and be placed in an easy to find location. A students network drive would be best.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Solid Works - CAD Software

Solid Works Teacher Resource Guide, Unit 1

Topic 2: Display Manipulation

Outcomes

Students will be expected to

5.2.1 use display tools to manipulate viewpoint of a model. (1.403, 1.405)

Focus for Learning

Teacher Preparation

During and following the creation of entities, the display of the entities may need to modified. Display manipulation in CAD involves using one of a number of commands that to control the size and position of the entities displayed on the monitor. For example, an entity can be displayed at enlarged or reduced scale by using one of several ZOOM commands.

Solid Works has a series of commands dealing with views. Automatically arranging objects or parts into:

- isometric views,
- wire frame,
- oblique,
- oblique shaded and a variety of others.

Students should experiment with all of these views and demonstrate their usefulness. A demonstration of how the display size and position of entities can be changed using the drawing previously developed by the students in topic 1 is useful here.

The entire view menu, which is contextual, should be reviewed in this section. Students should get a feel for how they are used, what they are and how to find them. They should also examine how in some instances views cannot be changed and why.

Performance Indicator

Each student will complete a self-directed tutorial that overviews the display manipulation tools available in SolidWorks.

Topic 2: Display Manipulation

Suggested Teaching and Assessment Strategies

Activation

- Students could research a variety of other CAD programs and through demonstration versions of those programs examine how they handle views of models and parts. Either a class presentation or discussion of how this is done in other programs could be undertaken.

Connection

- Students should complete the set of tutorials dealing with views, and how the menus are contextual.

Consolidation

- Students could create a part or use an existing part and take it through the variety of views available in Solid Works. Demonstration of this mastery for the teacher would fulfill this section of the unit. This could also be linked to outcomes from the previous unit dealing with detail and assembly drawings.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Solid Works - CAD Software

Solid Works Teacher Resource Guide, Unit 1

Topic 3: Modifying Entities

Outcomes

Students will be expected to

5.3.1 edit existing entities using available modify tools. (1.403, 1.405)

Focus for Learning

Teacher Preparation

During the construction of a drawing, entities have to be edited or modified. CAD software provides several commands that allow for efficient and quick editing. This is one of the advantages of using CAD.

Within SolidWorks the 2 D entity created to start a 3 D model or part, is the basis for the remainder of the design process within this program. A solid entity is created from the 2 D sketch and significant modification is fairly difficult. The base feature would have to be changed and that would require to a certain extent a restart of the whole process. Simple things such as dimensions can be modified at any time. The Smart Dimension command will allow for this to occur at any time whether in sketch or 2 dimensions, or 3 dimensions. This is one of the major differences between SolidWorks and other 2 D CAD programs.

Using the Edit command and other methods the teacher could demonstrate how the student can edit an entity created in CAD. A demonstration of the use of the Smart Dimension command within SolidWorks is useful here. The various uses for this command should be explored in some detail.

Performance Indicator

Students will individually complete a self-directed tutorial that overviews the commonly used modify tools in SolidWorks. They will then be required to apply some of the modify commands learned in the completion of a simple 2D drawing exercise.

Topic 3: Modifying Entities

Suggested Teaching and Assessment Strategies

Activation/Connection

- Students could research a variety of other CAD programs and through demonstration versions of those programs examine how they handle views of entities and modifications. Either a class presentation or discussion of how this is done in other programs could be undertaken.

Consolidation

- Students could create a part or use an existing part and take it through the steps necessary to make modifications in Solid Works. Demonstration of this mastery for the teacher would fulfill this section of the unit. This could also be linked to outcomes from the previous unit dealing with detail and assembly drawings.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Solid Works - CAD Software

Solid Works Teacher Resource Guide, Unit 1

Topic 4: Dimensioning

Outcomes

Students will be expected to

5.4.1 place dimensions on 2D CAD sketches (1.403, 1.405)

Focus for Learning

Teacher Preparation

While the sketch views provide the "picture" of the part, the addition of dimensions permits its fabrication. As with manual drawing, the dimensions provide the size and feature location information that fabricators need to make the part. Typical CAD software allows the user to customize the dimensioning features and to place a wide variety of linear and radial type dimensions consistent with good engineering practice.

As discussed in the previous outcome dimensions are one of those aspects that can be changed at almost any time within SolidWorks. The Smart Dimension tool will allow dimensions to be modified or added at any time within the design process. A variety of dimensioning options are open to the designer within this program. The various styles and options will be discussed in the next section

The introduction will involve a demonstration of the style and placement of dimensions by taking a simple 2D CAD sketch and dimensioning it for the students. This could lead to a demonstration of the use of the Smart Dimension command within Solid Works. The various uses for this command should be explored in some detail.

Performance Indicator

Students will individually complete a self-directed tutorial that overviews the commonly used dimension tools in SolidWorks. Each student will then place dimensions on the simple 2D CAD sketch that was developed in topic 1.

Topic 4: Dimensioning

Suggested Teaching and Assessment Strategies

Activation

- Students could research a variety of other CAD programs and through demonstration versions of those programs examine how they handle dimensions. Either a class presentation or discussion of how this is done in other programs could be undertaken.

Connection

- Students should complete the set of tutorials dealing with Smart Dimensioning both for 2 D and 3 D objects.

Consolidation

- Students could create a part or use an existing part and take it through the steps necessary to add and modify dimensions in Solid Works. Demonstration of this mastery for the teacher would fulfill this section of the unit. This could also be linked to outcomes from the previous unit dealing with detail and assembly drawings.

Extension

- Students could Smart Dimension a variety of 2 D shapes within Solid Works. A running log of how this is accomplished should be added to the students portfolio.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Solid Works - CAD Software

Solid Works Teacher Resource Guide, Unit 1-3

Topic 4: Dimensioning

Outcomes

Students will be expected to

5.4.2 create basic dimension styles. (1.403, 1.405)

Focus for Learning

Teacher Preparation

In different technical areas the drafter will use different styles to show the dimensions and notes on a drawing. Styles can also vary for specific applications and industries. The thrust of this activity is to give the student an introduction to dimension styles and how to create them.

