Drafting Fundamentals Instructor's Guide

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Section

1 INTRODUCTION

This instructor's guide is a basic planning resource for the preparation of daily, monthly, and full-term lesson plans. Chapter by chapter, the guide outlines basic teaching strategies, learning styles, and lesson plan designs. It also discusses teaching strategies for special student populations. Course outlines for six-, nine-, twelve-, and eighteen-week courses are included. Solutions to selected problems presented in the text are given in this guide.

The Textbook

Drafting Fundamentals is a comprehensive introduction to the graphic language of industry and technology. The book is designed to meet the needs of beginning drafting students. It introduces students to modern drafting theory and practice and to career possibilities.

The knowledge gained from an introductory drafting course can be useful throughout life. For students who take further drafting courses, this book provides a sound foundation. For students who do not continue in drafting (often, most students in a class), the book should build confidence in reading and using technical illustrations.

The writing style of the book is explicit and direct. Technical terms are explained and usually illustrated when first used and are printed in boldface type. The more important terms are included in the Glossary, at the end of the book.

The illustrations enhance the language and make the book a visual learning aid. Most of the illustrations show real objects rather than abstract shapes and should be especially helpful to students with reading difficulties.

Reading Level

The reading level of **Drafting Fundamentals** was measured using the Flesch, Dale-Chall, Farr-Jenkins-Patterson, and Danielson-Bryan formulas. Measured against these scales, the book has an eighth-grade reading level.

Use of Color

A second color is used throughout the book to draw attention to instructional points and notes and to emphasize the sequential order of drafting procedures. Curved leaders in color are also used with instructional notes. (Lines and notes printed in green would not normally appear on finished drawings, which are usually completed in black pencil or ink.)

Metrics and ANSI Standards

The dimensioning standards published by the American Society of Mechanical Engineers and recommended in **ANSI Y14.5M-1982** have been incorporated in most illustrations throughout the book. An exception is in the lettering size used in illustrations. ANSI recommends lettering .125" high on drawings up to and including 11" x 17" sheet sizes. Space requirements for illustrations and the reduction of drawings to the printed page would not allow this standard to be followed.

Several practices have been changed by the new standards. However, the student needs to be aware of practices and symbols of earlier standards, as well. The student will see prints that follow the earlier standards and should know how to relate previous conventions to the new standards. Furthermore, the student should surely practice the new ANSI standards.

Illustrations and problems are introduced in both SI metrics and U.S. customary measurements. The students should learn to measure and calculate with metric scales and terms in the same manner as with U.S. customary measurements. The authors suggest that the students avoid "converting" one measurement to another.

Several problem illustrations are shown on a square or isometric grid without dimensions. Usually, each square or division represents 1/4" in U.S. customary measurements and 6 mm in SI metrics. The teacher has the option of requiring U.S. customary or SI metric dimensions.

Career Sketches and Stories about Drafting

Each chapter features a career sketch of a real drafter. The sketches include information about the drafter's job, including preparation needed for the job. The drafter's comments, made during actual interviews, enliven these sketches. The sketches provide career information that should be interesting to students.

Each chapter also has a vignette that presents interesting facts about some aspect of drafting.

Equipment and Supplies

A drafting classroom should include the following basic supplies and equipment.

Drafting desks/tables: one each per student.

Straightedges: T-squares, parallel edges, drafting machines (arm or track). The student should have the use of one or a combination of more than one of the straightedge devices.

Scales: metric, architectural engineer's (one class set of each).

Triangles: 30°-60° and 45° triangles, one per student. Adjustable triangles, as needed.

French curves: one classroom set.

Bow dividers: one classroom set.

Compass: one classroom set.

Trammel points: one set.

Lettering guides (instruments): one per student.

Pencils, pencil pointers, eraser shields, erasers, and pens: individually, per student (as deemed necessary by the teacher).

Blueprint machine: one.

Flat drawer storage cabinet: one six-drawer.

Drawing boards: optional (depending on drawing surface on drafting tables).

Chapter Contents

The following description can serve as a guide in locating topics of interest within the text.

Chapter 1, "The Language of Industry and Technology." The use of drawings; types of drawings; drafting standards; careers; safety.

Chapter 2, "Drafting Equipment." General care; drawing boards and tables; T-squares; triangles; protractors; drafting machines; drawing pencils; drafting media; erasers; compasses; dividers; curves; lettering devices; templates; scales; drawing horizontal, vertical, and inclined lines; circles; arcs; irregular curves; measuring, and drawing to scale.

