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AUTHOR Putnam, A. R.; Duelm, Brian
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ABSTRACT

This presentation outlines guidelines for developing and implementing an introductory course in computer-aided drafting (CAD) that is geared toward secondary-level students. The first section of the paper, which deals with content identification and selection, includes lists of mechanical drawing and CAD competencies and a list of rationales for selected competencies from the two preceding lists. Considerations in sequencing the content of the course are also discussed. Addressed in the second part of the paper are the following instructional considerations: purchasing CAD equipment, researching the basic concepts of CAD, having a clear rationale for purchases, forming a selection committee, selecting a CAD system, and negotiating prices. A list of CAD software vendors concludes the presentation. Appendixes to the paper include a lesson plan outline covering four skills addressed in the proposed CAD course. (MN)

PREPARING STUDENTS FOR COMPUTER AIDED DRAFTING (CAD)
A Conceptual Approach

By
A.R. Putnam, Ed.D., Associate Professor
Brian Duelm, Graduate Assistant
Department of Industrial Technology Education
School of Technology
Indiana State University

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of the American Vocational Vocational Association
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Description Phase

Who are we designing instruction for?

Element one: Who is the intended learner; (grade level, etc.)

It is important here to set the level at which we intend to write. In this example, we are going to design for beginning students at the secondary level. This unit could easily be modified for beginning post-secondary students.

Element two: What skills does the learner already have?

In this example, we will assume no previous drafting or computer experience.

Element three: What is the purpose of the class; (entry level employment skills; post-secondary preparation, etc.)

For this example, this class is intended to prepare the student for more advanced courses.

(Place Figure 2 about here)

Content Phase

What instruction are we designing?

We are now ready to determine the content of the course; What are we going to teach and with what intended results?

Element one: Content identification.

This is accomplished by listing possible content items from which we will build the curriculum. A good competency list, validated for the level of the intended learner is the best place to start. For this example we are using: Everly and others, Drafting Competency Based Curriculum, Bureau of Vocational,

Technical, and Adult Education, West Virginia State Department of Education, Charleston, West Virginia, 1977; validated for exploratory secondary level by A.R. Putnam for Kentucky Bureau of Vocational Education Research Coordinating Unit, July, 1980.

Mechanical Drawing:

1. Freehand sketching
2. Care and use of drafting equipment
3. Lettering
4. Measurement
5. Scales
6. Drafting media
7. Title block
8. Border lines
9. Alphabet of lines (line symbols)
10. Geometric construction
11. Dimensioning
12. Orthographic projection
13. Isometric projection
14. Oblique developments
15. Perspective
16. Auxiliary views
17. Shading
18. Sectioning
19. Symbols
20. Threads
21. Fasteners
22. Tolerances
23. Detail drawings
24. Common abbreviations
25. Use of notes

If you already have CAD facilities available, you may wish to include non-system specific CAD competencies (competencies which are common to all CAD systems) here.

CAD COMPETENCIES:

1. Logging in
2. Logging out
3. Disk Operating System
4. Filenames
5. Formatting disks
6. Copying files
7. Listing directories
8. Changing filenames
9. Deleting files
10. Digitizing

11. Plotting
12. Screen scale
13. Drawing units
14. Coordinate systems
15. Text buffer
16. Line selection
17. Line insertion
18. Rectangle insertion
19. Placing a point
20. Drawing circles
21. Drawing arcs
22. Fillets
23. Hatching
24. Windowing
25. Moving an entity
26. Copying an entity
27. Mirroring an entity
28. Rotating entities
29. Zoom
30. Page (pan)
31. View
32. Fill
33. Choosing layers
34. Layer status
35. Grids
36. Snap
37. Isometric grids
38. Creating group entities
39. Inserting groups
40. Rotating groups
41. Text fonts
42 Text justification
43. Text insertion
44. Linear dimensioning
45. Angular dimensioning

Element two: Content selection

From the lists of competencies used, select what will be taught in the course under development. As it is our intent to teach concepts which can be applied to either manual or computer aided drafting, we must now break the competencies down into supporting/enabling concepts without regard to specific machine manipulation skills.