Within SolidWorks there are a number of styles that can be affected within the Smart Dimension tool:

- tolerance/precision,
- dimension text,
- witness/leader display,
- primary value,
- display options, and
- break lines.

Each of these could be reviewed by students and an overview of what each can do should be done by the teacher prior to use. The interactive help function, help guides, tutorials and other tools within SolidWorks will help with this instruction. The best way to try them out though is to use them, whether in a real situation or a mock one. Students will become more familiar and more comfortable with their use if they have used them in many different way and many different times.

The main dimension style tools and a demonstration of how a dimension style can be created should be introduced here.

Performance Indicator

Students will individually complete a self-directed tutorial that overviews dimension style tools in CAD. Each student will then create a dimension style for the simple 2D CAD drawing that was developed in topic 1.

Topic 4: Dimensioning

Suggested Teaching and Assessment Strategies

Activation/Connection

- Students could research a variety of other CAD programs and through demonstration versions of those programs examine how they handle dimensions styles and changing of styles. Either a class presentation or discussion of how this is done in other programs could be undertaken.

Consolidation

- Students could create a part or use an existing part and take it through the steps necessary to change dimension styles in Solid Works. Demonstration of this mastery for the teacher would fulfill this section of the unit.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Solid Works - CAD Software

Solid Works Teacher Resource Guide, Unit 1-3

Topic 5: Plotting

Outcomes

Students will be expected to

5.5.1 develop and implement basic page setups for plotting/printing. (1.405)

Delineation

- Students will plot/print a 2D CAD drawing. (1.405)

Focus for Learning

Teacher Preparation

Although a CAD drawing is stored electronically, a hardcopy or plot is still required for reference on-site. Production personnel use the plot or blueprint in the shop during fabrication, while the original file remains under the control of the drawing office. Plotting a drawing requires consideration of the plot scale, the sheet size, and the plotting device. One of the first steps in the plotting process involves setting up the page or specifying the sheet size, plot scale, and printer type. This page setup helps ensure consistent high quality plots.

A demonstration of how to set paper size and its affect on the printing would be useful here.

Performance Indicator

Students will individually complete a self-directed tutorial that overviews plotting in CAD. Each student will then plot the simple 2D CAD drawing that was developed in topic 1 using a page set-up for a letter size plot.

Topic 5: Plotting

Suggested Teaching and Assessment Strategies

Activation

- Students could practice using a variety of print set-up options to prepare their drawing for print. These should be previewed to check for appropriateness for the task at hand.

Connection

- Students could complete the tutorial on printing from the SolidWorks online tutorial.

Consolidation

- Students could print their drawing for placement in their portfolio and review by the instructor. These should be previewed before printing to save paper.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Solid Works - CAD Software

Solid Works Teacher Resource Guide, Unit 1-4

Printer or Plotter capable of processing A3 size paper

Topic 6: Computer Aided Manufacture (CAM)

Outcomes

Students will be expected to

5.6.1 identify the elements of the CAD/CAM/CNC process. [1.403]

Focus for Learning

Teacher Preparation

The elements of CAD/CAM/CNC are what make the process work. Each of the stages uses software that is most appropriate to the work at hand and may be accomplished by specifically trained individuals. The first step is the design, which may start out as a sketch as we discussion early in Unit 4. From this, a rendering in a CAD program is made. This drawing is much more precise than the sketch and includes all of the information necessary to produce the product as a whole.

The CAD drawing completes the first element of the process. The next step is CAM. CAM stands for Computer Aided Manufacturing, and involves a specific program to aid in this endeavour. The CAM package plots the tool paths, defines the tools and basically lays out what will happen on the CNC machine. It usually does this in a graphical form, and may include elements of design in its programming. The CAM package plots how the tools will move, what they will do and how they will do it. It does all that and also converts the end product into what is called G and M code.

G and M code is the language of the CNC machine. G-codes are the codes that position the tool and do the actual work, M-codes manage the machine and T codes are tool-related codes. This is the language the machine talks in.

We have now moved onto the CNC element of the process. The G and M code is transferred to the CNC machine, and the program is ready to run. There are some steps for preparation though. Even though the CAM program has set the tool paths and decided how things will run from there, it does so from a specific zero point. The CNC machine must be “zeroed” to that point before the program can run and the product created. As well the stock must be placed in the proper location and prepared to take the tool. Finally in some CNC machines (such as ours) the proper tool must be placed in the collet. Once that is finished the process is complete and the product is ready to run.

These three elements ultimately combine to create a single process and product.

Performance Indicator

Students could create a process chart to show the steps in this multifaceted process.

Topic 6: Computer Aided Manufacture (CAM)

Suggested Teaching and Assessment Strategies

Activation

- Students could prepare a drawing that could be transferred to a CAM program. This drawing must be in a format that is accepted by the CAM software.

Connection

- Students could research the origins of G and M codes and why they are used in CNC machines. A short presentation to the class or a poster for display could be developed with the information found.

- Students could also research the origin of CNC machining as a whole and discuss the possible reasons it was invented. Comparisons between the CNC available today and in the past should be made.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Solid Works - CAD Software

Topic 6: Computer Aided Manufacture (CAM)

Outcomes

Students will be expected to

5.6.2 demonstrate the process to export CAD files for transfer to CAM software. [1.403, 1.405, 2.402]

Focus for Learning

Teacher Preparation

Although this material is covered in greater detail in the course Design and Fabrication 2202, it was felt that introduction to the material in this course was important to help justify certain aspects of CAD development and to spark interest in the follow-up courses in this area.

While commercial CAM software simplifies the development of part files for control of CNC machines, the traditional machining challenges of determining feed rates, speeds and tool types remain. CAD/CAM operators should, therefore, possess both high level computer skills and advanced machining skills.