Chapter 3, "Drafting Geometry." Points and lines; development of angles; triangles; quadrilaterals, polygons, solids, prisms, pyramids and cones; circles; geometric construction.

Chapter 4, "Lettering." ANSI standard letters; numerals; proportions of letters and numerals; letter and word spacing; line spacing; use of lettering instruments.

Chapter 5, "Freehand Sketching." Sketching to scale; line character; techniques of sketching straight lines and arcs; sketching an ellipse; proportions; enlargements and reductions; multiview sketching; pictorial, isometric, and oblique sketching; perspective sketching.

Chapter 6, "Pictorial Drawing: Isometric and Oblique." Isometric axes; isometric drawing of normal, inclined, and oblique surfaces; hidden and center lines; irregular objects; curves and circles; lettering and dimensioning; oblique axes; oblique drawing of normal, inclined, and oblique surfaces; hidden and center lines; irregular objects; curves and circles; oblique dimensioning.

Chapter 7, "Multiview Drawings." Multiview projection; glassbox and hinge line; principal views; view selection; transferring depth dimensions; alphabet of lines; projection of points, lines, and planes; projection of parallel edges and surfaces, and inclined and oblique surfaces; projection of curved edges and surfaces, and cylindrical surfaces; drawing holes, fillets, rounds, and runouts; hidden lines.

Chapter 8, "Dimensioning." Dimensioning fundamentals; extension and dimension lines; leaders; arrowheads; fractional and decimal inch dimensioning; S.I. metric dimensions; placement of dimensions; aligned and unidirectional dimensioning; scales of drawings; dimensioning angles, arcs, cylindrical parts, and holes; tolerances; datums; finish marks; dimensioning curves, rounded ends; use of notes.

Chapter 9, "Sectional Views." Cutting plane; hidden lines; symbols; full section, half section, quarter section, and revolved sectional views; removed sectional view; webbs and ribs; holes; sectioning assembled parts.

Chapter 10, "Auxiliary Views, Revolutions, and Basic Descriptive Geometry." The reference line; function of auxiliary views; classification of auxiliary views; complete and partial auxiliary views; showing curves; the angle between two planes; use of hidden lines; sections; successive auxiliary views; the true size and shape of an inclined surface; a second auxiliary view; the true length of a line; revolutions.

Chapter 11, "Manufacturing Processes and Production Drawings." Woodworking; machine drawings; pattern making and casting; forging; drafting for metal machining and machine parts; detail drawings; assembly drawings; pictorial drawings; sheet metal drafting; welding drafting; electrical drafting; the title block; bill of materials; checking drawings; duplicating drawings.

Chapter 12, "Computer-Aided Drafting." Function and overview of CAD; the plane of coordinates; input devices; common CAD commands; information processing units; software; memory recording devices; output devices; sample CAD program.

THE GOALS OF THE INTRODUCTORY DRAFTING COURSE

II.

Most introductory drafting courses at the secondary level are offered by instructors in industrial arts departments. Students in these courses represent a cross section of the student population. In most cases less than 10 percent of the students may consider drafting as a career. However, the knowledge and skills students learn in the introductory course will serve them throughout their lives. Thus, the goals of the introductory drafting courses may be identified with those of industrial arts.

Over the years industrial arts educators have developed commonly accepted objectives. In 1980, a landmark study was conducted by the "Standards for Industrial Arts Programs" Project at Virginia Polytechnic Institute and State University in Blacksburg. This study reported the objectives of industrial arts chairpersons. Each of these objectives may be applied to the introductory drafting course.

By 1985, a majority of industrial arts educators had agreed on a new direction and emphasis for their profession: technology education. Early that year, the American Industrial Arts Association (now the International Technology Education Association) published the booklet **Technology Education: A Perspective on Implementation.** It defines **technology education** as "a comprehensive, action-based educational program concerned with technical means, their evolution, utilization, and significance; with industry, its organization, personnel, systems, techniques, resources, and products; and their social/cultural impact." It states that "the function of schools [is] to give every student an insight and understanding of the technological nature of the [American] culture."

A technology education program can prepare a student for several possible career goals. Regardless of his or her career choice, technology education will give the student a greater knowledge of the technological world.