Transferring files is not simply a matter of saving the file and opening it in a CAM software. Most of the time, CAM software requires specific file formats or manipulations to allow the CAD files to be read. In most cases some file changes would be required and a close attention to detail when moving from one program and format to another is important. When researching careers in this area, this is why you will find some overlap between the CAD designer and the CAM programmer.

In SolidWorks, transferring the files to a popular CAM package is just a few step process, but once the solid design is transferred to the CAM package a number of short steps are necessary to make it usable. These steps are covered in the MasterCAM tutorial and should be reviewed by students.

Performance Indicator

Working individually, the students will develop the part file for the part introduced in topic 1 follow the steps to export it to a CAM program.

Topic 6: Computer Aided Manufacture (CAM)

Suggested Teaching and Assessment Strategies

Activation

- Students could research a variety of other CAD programs and through demonstration versions of those programs examine how they handle exporting to CAM. Either a class presentation or discussion of how this is done in other programs could be undertaken.

Connection

- Students should complete the set of tutorials dealing with Solid Works to MasterCAM file transfers. Only a print tutorial is available for this section.

Consolidation

- Students could create a part or use an existing part and take it through the steps necessary to export to a CAM program from Solid Works. Demonstration of this mastery for the teacher would fulfill this section of the unit.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Solid Works - CAD Software

Topic 6: Computer Aided Manufacture (CAM)

Outcomes

Students will be expected to

5.6.3 identify various CAM packages that are available for use. [1.403, 1.405, 2.402, 2.403]

Focus for Learning

Teacher Preparation

As discussed in a previous outcome, CAM software translates CAD drawings into code readable by CNC machines. CAM programs can be generic, such that they can be used for many different tasks, or industry specific, such that they can only be used with a set tool choice, a set material choice and a number of other limiting parameters. In either case,

Examples of generic CAM used in schools include but are not limited to:

- Master CAM
- Feature CAM
- Art CAM

These are basic, generic CAM packages that allow a number of CNC machines, tools and materials to be used. They are useful for their adaptability and ease of use.

A variety of other softwares are available, some as demoware and some as freeware. These can be found online. Finding one of these CAM packages, installing it and working with it would be a good student activity in this section.

As well, CAM programs can be industry specific. Guest speakers and a visit to a local business that used CAM and CNC would be a worthwhile activity

Topic 6: Computer Aided Manufacture (CAM)

Suggested Teaching and Assessment Strategies

Activation

- Students could research the variety of CAM softwares available for use and the specific use each could have in industry. A discussion or presentation to the class could occur at this point.

- Students could do a search of CAM software online, finding freeware that is available in this area. A quick view of the software in question and a report on its usefulness could be placed in the students portfolio.

Consolidation

- Students could, using one of the demo or freeware programs, complete a conversion from Solid Works to CAM. The should run through a rudimentary tool path.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Solid Works - CAD Software

Topic 6: Computer Aided Manufacture (CAM)

Outcomes

Students will be expected to

5.6.4 define and describe what is involved in CNC. [1.403, 1.405, 2.402, 2.403]

Focus for Learning

The final step of the CAD/CAM/CNC process is CNC. CNC stands for computer numerically controlled, and effectively means that a device, such as a lathe or router, can be controlled via a series of numerical commands. These commands are the G and M codes we talked about earlier in this unit. Each of these codes is accompanied by a number, and the number tells the CNC machine what to do, where to move, what tool is being used, etc. The power of the CNC machine lies in several factors:

- repeatability - the ability to do the same detail as a fabrication process over and over again with a high degree of precision.
- intricacy - the ability to do work in fine degrees, more intricate than what is possible by doing things by hand
- rapidity - doing intricate work quickly and well

CNC machines have many applications in the industrial world. The simpler lathes and routers (sometimes called 2 and 3 axis machines) used in schools are copies of ones used for making table legs, cupboard doors and ornate wood reliefs. More complex machines, with up to 5 axes (the table moves in 2 dimensions as well), create specialized fittings, elaborate parts and low tolerance tools.

This section is essentially an overview of CNC, giving students a sense of what is involved in the process, what the machines can do, and what types of careers are available to people who have this skill.

Topic 6: Computer Aided Manufacture (CAM)

Suggested Teaching and Assessment Strategies

Activation

- Students could research the variety of CNC machines used in industry and identify them by their movable axes. An assignment on this could be put into the students digital portfolio.

Connection

- Students could research the similarities between CNC and robotics controls. A discussion in class about these similarities could be entertained.

- Students could research the origins and evolution of the CNC/ NC machine. This could be developed into a timeline or as a written assignment passed in by the student or placed in their portfolios.

Consolidation

- Students could examine common items in the fabrication lab and their homes to try and identify things which may have been created using a CNC machine. These examples should be discussed in the class later to check the veracity of the students choices.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Solid Works - CAD Software

Unit 6
The Design Project

Purpose

The purpose of this unit is to allow the students to apply the knowledge and skills that they have acquired in the first five units through the completion of a group design project. The students will simulate the process actually followed in the field from the initial design concept through to development of the physical prototype. This unit will also develop the students' proficiency in the use of CAD through the completion of a set of working drawings and enhance their hands-on skills through the operation of shop equipment during the production and testing of the physical prototype. Unit 6 includes seven main topics as follows:

- **Topic 1:** The Design Portfolio (2 hours)
- **Topic 2:** Defining the Problem (2 hours)
- **Topic 3:** Generating Options (2 hours)
- **Topic 4:** Selecting the Best Option (2 hours)
- **Topic 5:** Developing the Solution (16 hours)
- **Topic 6:** Prototyping and Testing (20 hours)
- **Topic 7:** Evaluation and Redesign (2 hours)

Profile

The product development cycle from the design concept to the physical prototype takes a variety of specialized skills and individuals working as a team. This unit will build on some of the previous group activities that students have done in the course but will give them more exposure to group dynamics as they work together to complete the project. Projects rarely go as smoothly as desired and students will have to learn how to deal with the stresses and frustrations brought on by group decision making and impending deadlines.

The design project will allow the students to fully experience the design process and they will be required to apply both their academic skills through completion of a design portfolio and their shop skills through the building of a physical prototype. The interrelation between design and fabrication is reinforced through this project as students learn by doing that both activities are mutually dependent.

Implementation

Unit 6 represents a synthesis of the first five units. Each topic in this unit corresponds to the main steps in the design process. Topics 1 to 4 focus on the generation of alternative design solutions and the selection of the best option for further development. Topics 5, 6 and 7 focus on development, testing, and refinement of the preferred solution in the form of a physical prototype. Ideally, the entire second term of the course would be dedicated to completion of Unit 6. The teacher can, however, adjust the project scope accordingly if coverage of Units 1-5 extends beyond the recommended durations.

For this introductory design and fabrication course, the design projects should be selected by each group of students from one of several possible projects suggested by the teacher. This will help the teacher to ensure that projects are of reasonable scope and capable of being produced with the available shop resources and within the available timeframe.

Due to the nature of design projects, the teacher will be expected to play the role of facilitator. The teacher will be expected to offer intermittent classroom instruction, formally and informally consult with student groups, and generally manage project activities to ensure that students work within time, budget and physical resource constraints. Students will be expected to supplement class/lab instruction with self-directed study, as each design project will present unique challenges.

Unit 6 consists of 46 hours of instruction and represents approximately 42% of the total course delivery time.

Evaluation particulars are provided in the Teacher Resource Guide.

Unit Overview cont.

Suggested Timeline

The timeline noted below is a guideline for the teacher.

Topic 1: The Design Portfolio (2 hours)
- SCO 6.1.1

Topic 2: Topic 2: Defining the Problem (2 hours)
- SCO 6.2.1
- SCO 6.2.2
- SCO 6.2.3

Topic 3: Generating Options (2 hours)
- SCO 6.3.1

Topic 4: Selecting the best option (2 hours)
- SCO 6.4.1
- SCO 6.4.2

Topic 5: Developing the Solution (16 hours)
- SCO 6.5.1
- SCO 6.5.2

Topic 6: Prototyping and Testing (20 hours)
- SCO 6.6.1
- SCO 6.6.2

Topic 7: Evaluation and Redesign (2 hours)
- SCO 6.7.1
- SCO 6.7.2
- SCO 6.7.3
- SCO 6.7.4

Topic 1: The Design Portfolio

Outcomes

Students will be expected to

6.1.1 list the requirements of the design portfolio. (1.405)

Focus for Learning

Teacher Preparation

The design of a product and the associated activities such as research, meetings, evaluations and so on are ongoing activities and the design team has to keep records. The teacher should explain that students will be required to complete a design portfolio as they progress through the project.

As stated in the Atlantic Canada Foundation document on Technology Education, the design portfolio is essentially a diary of the project progress and contains all relevant information, especially trial and error information. It is used to illustrate the thinking and planning processes that students engage in while developing a technological solution to a problem. Assessment of this process is often indirect, in that the evidence comes from a variety of sources. The value of the portfolio depends on how well it represents this process.

As a first step in developing the design portfolio, the student groups will be required to write a design brief. As stated in the Atlantic Canada Foundation document on Technology Education, the design brief is negotiated between student and teacher and sets the conditions under which the student engages in a design activity. While design professionals are assessed mainly on the solution to the problem, students are assessed mainly on growth in their design capability.

Performance Indicator

Students should prepare the outline for a design portfolio. This outline should contain the design brief, title of the project selected, client (teacher's name), project location, and members of the design team (student group). As the students progress through the unit, their portfolios will be updated as directed by the teacher.

Topic 1: The Design Portfolio

Suggested Teaching and Assessment Strategies

Activation

- Students could research the origins and evolution of the design process. This could entail a written assignment, a presentation to the class or a timeline poster to be displayed.

Connection

- Students could create a graphic to represent the design process. This could be done as a flow-chart to accurately depict the various stages and paths such a process will take.

Consolidation

- Students could begin their design portfolio at this time. This is a separate portfolio from the digital portfolio the students have putting their work into up to this point.

- Students could develop their project ideas at this point. Although the problem statement occurs next, some idea of what the project will entail should be a part of developing the problem statement

- Students will work in small groups to develop the design brief. This will include meetings as a group, interviews with the teacher and is expected to be an ongoing process.

Resources and Notes

Design and Fabrication 1202 Teacher's Resource Guide

Topic 2: Defining the Problem

Outcomes

Students will be expected to

6.2.1 develop a problem statement. (1.401)

Focus for Learning

Teacher Preparation

The development of a problem statement is the initial and probably most important part of the design process. The problem statement focuses the team and delineates the broad parameters of the design process. Any design project is the result of a perceived need for a product. That need may relate to the requirement to upgrade or improve an existing product or system, or to fulfill a consumer requirement for a new system or product.

The need for a product needs to be defined and then development of the problem statement should occur. For example the problem could be posed involving mobility for people who are paraplegic and suggest a need to design and develop a powered wheelchair. After a discussion of the problem and examination of existing systems, they would develop a problem statement indicating what it is that they propose to do to solve the mobility problem.

As an activity, students could also work to define a perceived need. In industry tools such as polls and customer surveys are used as a means to identify new products. In a school sense the students could poll their peers, put out a questionnaire to staff and students or hold focus groups to find out what the school feels is a need. It should be noted that this should be a fairly restrictive process offering a choice of things that students are able to accomplish within the fabrication lab. An example of this would be to develop microwave stands for the cafeteria instead of leaving them on table and taking up more space.

If this is to be a major design project involving the whole class then the scope of what will be done should reflect this. If on the other hand the design project will involve a series of groups then the scope can be significantly reduced.

Performance Indicator

The student groups will develop a problem statement for their chosen design project.

Topic 2: Defining the Problem

Suggested Teaching and Assessment Strategies

Activation

- Students could research other problem-solving approaches (such as the scientific method) and their similarities to the design process. A poster comparing and contrasting these methods could be placed in the Design and Fabrication labs.