Industrial Arts Objectives

The general objectives of industrial arts listed below reflect the goals of technology education. The industrial arts objectives reprinted below are from the 1980 report of survey data from the "Standards for Industrial Arts Programs" project at Virginia Polytechnic Institute and State University.

1. To develop in each student a measure of skill in the use of common tools and machines.
2. To provide general all-around technical knowledge and skills.
3. To discover and to develop creative technical talents in students.
4. To develop worthy leisure-time interests.
5. To develop problem-solving skills relating to materials and processes.
6. To develop an understanding of our technical culture.
7. To help students make informed educational and occupational choices.
8. To develop consumer knowledge and appreciation and use of industrial products.
9. To provide prevocational experience of an intensified nature for those students interested in technical work.
10. To provide vocational training for students who would not otherwise have this opportunity.
11. To develop an understanding of the nature and characteristics of technology.
12. To develop an understanding of the appreciation of science and math.

Technology education can help the student to develop and apply a variety of technical and decision-making abilities. The objectives listed here have been reprinted from **Technology Education: A Perspective on Implementation** (International Technology Education Association, 1985). Technology education can help the student to:

- Know and appreciate the importance of technology.
- Apply tools, materials, processes, and technical concepts safely and efficiently.
- Uncover and develop individual talents.
- Apply problem-solving techniques.
- Apply other school subjects.
- Apply creative abilities.
- Deal with forces that influence the future.
- Adjust to the changing environment.
- Become a wiser consumer.
- Make informed career choices.

Technology educators universally place the introductory drafting course in "Communications," one of the commonly accepted technology "clusters." As Fig. 1-19 of **Drafting Fundamentals** indicates, drafting is a technological subject of major importance. It is a significant activity in the communications network that connects all branches of technology. Without drafting, technology as we know it might not exist.

The drafting instructor should have little difficulty in relating the introductory drafting course to the objectives and goals listed above. The drafting course presented in **Drafting Fundamentals** acquaints the student with the language of industry and technology. It gives the student an exploratory experience in various drafting fields. It also helps the student develop talents for rendering technical graphic illustrations.

II

III. SUGGESTED COURSE OUTLINES

The authors of **Drafting Fundamentals** have arranged each textbook chapter in a way that presents a logical sequence of instruction. It is recognized, though, that each teacher has developed an individual style and method of teaching. Such an approach may dictate that subjects be discussed outside the sequence presented in the text. Also, the time available for the course may require the teacher to shorten the discussion of the essential topics. With such a possibility in mind, the authors present below suggested course outlines for a six-week, nine-week, twelve-week, and eighteen-week course.

The following course outlines are examples of drafting courses set up for these specific time periods. Obviously, not all the material in a chapter needs to be presented.

Six-Week Course

Topic	Chapter	Time
Drafting Equipment	2	2 days
Drafting Geometry	3	3 days
Lettering	4	1 day
Freehand Sketching	5	4 days
Pictorial Drawing	6	2 days
Multiview Drawing	7	3 days
Dimensioning	8	1 day
Working Drawings	11	10 days
Careers	1	2 days
Testing		2 days
		30 days

Nine-Week Course

Topic	Chapter	Time
History	1	1 day
Types of Drawings	1	1 day
Drafting Equipment	2	3 days
Drafting Geometry	3	5 days
Lettering	4	2 days
Sketching	5	5 days
Pictorial Drawing	6	8 days
Multiview Drawing	7	8 days
Dimensioning	8	1 day
Working Drawing	11	8 days
Careers	1	2 days
Testing		1 day
		45 days

Twelve-Week Course

Topic	Chapter	Time
History	1	1 day
Types of Drawings	1	1 day
Careers	1	2 days
Drafting Equipment	2	3 days
Drafting Geometry	3	5 days
Lettering	4	2 days
Sketching	5	5 days
Pictorial Drawing	6	8 days
Multiview Drawing	7	12 days
Dimensioning	8	1 day
Sections	9	3 days
Working Drawing	11	15 days
Testing		2 days
		60 days

Eighteen-Week Course

Topic	Chapter	Time
Graphic Language and Careers	1	2 days
Drafting Equipment	2	5 days
Drafting Geometry	3	5 days
Lettering	4	2 days
Sketching	5	5 days
Pictorial Drawing	6	10 days
Multiview Drawing	7	15 days
Dimensioning	8	3 days
Sections	9	5 days
Auxiliaries and Revolutions	10	5 days
Working Drawing	11	20 days
Computer-Aided Drafting	12	10 days
Testing		3 days
		90 days

PRESENTATION OF LESSON PLANS IV.