Connection

- Students could develop a questionnaire or focus group to discuss with their peers and teachers some things that could be produced to make things better in their school. The results of such a discussion could form the basis of the problem statement.

Consolidation

- Students could put the research and background material they used to develop their problem statement in their design portfolio.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 2: Defining the Problem

Outcomes

Students will be expected to

6.2.2 develop design objectives and related criteria. (1.401, 5.401, 5.402, 5.403)

Focus for Learning

Teacher Preparation

Following the development of a problem statement the design team has to develop a set of measurable objectives that the design must meet. For each objective or design goal, corresponding criteria must be assigned that quantify or qualify the degree to which the objective must be met. For example, the objective "The paraplegic mobile wheelchair design must have sufficient payload capacity" could have the associated criteria "Can accommodate up to 300 lbs payload".

An emphasis on the need for measurable criteria where possible is important. In some cases, quantifying an objective in this manner is not possible and the criteria may be a qualifier. For example, the objective "The paraplegic mobile wheelchair design must be aesthetically pleasing" could have the associated criteria "Must be approved by a review panel comprised of marketing representatives". It should also be noted that objectives are not static and may change as the project progresses.

For the more practical in school projects, the measurable criteria should be determined by the stakeholders, the students and teachers. So if the project is to be microwave stands then there are certain logical things that have to be accomplished. It has to be sturdy enough to hold the microwave, with a large enough top to fit the microwave upon it and so on. The stakeholders in this instance may also look for it to blend into the decor of the cafeteria, have shelves for putting things on etc.

Performance Indicator

The student groups will review a sample listing of objectives/criteria for the powered wheelchair example and then develop the objectives and criteria for their chosen design project. These should be recorded in the design portfolio.

Topic 2: Defining the Problem

Suggested Teaching and Assessment Strategies

Activation

- Students could research a product development and outline the steps concerning the measurable criteria. This research would involve online searching and maybe some industry contact.

Connection

- Students could present their measurable criteria to the class as a whole and take input from group discussions. This will help to refine the criteria and make the process more effective.

Consolidation

- Students could develop general criteria whereby their products can be measured against. This could be done in a large group or small group setting, but should have some teacher input.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 2: Defining the Problem

Outcomes

Students will be expected to

6.2.3 identify design constraints. (1.401)

Focus for Learning

Teacher Preparation

Most design projects have constraints that limit the solution options available to the design team. Constraints are generally classified as physical, cost or time constraints. An example of a physical constraint relating to the paraplegic wheelchair design, for example, would be that the chair must fit through conventional 36" doorways. A cost constraint could be that the wheelchair must retail for less than $2500.00. A time constraint could be that the design project must be completed within 3 months.

These design constraints will have a significant impact on what is finally produced, especially if the project is one suggested by staff and students.

- **Costs**: this will have to be negotiated with the teacher and perhaps the administration. A ballpark figure would be what a commercially made product would cost.
- **Physical:** the final product must be able to fit out the door of the fabrication lab or fit out in pieces. This is a significant design constraint for many things created in this space.
- **Time**: depending on the length of the project this will be limited by the amount of class time and the length of the school year. This can be modified by making time available after school for the completion of certain aspects, but working within constraints is a good practice.

The three types of constraints should be introduced in a discussion and examples supplied where there are physical, cost and time limitations that impact design.

Performance Indicator

The student groups will review a sample listing of constraints for the powered wheelchair example and then identify the constraints on their chosen design project. These should be recorded in the design portfolio.

Topic 2: Defining the Problem

Suggested Teaching and Assessment Strategies

Activation

- Students could research a product development and outline the design constraints involved in this development. This research would involve online searching and maybe some industry contact.

Connection

- Students could present design constraints to the class as a whole and take input from group discussions. This will help to refine the constraints and make the process more effective.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 3: Generating Options

Outcomes

Students will be expected to

6.3.1 develop alternative solutions concepts (1.402, 1.403)

Focus for Learning

Teacher Preparation

When completing a design project, the design team must develop a solution that satisfies as many of the objectives as possible within identified constraints. As they generate possible solutions to the design project, the design team must be cognizant of the objectives, related criteria and constraints. A key consideration at this stage is the importance of meeting each objective in the final solution. Generally, not all objectives are of equal importance and it may even be necessary to omit or revise objectives/criteria as the project proceeds. A number of solutions meeting different objectives/criteria in different ways may be developed. One must be chosen in the end. This is not a bad thing, although choosing which solution is the best may be a time consuming process. As well if the proposed solution does not pass its later review and evaluation an alternative will need to be available for consideration

There are a number of methods such as brainstorming that can be used to help generate alternative solutions to a design problem. Research on existing related technologies is also an important pre-requisite to alternative solution generation. There should be an emphasis on the fact that engineering design is rarely aimed at invention but rather at combining and modifying existing proven technologies.

Performance Indicator

Each student group will brainstorm possible solutions to their chosen design project. The teacher should stress that critique of suggestions by members is not acceptable at this stage in the process. Each group will then be required to summarize the results of their brainstorming session to the class. Each group will be required to add this summary to the design portfolio.

Topic 3: Generating Options

Suggested Teaching and Assessment Strategies

Activation

- Students could research a product development and develop their own alternative solution. This solution could be produced in a poster format and displayed in the design and fabrication area.

Consolidation

- Students could put alternative solutions in their design portfolio. It is important for this to be done so that if an alternative solution is needed there will be a good record of it.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 4: Selecting the Best Option

Outcomes

Students will be expected to

6.4.1 evaluate alternative solutions in terms of design objectives. (1.403, 1.404)

Focus for Learning

Teacher Preparation

During a design project the design team will generate several possible solutions to the problem. The next stage in the process is determining how well each of the solutions meets each of the objectives. Each objective has a degree of importance in the solution of the problem. For example, in the paraplegic wheelchair design project the weight restrictions would be of more importance than the aesthetics. When listing the objectives and the associated criteria, the design team should attach a weighting system that reflects the importance of each objective. The use of a decision matrix in selecting the solution that appears to be the best option for further development would be a good instructional strategy.

With the school-based product weighing the design is more a matter of questioning the stakeholders rather than developing it in house as it were. Students and staff should be polled to see which of the design objectives are the most important and which is the least. It is assumed that solutions that are outside the design constraints either costing too much, taking too long or being too large will be disqualified at the beginning of the process. From this weighing students could develop their decision-making model to help to choose the best solution. Once again the rejected solutions should not be discarded as the may become useful at a later stage of the process.

Performance Indicator

Each student group will review a sample decision matrix for the paraplegic wheelchair example. Students will then develop a decision matrix for their chosen project and use it to help select the preferred solution for further development.

Topic 4: Selecting the Best Option

Suggested Teaching and Assessment Strategies

Activation

- Students could poll the school body to determine the weighing of the various objectives. Once doing so, they can then develop a decision-making matrix that can be used to evaluate each proposal and arrive at the best choice. A variety of examples of decision making models are available in the Career Development 2201 teacher's resource and curriculum guide.

Connection

- Students could champion a solution to their problem statement. They could prepare a presentation arguing for their solution and make the case in front of the class or the group that is doing this design. A winner based on the presentation and meeting the other criteria could be chosen.

Consolidation

- Students could put their evaluation and all the materials developed in the process into their design portfolio. This information may be useful at a later date if an alternative solution becomes necessary.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Career Development 2201

Curriculum Guide

Topic 4: Selecting the Best Option

Outcomes

Students will be expected to

6.4.2 select the best alternative. (1.403, 1.404)

Focus for Learning

Teacher Preparation

Selecting the best alternative for a design problem involves picking the alternative that best satisfies all of the objectives. The best option typically scores highest on the decision matrix for objectives and criteria. In some cases, however, the best option may actually incorporate elements of several of the alternative solutions considered.

Choosing the best option requires that students think logically and be confident in their decision-making abilities. The fear of failure may make students reluctant to make decisions and it must be emphasized to them that this uncertainty is a normal part of the design process. They must also learn that information acquired through research and consultation with practitioners is critical to helping them make the correct decision. There is always a possibility of failure but the risk of failure is reduced when students are well-informed in their chosen area of study.

The entire design process could be summed up with the cliche “If at first you don’t succeed...try, try again.” Students should be told that having a solution that is unsuccessful is almost as important as having a working one. Engineers rarely make the correct choices every time and must get used to the idea that every failure adds something to the process. It is possible that a failed solution at this stage may be used later and that elements of all alternatives may end up being part of the final solution.

Performance Indicator

Each student group will select the best solution option for further development and write a brief rationale specifying why this option was chosen. This rationale should be added to the design portfolio.

Topic 4: Selecting the Best Option)

Suggested Teaching and Assessment Strategies

Activation

- Students could research a product development and how the final choice of which alternative solution was best was made. This assignment will involve some online research and maybe questioning of a local industry or design firm. A guest speaker in this area would be a useful addition for this outcome.

Consolidation

- Once a final best solution is decided upon, a discussion of how to bring the best aspects of competing solutions into the process should be undertaken. A presentation of what the best solution entails would be a good starting point, followed up by more brainstorming about how to incorporate other ideas.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 5: Developing the Solution

Outcomes

Students will be expected to

6.5.1 develop a production plan for prototype fabrication. (1.402, 1.403, 2.401, 2.402, and 2.404)

Focus for Learning

Teacher Preparation

A prototype is the first product of a design. It is meticulously crafted and follows the design elements to the letter. It is frequently hand crafted and periodically destroyed/used up by the evaluation process. Sometimes it is to scale and sometimes it is smaller. Producing the prototype is the first step in the fabrication process, which will immediately follow the design process.

Developing a prototype design can be a complicated process involving many different disciplines including personnel from engineering, production, quality control, purchasing, and planning. There should be a class discussion on the importance of developing a plan that lists all required activities with associated timelines and resource requirements.

A production plan involves a series of planning steps

- Materials to be used,
- Processes to be used,
- Tools, equipment and machinery to be used,
- The sequence of production,
- Production scheduling,
- Timing so that prototype can be developed and evaluated and replaced if necessary.

There are a number of planning software packages available to help in this, and something like Microsoft Project, could be used at this point. Some freeware products will also do the same thing and produce the timelines and GANTT charts that will aid in planning.

Performance Indicator

Each student group should review a sample project plan that has been distributed by the teacher. Each group will then develop the plan for their chosen project that lists the key activities and associated timelines in the form of a GANTT chart, as well as the related resource requirements. Spreadsheet or project management software should be used for this if possible. This plan should be added to the design portfolio.

Topic 5: Developing the Solution

Suggested Teaching and Assessment Strategies

Activation

- Students could research the concept of production plan specifically with respect to prototypes. Online research or a visit to a local production facility are two methods that can be used.

Connection

- Students could put their production plan into their design portfolio. It is important that copies are available if something goes wrong with the process so that the plan can be checked to see if the implementation or the plan were at fault.

Consolidation

- Students could develop their own GANTT chart for their production schedule, making sure that each aspect of the fabrication takes place in the required order and timing. This chart will be their guide through the prototype production.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 5: Developing the Solution

Outcomes

Students will be expected to

6.5.2 develop detail and assembly drawings for the prototype. (1.405)

Focus for Learning

Teacher Preparation

As discussed in Unit 4, before an engineered part can be made, the necessary shape, form and dimension information needed to manufacture it must be known. In the case of assemblies that consist of multiple parts, information regarding part identity and how the various parts fit together is also required. Working drawings provide this information. A "set" of working drawings includes detail drawings, which provide the shape, form and dimension information for each part, and the assembly drawing, which identifies each part and illustrates how parts should fit together.