The preparation of lesson plans can be the most important task that a teacher must learn to do. This applies to the experienced teacher, as well as the beginning teacher. The preparation and use of good lesson plans can mark the success of a teacher. This task occurs daily and may cover several lessons. One lesson may take one or several class periods. In contrast, several lessons may be taught in one class period.

The lesson design comes before the lesson plan. The lesson plan shows the order of the lesson and how it will be conducted. The lesson design is a statement of what the student is to learn.

A daily lesson plan may include several lessons, each reflecting the lesson design. A one-month or six-week lesson plan can consist of many daily lesson plans. Each of these plans would include lesson design elements.

A good lesson design incorporates learning and retention theories and motivation. Teaching has not taken place unless learning has taken place. In view of this principle, how students learn, how to motivate them to learn, and how to assure that they retain what they learn should be considered when designing and conducting a lesson.

Each lesson will vary in content, presentation, and the time required. All lessons, however, should have several common elements. Treatment of these common elements should be considered when designing a lesson.

Lesson Design Elements

Stage Setting. The teacher should prepare the students for the lesson by setting the stage. For example, we derive more from a book if we know what its setting is. The same is true of a class lesson. Setting the stage should focus the students' attention on what is to be learned. It should take their mind off other things.

Stating the Objectives. Lesson objectives should be stated to the students in meaningful terms. Students will learn better when they know what they are about to learn and why it is necessary.

Presentation. This is the new information that the student must have to meet the objective. Ways to present this information will be described on pages 17-39.

Demonstration. Seeing what is to be done and how it is to be done is an important element in teaching. Proper demonstrations help the student understand the information.

Comprehension. Before asking the students to perform a task that depends on information the teacher has given them, the teacher should check the students' understanding of the information. Merely asking "Are there any questions?" does not check their understanding. (See pages 13-14.)

Assisted Practice. The teacher needs to assist the students in their initial practice of a new skill. This assistance gives the students confidence and catches any errors.

Application. The application of what is learned should be assigned only after the teacher is reasonably sure that the students will not make serious errors. This assurance comes from checking their comprehension and assisting their practice of skills. Students learn **while** doing. Application of their learning is an essential part of the retention and learning process.

Sample Daily Lesson Plan

The following is a sample lesson plan based on the elements of lesson design.

Sections

Stage Setting

(Teacher explains) "You have been drawing multiple views of objects that describe how the object looks as you face its surface. If it wasn't solid, you drew minor details on the inside of the object with hidden lines. Many times an object has many details inside the object. To show all these details with hidden lines would be confusing. This object, which I am holding in my hand, is one such object.

"The best way to indicate the details on the inside of the object is to cut the object in half and remove the outside portion so we can see the inside. The hidden lines are then drawn as object lines."

Stating the Objectives

"1. By the end of the lesson today you will be able to identify and name the different types of sections.
2. You will be able to give reasons for using sectional views.
3. You will be able to identify the material symbols used in sectioning.
4. You will be able to draw cutting planes and sectional views properly."

Presentation

The teacher should discuss the following:

1. Purpose of sectional views.
2. Cutting plane.
3. Symbols used to represent different materials.
4. Placement of sectional views.
5. Types of sectional views
   A. Full section — explain in detail.
   B. Half section — introduce. (Detailed information to be presented in later lesson, after the presentation of full sections.)
   C. Quarter section — same as B.
   D. Revolved section — same as B.
   E. Aligned section — same as B.
   F. Detailed section — same as B.
   G. Removed section — same as B.

Demonstration

Illustrate the drawing of a full section view.

Comprehension

Throughout the presentation and demonstration, check the students' understanding. Ask questions of the class and of certain individuals. If a point has not been learned, reteach it.

Assisted Practice

Draw Problem 9-1. Draw the front, top, and left side view of the shaft's support stand. Draw the left side view as a full section view. The material is cast iron. (The teacher circulates around the room, helping and checking each student's progress.)

Application

Draw Problems 9-2 and 9-5, after reading Chapter 9 through Topic 9-6.

Follow the above lesson with successive similar lessons on other types of sectional views. Continue until the students have covered all the types deemed necessary for the course. The elements of lesson design are incorporated in subsequent lessons. "Setting the stage" may not be necessary each time. You might, for example, state simply, "Yesterday you learned how to draw a full section. Today we will learn how to draw a half section." You have thus set the stage and stated the objectives for the day's lesson.

Sample Long-Range Lesson Plan

The following sample lesson plan may be used to start the school year.

Monday, September 1
A. Orientation of students to course. Statement of classroom rules and teacher's expectations.
B. Discuss list of materials needed.
C. Begin lesson on graphic language.
Tuesday, September 2
A. Finish lesson on graphic language.
B. Check out equipment and supplies.
Wednesday, September 3
A. Lesson on the use and care of drafting equipment.
B. Exercises with drafting equipment.
Thursday, September 4
A. Lesson on the use and care of drafting equipment.
B. Exercises to acquaint students with drafting equipment.
Friday, September 5
A. Review of week's lesson.
B. Practice use of drafting equipment.
Monday, September 8
A. Short test on use of drafting equipment.
B. Practice use of drafting equipment.
Tuesday, September 9
A. Practice use of drafting equipment.
B. Identification test on drafting equipment.
C. Assign reading in Chapter 3.
Wednesday, September 10
A. Lesson 1 on geometric construction.
B. Practice geometric construction.
Thursday, September 11
A. Lesson 2 on geometric construction.
B. Practice geometric construction.
Friday, September 12
A. Lesson 3 on geometric construction.
B. Practice geometric construction.
Monday, September 15
A. Lesson 4 on geometric construction.
B. Practice geometric construction.
C. Review geometric construction.
Tuesday, September 16
A. Practice geometric construction.
B. Test on geometric construction.
C. Assign reading in Chapter 4.
Wednesday, September 17
A. Lesson 1 on lettering.
B. Practice lettering.
Thursday, September 18
A. Lesson 2 on lettering.
B. Practice lettering.
Friday, September 19
A. Lesson 1 on sketching.
B. Practice sketching.

The foregoing three-week, long-range plan should be written. A lesson plan using good lesson design should be written for each lesson.

As well as being the instructor, the teacher is the classroom manager. The teacher is responsible for preparing good lessons and good presentations. He or she should use the best teaching techniques, incorporating contemporary learning theories. The teacher also is responsible for maintaining an updated curriculum. Because technology changes daily, the application of technology, such as drafting, must keep pace. The teacher who relies only on what was learned in college will not present up-to-date information. If teachers want to stay abreast of current trends in drafting technology, they should be involved in the following ways:

1. Attend meetings, miniconferences, and conferences of local, state, and national industrial arts associations.

Read the educational journals that report contemporary ideas and information. Local, state, and national vocational associations are excellent resources.

2. Join the local chapter of the American Institute of Design and Drafting, if one is available. The Institute and its local chapters hold meetings and conferences. They also publish newsletters.
3. Read trade journals on drafting, design, construction, and manufacturing.
4. Organize a drafting advisory committee of people from the community. Such a committee can be most effective in assuring an updated curriculum. They can also help develop and maintain support for the program.

   The advisory committee, made up of three to seven interested citizens, can meet three or four times a year. In their meetings, they should evaluate the curriculum and equipment. They should recommend any changes that need to be made.

TEACHING STRATEGIES FOR A STUDENT-CENTERED CURRICULUM

V

Much has been written about the theory of learning — or how we learn. The teacher constantly needs to keep in mind the many approaches to learning. Students are individuals and they have their own learning styles.

There is a wide range of suitable learning environments. Some students prefer quiet; others prefer noise. Some need to be sitting formally at a desk or table; others study better in a lounge chair. Students in a class learn better if they follow their own individual learning styles. The more the teacher knows about each student's learning style, the better the teacher will be able to meet the student's needs.

Since it is difficult to address each student's individual learning needs, the teacher should use a variety of techniques in performing the teaching task. However, the teacher should set the stage and follow an orderly system as much as possible.

Motivation

Motivation is a teaching technique that needs to be practiced several times a class period. Motivation is influenced by several factors. These include success, interest, feedback, anxiety, and rewards.

Success. The learner is motivated favorably by completing a task. The difficulty of the task needs to be set at the appropriate level. The task, for example, might be easy enough to be completed favorably, hard enough to be challenging, or different from one the learner has attempted before.