In this case the students, working in small groups, should each develop a detail drawing of their chosen fabrication project. The detail drawings must outline exactly what each of the part will look like. Once these are complete students will work together to develop the assembly drawing. Each part must fit exactly, and the assembly drawing must indicate where each one will reside. The concept of tolerance should enter the discussion at this point, as being too far outside the given parameters will mean an incomplete or ill-fitting part. This is good practical experience for several of the topics found in Unit 4.

As they develop their working drawings, emphasis should be placed on:

- material,
- fabrication methods,
- operator skills,
- time, and
- budget.

Performance Indicator

Each group will develop a set of working drawings, including detail and assembly drawings, for their preferred solution. Some facilitation and minimal instruction would be the preferred method at this time, and students should be taking full control of the design and fabrication of their prototype.

Topic 5: Developing the Solution

Suggested Teaching and Assessment Strategies

Activation

- Students could research the link between assembly drawings and production plans in industry. This research could include online searches, or interviews with production engineers.

Consolidation

- Students could create their detail and assembly drawings using SolidWorks. In this way they will have an opportunity to test their assembly before production. A digital copy of this file could be printed or placed in the students digital portfolio.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 6: Prototyping and Testing

Outcomes

Students will be expected to

6.6.1 fabricate the design prototype. (1.404)

Focus for Learning

Teacher Preparation

For both students and professional designers, this is likely the most exciting stage of the product development process where theory meets reality. Before production starts, the completed working drawings and related calculations should be re-checked for errors. The teacher should emphasize to students that they will undoubtedly encounter problems in translating the design idea to a finished product, and, in some cases, re-design may actually be necessary. Students should also be advised that when they encounter problems during production, they will have to be clearly defined and then a solution found. This will help students to develop problem solving skills.

If a problem is discovered the production must stop. Time has to be taken to work through the problem before production continues. This will impact the production plan, and may even effect the final design. This is where having the competing designs still available may help in making changes.

Assigning jobs for each individual at this point is a good idea. Not everyone can cut, not everyone can nail and etc. Each assigned task, tool or process should have an individual assigned for fabrication. It is understood that all individuals using the fabrication equipment have been checked out on the machinery with regards to safety and have passed the requisite safety test.

Fabrication usually ends with a finish cut or detail and the prototype is no different. The finished product should be pleasing to the eye as well as following the plan as closely as possible. A little sanding, a bit of paint and the prototype is ready for viewing.

Performance Indicator

Each group will develop a physical prototype of their preferred solution. Any design changes deemed necessary during this process should be documented in the design portfolio and the working drawings revised as required.

Topic 6: Prototyping and Testing

Suggested Teaching and Assessment Strategies

Activation

- Students could develop a process for checking the production process at each stage so that errors can be identified and dealt with in a timely fashion. Once this process has been developed it should be shared with the class in a presentation and a discussion could ensue.

Connection

- Students could put an entry into their course portfolio outlining their role in the fabrication process.

Consolidation

- Students could produce their prototype in appropriate sized groups. In each case it is expected that everyone within the group will have an equal share of the work and an equal share in the process. The fabrication should take place in an assembly fashion, with all parts being fabricated before final assembly begins.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Topic 6: Prototyping and Testing

Outcomes

Students will be expected to

6.6.2 test the design prototype for functionality. (1.404)

Focus for Learning

Teacher Preparation

Probably the most exciting part of the design project is testing the physical prototype. As indicated earlier the value of the prototype depends on the extent that it meets or exceeds the original design objectives and criteria. Most designs do not initially meet all of the criteria since there are often unforeseen problems that do not become apparent until after prototype testing. Prototype testing can sometimes require many hours of operation under actual and/or simulated conditions. Following this the design is evaluated and areas of concern identified. Accordingly, the teacher should develop a prototype test procedure that allows students to verify whether or not their design meets functional requirements.

For the simple design of a microwave cart, can you put a microwave on it, plug it in and use it would be a test of functionality. The more complex the device the more complex the test will be as the full range of functionality must be tested.

Testing should be as rigorous as possible. As discussed previously some prototype testing included the ultimate destruction of the object in question. In this case though this would not be a necessary action. Students and the teacher should run their prototype through all the possible avenues, and actions by others.

The results of the testing should be well documented as these will form part of the evaluation process to follow. All observations should be recorded in detail just like an experiment. This is essentially what the testing phase is.

Performance Indicator

Each group will operate and test their prototype in accordance with the teacher's testing requirements. Test results should be recorded in the design portfolio.

Topic 6: Prototyping and Testing

Suggested Teaching and Assessment Strategies

Connection/Consolidation

- As students test their prototype, small inconsistencies or problems may become obvious. Students could identify these problems and work through the design process to solve them. Aspects of unsuccessful competing product designs could be used to solve these problems if necessary.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Prototype Testing Area

Topic 7: Evaluation and Redesign

Outcomes

Students will be expected to

6.7.1 evaluate the prototype in terms of design objectives. (1.404)

Focus for Learning

Teacher Preparation

As indicated earlier the success of the prototype depends on the extent that it meets or exceeds the original design objectives and criteria. Those criteria were established earlier in this unit and should be stored in the design portfolio. A simple yes or no question in each case should be sufficient.

For example, if the students are building microwave carts, the design objectives could be something like this:

- to be on wheels,
- small enough to move through doorways,
- sturdy enough to hold a microwave easily, and
- not be so large as to take up more space than a simple table.

Asking each of these as simple question will determine whether or not each was met.

Design objectives were one part of the determination process, but so were design constraints. Although the chosen design would have had to address these constraints, now that the prototype is finished making sure the constraints have been addressed is also part of the evaluation process.

The constraints were:

- costs - now that the prototype is done a more accurate cost estimate should be available
- time - although the prototype is done very well rather than very quick, an estimate of the time for fabrication should be made
- size - designed size and actual size are sometimes different, the prototype will give the most accurate representation

Performance Indicator

Each student group will evaluate their design prototype by comparing to a check list of the original design objectives, criteria and constraints. Based on this evaluation, students should note areas for improvement. Completed evaluations and noted improvements should be recorded in the design portfolio.