Interest. Students are motivated to learn something that interests them. Make the learning experience novel. Relate it to something they know. Use various media, such as film, chalkboard, and cartoons.

Environment. The student needs a pleasant learning environment. Often, this depends on a comfortable and inviting classroom.

Feedback. Students are motivated when they are able to gauge their progress. Positive feedback can motivate students to exceed their own expectations.

Anxiety. Raising or lowering the anxiety level of the students is also a motivating factor. If it is too high, it may interfere with their ability to learn or perform. If they have low anxiety, an "I don't care" attitude may result. Visibility, work standards, time available, and classroom environment can raise or lower a student's level of concern. (Simply moving close to a student can increase anxiety.)

Rewards. Both extrinsic and intrinsic rewards can be motivating to students. An extrinsic reward is, for example, a compliment or a good grade. Intrinsic rewards depend on the student's appraisal of his or her success in a task.

Student clubs and student competitions are also rewarding. Both have been proven to be good motivators.

Retention

A student who learns, but does not remember what has been learned, has not learned well. The probability that a student will retain information can be increased if the teacher is attentive to the factors discussed below.

Relevance. The information to be learned should relate to knowledge or experience that the student already has. The student also needs to understand the purpose of the new knowledge.

Learning Environment. It has been demonstrated that the quality of the learning environment influences retention.

Knowledge Base. A student's knowledge of the material on which new information builds has a direct relationship to how much is remembered. A student who has some prior knowledge of the content will be able to remember more new content than a student with little or no knowledge of the subject.

Practice. Practice in using the new knowledge or skill aids retention. A schedule of regular practice increases the probability of retention. Such practice should begin immediately after the original learning takes place. The practice should then be repeated throughout the year.

Information Transfer. The positive transfer of information already learned helps the student relate the new information to what has already been learned. For example, relating information learned in multiview drawing will help students retain information on auxiliary views.

Questioning Techniques

The teacher needs to gauge each student's grasp of the information as the teaching/learning process progresses. The teacher must constantly be aware of the learner's point of view. Such awareness will help the teacher determine if the learner understands what is being taught. Again, there are several techniques for asking those questions that are needed to evaluate understanding.

Sampling. Ask the class a question. Give students a few minutes to think about the question. Then call on

one of the more able students to answer the question. This should ensure a correct response.

Several wrong answers do not reinforce learning. If it appears that several students do not understand the concept, then the subject needs to be taught again.

Choral. Asking the class to respond in unison may not reveal those students who do not know the answer, but it helps teach them the answer without humiliation.

Signals. The use of hand signals (such as thumbs up or thumbs down) allows students to answer as a group without a lot of noise. Having the students close their eyes before they answer will reveal those who know the correct answer without embarrassing those who do not.

Dignify incorrect answers. Students do not like to appear ignorant. Frequently, students will not respond to a question because they think their answer will be incorrect. A teacher must remove this apprehension from the students. A teacher can use the incorrect answer as an instructional tool. This can be done by supplying a question or statement to which the answer belongs. This technique preserves the line of communication between the teacher and the student.

The teacher may need to "prompt" the student, offering clues to the right answer.

Levels of questions. Varying the degree of difficulty of the questions challenges the student. It also gives the teacher an indication of how much the students understand. The teacher should follow Bloom's descriptions of the cognitive domain to design questions of varying levels, especially for written tests. These questions test the student's knowledge, comprehension, and application, as well as the capabilities for analysis, synthesis, and evaluation. Sample questions are given below.

Knowledge: List in order the three steps in bisecting a given line with a compass.

Comprehension: Describe in your own words how to draw a pentagon inside a given circle.

Application: Tell how someone you know, who is not an engineer or drafter, might use the information in Chapter 9 ("Sectional Views").

Analysis: Summarize Chapter 1 ("The Language of Industry and Technology") in three concise paragraphs.

Synthesis: Design a problem that would require the use of information on auxiliary views for its solution.

Evaluation: Prepare an argument for including Chapter 4 ("Lettering") in the textbook.

Grading Students' Work

Feedback and knowledge of results are important factors in learning and motivation. Work turned in to be graded should receive short turnaround time. The students need to know where they may be falling short of what is expected. They also need to have positive reinforcement of those things they are doing right.

The evaluation of drawings can be very subjective. For example, the grade weight placed on line quality, accuracy, and lettering is subject to study. A close look at the assignment's objective should be the guiding point. If the solution to the problem is the main objective, that should carry more weight. If, however, high-quality line work and lettering are really important for a first-year drafter, the objective, instruction, and assisted practice should be adjusted accordingly.

Uniform marks or a code of marking should help the teacher shorten the turnaround time for grading drawings. The system of marks given below is one of several that might be followed.

Symbols of the Checker

AE Accuracy error (content)
IL Improve lettering
UG Use guidelines
DE Dimensioning error or dimensions missing
CO Centering of drawing is off
VS View size is wrong or the wrong size medium used
IA Improve arrowheads or arrowheads missing
OL Object lines (thick lines) are made poorly
DL Dimension lines (thin lines) are made poorly
TR Time required was too long

Organizing the class with "checkers" similar to those used in industry may also help the grading process. Each student could check another's work, using the "Questions from the Checker" on pages 317 and 318 of the textbook. This activity should assure better work from the students. It also reinforces learning for the student doing the checking.

Exceptional Students

Drafting, a universal language, should be available to all students. All students should experience a degree of success. A typical drafting class may include some gifted and talented students, as well as students with varying learning problems. Each should have rewarding experiences in drafting.

Students who have an aptitude for drafting often become bored and restless with routine teaching methods. Those students should be identified early in the year. They should then be taught with methods different from those normally used. Advanced problems, individual research, and tutoring are three ways to maintain the interest of advanced students at a high level.

Some students may not have the ability to grasp the content as quickly as others. These students also need special attention. Presenting the skill or knowledge in smaller instructional units, adjusting assignments, and allowing extra time may encourage these students.

Some students with the ability to learn facts may have difficulty in drawing. They may not have the manual dexterity to do well in drafting. In contrast, students with learning problems have been known to be quite talented on the drafting board. Students with a gift for acquiring and retaining knowledge have been known to be unable to grasp the special concepts of drafting.

The key to working with all students is to know their limitations and to help them grow from where they are as much as possible. As the teacher, you can make their

drafting experiences rewarding, pleasant, and profitable. Your approach will help to shape their attitude toward drafting.

The handicapped student requires special consideration. Some drafting students have various physical handicaps. They may be visually impaired. They might have hearing problems. Some students may have learning and emotional problems. These students have the same right as other students to solid and well-focused drafting instruction.

Science has developed many devices to help those with motor skill, visual, and hearing problems. Special in-service aids also are available to help teachers work with students who have special problems.

The drafting teacher should be involved in the acceptance of a handicapped student into the drafting program. The drafting teacher should confer with others acquainted with the student. The goals or expected outcomes should be weighed against the realistic possibility of success. The availability of special desks and special drafting equipment should be considered.

An individual education plan (IEP) should be developed with the drafting teacher. This will assure that the goals and objectives of the student are addressed. These goals should be realistic and attainable. In addition, the IEP should contain specific services to be provided to the student, as well as timelines for the completion of objectives and methods of evaluation.

All students deserve the attention of the teacher. The unusually talented student should not be held back and denied educational growth. The student of normal ability should not be ignored. The student with special needs will require special attention. To meet these varied needs, the teacher should organize the class to provide individualized instruction to each of these groups daily.

Individualized instruction can be accomplished with the use of various teaching strategies, used singly or in combination. These include individually paced modules, minilessons for individual groups, and a designated resource/research area equipped with slides, tapes, reference materials, and computers.

Mastery of the lesson design elements and methods of presentations presented earlier in this guide will assist the teacher in meeting the many demands of varied types of students within the class.

Left-Handed Students

A drafting class may have some left-handed students, because left-handers constitute 8 to 10 percent of the student body. There is no reason to deny a left-hander the opportunity to take a drafting course, or become a drafter. Left-handed drafters can be just as competent as right-handed drafters.

For years, manufacturers of drafting machines produced special models for left-handers. These work in a way opposite to the operation of standard machines for right-handed drafters. Looking toward the future, the increased use of computer-aided drafting (CAD) systems by drafting departments will eliminate the difficulties that left-handers have had to overcome with traditional drafting equipment.

In the school drafting room, left-handed students may reverse the T-square and place the head along the right edge of the drafting board. This will allow them to use the equipment in a manner opposite to a right-hander. Left-handers may draw horizontal lines from right to left, slanting the pencil about 5° to the left. They may also place the vertical edge of the triangle to the right and draw vertical lines from bottom to top, slanting the pencil about 5° toward the top, opposite to the way a right-hander slants it. Both of these procedures help left-handers avoid pushing the pencil point into the paper.