Topic 7: Evaluation and Redesign

Suggested Teaching and Assessment Strategies

Activation

- Students could develop a chart that will allow them to evaluated their prototype properly in terms of design objectives. This chart could be as a group activity and then shared within the class.

Connection

- Students could test their prototype in terms of the design objectives. A simple chart asking each objective as a question and then responding to the question will serve the purpose.

Consolidation

- Students could evaluate their design constraints along with their prototype, discussing whether their constraints were properly formed and created. This can also form the basis of the final evaluation.

Resources and Notes

Design and Fabrication 1212
Student Text

Design and Fabrication 1212
Teacher's Resource Guide

Topic 7: Evaluation and Redesign

Outcomes

Students will be expected to

6.7.2 evaluate the prototype performance based on testing. (1.404)

Focus for Learning

Teacher Preparation

The degree of success of a design is based on how well it meets or exceeds the design objectives. In practice, this assessment involves actual testing of the physical prototype to determine if it functions as intended. There is always room for improvement in a design and any needed improvements should be discovered when the prototype is tested. This is what comes of the evaluation.

An evaluation takes all the observations, all the results, all of the checklists as a whole and makes a definitive conclusion. Sounds much easier that it is really. For this type of evaluation we must fall back onto the beginnings of the process. Look at our problem statement, look at the results of the functionality tests, look at the design and the prototype in terms of these concerns; and make a decision as to whether the tests supported this design or not. We evaluated already in terms of our design objectives, and this will be added to the final decision.

In industry a series of tests are used in the evaluation process, and the results from each are used to form a conclusive pass/fail result. Each of the tasks tests a different aspect of the prototype and even a negative result can have positive implications.

Performance Indicator

Each student group will analyze their prototype test results and compare its performance to that expected from the design objectives and criteria. Areas for improvement should be noted and documented in the design portfolio.

Topic 7: Evaluation and Redesign

Suggested Teaching and Assessment Strategies

Activation

- Students could research the testing done in industry and how the evaluation process uses these results.

Connection

- Students could discuss the results of the testing and the objective evaluation in total and whether there could be a better way to do an evaluation. The discussion could include students suggesting other ways of testing or tests that could have been done but were not to strengthen or weaken the outcome

Consolidation

- Students could determine whether or not their chosen design has passed or failed at this point. If it does not meet enough of the objectives or failed its functionality test then at this point consideration of whether to stick with this design should be made. This could take place in a group or class discussion.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Design Portfolio

Topic 7: Evaluation and Redesign

Outcomes

Students will be expected to

6.7.3 suggest any required modifications. (1.404, 2.403)

Focus for Learning

Teacher Preparation

Since most initial designs do not initially meet all objectives and criteria, there are typically modifications required. Sometimes problems are not apparent until after the product is mass produced and feedback is received from consumers. The teacher should emphasize to students that design problems should be corrected at the earliest possible stage because the potential negative impact on product cost, user safety, and overall product quality increases in severity with each successive step in the design process. The student must also be reminded of the importance of getting objective opinions from 3rd parties, ideally potential end users, and being professional when critiques are offered.

Modifications do not mean that the design is a flop or has to be discarded. This is the main reasons we kept the information from the competing designs, as elements of them could easily be incorporated into the current design. Students are this point have to be reassured that failure of this sort of testing is not the end but only part of the process.

Performance Indicator

Using the results of the design evaluation and prototype testing, the student groups will suggest design modifications that address the areas for improvement previously noted. These efforts are usually aimed at minimizing cost, weight and the number of required components as well as improving the aesthetics of the physical prototype. Suggested modifications should be recorded in the design portfolio.

Topic 7: Evaluation and Redesign

Suggested Teaching and Assessment Strategies

Activation

- Students could research a product in industry that had been modified after prototyping. This very well could include any product on the market, but students should zero in on one that the information is available for. A presentation to the class on the process this product went through should be made.

Connection

- Students could research what occurs when something is missed in the testing and evaluation procedures. The concept of recalls could be discussed at this time.

Consolidation

- Students could discuss the results of the testing and evaluation procedure. Although discarding the design is an option and one which has been discussed before, modification is a much simpler process that would not require as much time and energy. This should be discussed with students as a viable option.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Design Portfolio

Outcomes

Students will be expected to

6.7.4 identify the entrepreneurial opportunities for the project. (4.402)

Focus for Learning

Teacher Preparation

Engineering is the application of science to the solution of practical problems and that is where design work originates. Individuals and groups design products and systems in response to some real or perceived need in society. Engineering consulting firms are generally involved in applying the design process to technical problems with a view to making a profit at the end of the day. There are numerous entrepreneurial opportunities related to design in such areas as selling design concepts, setting up production facilities, establishing distribution networks, product marketing, production system maintenance and material/equipment supply.

Within the school environment students should be asked to extend this thought beyond entrepreneurial consideration. Fund raising could be one such idea, how can we use this design to make funds for the school. Another opportunity, much simpler but more altruistic would be how can we use this design, the processes we have learned to make improvements to our school. The in school design activity would support this. Students could become more involved in the betterment of their school, and in some ways feel pride in their accomplishments and a sense of true belonging.

The teacher should provide local examples of how design supports entrepreneurship.

Performance Indicator

The students should determine the possible sales and other economic opportunities for their project. They should conduct a small market survey to determine the acceptability of their project. The students should generate a list of the direct economic benefits of their project and any potential spin off benefits.

This list should be recorded in the design portfolio.

Topic 7: Evaluation and Redesign

Suggested Teaching and Assessment Strategies

Activation/Connection

- Students could develop a series of questionnaires and polls to give the staff and their peers at their school to identify other projects they could create to help improve their building. These could form the basis of future projects in the Design and Fabrication Lab.

Consolidation

- Students could develop a plan for promoting the entrepreneurial aspects of their product. This could involve discussions with the Enterprise teacher or even with various youth entrepreneur groups such as Junior Achievement of the Y-Enterprise center.

Resources and Notes

Design and Fabrication 1202

Teacher's Resource Guide

Design Portfolio