Drawing standard inclined or vertical letters by hand is a challenge for left-handed drafters. The order of strokes shown in Chapter 4 of **Drafting Fundamentals** is for right-handers. Each left-hander should experiment with strokes in an opposite direction or reverse order. By doing this, the left-handed drafter can work out a sequence that seems natural. The first objective is to learn and use the correct shapes, sizes, and proportions of letters and their different parts. Another important objective is to draw the letters neatly, making them as clear as possible. If the letters are inclined, they should have a uniform slant. Letters that slant upward and to the right in the traditional direction are difficult for left-handers to draw. Vertical lettering is easier for left-handers to learn and use. Therefore, vertical lettering is highly recommended for left-handers.

Left-handed drafting students sometimes find it easier to draw inclined letters if they slant them upward to the left, rather than to the right. The practice is not totally objectionable. Some industrial drafting departments permit such lettering, provided the letters slant uniformly and are clear to read. When left-handed drafters draw letters in this fashion, there is less chance of their hiding parts of the letters with their pencils or hands. They can then see what they are drawing, and their lettering is better.

Competency-Based Instruction (CBI)

An instructor's guide would not be complete without some discussion of competency-based instruction (CBI). CBI has been researched and piloted for several years. Much has been written on this by-now familiar subject, which is only outlined in this brief discussion. If you want to use this method of instruction, the chapter lesson plans are designed in such a way that they can be easily adapted to the CBI approach.

CBI involves dividing a program of instruction into performance tasks. Each task may be broken down into smaller units, or terminal performance objectives (TPO). Each TPO restates the task and specifies what the student will be expected to accomplish, as well as the performance standard for a criterion examination. Each TPO could involve from one to six microperformance objectives (MPO).

The student accepts the task. The student then proves mastery of the information in the task-learning

guide. This is done by demonstrating the performance of the task and by passing a criterion examination to a previously established level of proficiency. The student accomplishes both objectives within a specified time.

Emphasis is on individualized instruction. A student receives a learning packet or guide for each task. The student then systematically follows the instructions in the learning guide, working at his or her own pace until the task is completed. Satisfactory completion of the task includes a performance exam and criterion exam. If the student fails to perform satisfactorily in the evaluation stage, the student must then reread and restudy the learning guide.

The learning guide or packet includes:

1. A cover sheet with the task name, number, purpose, and prerequisite, if any.
2. A learning contract that includes the terminal performance objective and microperformance objectives, as well as a statement that declares what will be completed in a certain amount of time. The learning contract is signed by the student.
3. The MPO sheets, which include each learning step and the resource (reference) necessary to accomplish the MPO.
4. Activity sheets that support the learning steps.

The design of the following chapter lesson plans lends itself to the development of CBI learning guides. The lesson plans, used in conjunction with the textbook, make good CBI learning packets. Chapter objectives are stated and learning topics are listed throughout the chapter lesson plans.

Advantages and disadvantages to using the CBI approach are listed here. Teachers who use the CBI method indicate that it is well worth the time they spent to get it started in their classes. You should weigh the implications before starting.

Advantages

1. The instructor and student have more one-on-one time together for instruction, especially in a vocational drafting class with fifteen students and two- or three-hour classes. In one-hour classes with twenty to twenty-five students to a class, the instructor will be pressed for time.
2. Good students seem to learn more, retain more, and progress faster than they do with conventional methods of teaching.
3. The program content is written, and may be posted for inspection by students, administrators, board members, parents, and other class visitors.
4. Students progress at their own speed. Their work is judged against an established standard instead of against the work of other students.
5. The instructor is prepared for class and the lesson plans are available for substitute teachers.
6. The program permits an open entry, open exit policy for new students.

Disadvantages

1. The instructor must accomplish a lot of curriculum writing to set up the program.
2. Low achievers and slow-starting students who need to be told everything will have a hard time, especially with the reading and research.
3. A CBI program requires a great amount of record-keeping, filing, and clerical work to keep track of students' progress.
4. Constant evaluation and revision of the tasks is important, to be sure the program is doing what is should and to keep the learning guides up to date.
5. It may take several years of use to "debug" the program.