Concept	Rationale
1. Freehand sketching	- essential for visual reasoning
2. Measurement & scale	- essential for size and spatial requirements

3.	Alphabet of lines	- essential for object construction
4.	Geometric construction	- essential for object description
5.	Depth representation	- essential for enabling concept for object rotation
6.	Object rotation	- essential for shape description
7.	Dimensioning	- essential for size description
8.	Details	- essential for clarity
9.	Technical requirements	- essential for accuracy

This list is inclusive of the entire list of competencies. Some competencies are combined into the underlying concept, others are deleted as specific machine manipulation skills (i.e., lettering. Legible printing can be taught under "Freehand sketching.")

If you have included CAD competencies earlier, you will include CAD concepts here.

CAD CONCEPTS

1. Operating Procedures
2. Utility Commands
3. Entity draw commands
4. Edit and Inquiry commands
5. Display controls (screen image controls)
6. Layers
7. Drawing aids
8. Complex objects
9. Text
10. Dimensioning

Element three: Sequence content

Developmental learning theory is now called upon to help sequence the concepts into a teachable order. Experience with beginning drafting students from Jr. High School through post-secondary has shown logical developmental progression, beginning with the familiar, most effective. The conceptual method was chosen because conceptual understanding is vital if skill transferal is to take place. The school is, after all, an artificial environment, and the skills and knowledge are taught to be used elsewhere. Additionally we are now teaching knowledges and skills which the learner must demonstrate on two mediums; computer and manual.

Freehand sketching is a logical place to start as it is a fundamental element of both manual and computer aided drawing. Measurement and scale, alphabet of lines, geometric construction, and dimensioning can all be included in practice exercise using freehand drawing as the vehicle of instruction.

Transition from two dimensional graphic description to three dimensional on a two dimensional plane is one of the hardest for beginning students. An effective method of solving this problem without the traditional lengthy and confusing discussion of viewing planes is to develop the next logical step. From a two dimensional geometric object, project the depth on to a two dimensional plane.

Oblique projection is a very convenient technique to use in developing this important transition. After drawing flat geometric objects such as gaskets, choose an object with consistent depth or thickness. The concept of true shape is already established, and it is readily apparent that representation of depth must be developed for accuracy. The concept of representing a third dimension on a two dimensional plane remains constant for both manual and computer aided drafting.

After a discussion of front view selection when more than one view is drawn, develop oblique lines (cabinet projection is recommended for an example) then draw in the rear view. When the views are separated along their intersecting planes, it can be clearly seen that the graphic description of the object is not accurate, and that the representation (illusion) of depth has been created by distortion.

Rotation of the object and true shape projections of the other-than-front views can now be shown as a logical solution to the distortion problem. The concepts of dimensioning (size description), details, and technical

requirements (i.e., fasteners, threads, notes, etc.) can now be developed.

Element four: Expected outcomes

For each concept we intend to teach, we must now develop at least one terminal target performance. Our performance objectives must be realistically obtainable for our target population. Generic performance objectives should be avoided as they accomplish little. We must now determine specifically what we want the learner to do to demonstrate the desired proficiency, how well it must be done, and under what conditions it must be performed. For example; under Dimensioning: is the learner to pass a written test on rules of dimensioning with at least 80% correct answers, or, dimension a required drawing or group of exercises with 90% accuracy. If both, then there are two objectives. The performance objective must be specific, obtainable, and describe the intended method of measurement.

Instruction Phase

How are we to teach the content?

Having described what we will teach, and how well it is to be mastered, we now will describe how we will teach it.

A most effective way is to develop an instructional schedule. Instructional schedules are a schematic of the course you are designing.

(Place Figure 3 about here)

Information on an instructional schedule includes sequence, topic, content, reference, student assignment, equipment and/or supplies needed, and evaluation. During this phase, all instruction is mapped out. When the instructional schedule is finished, the task remaining is simply to develop the materials already planned.

Purchasing CAD Equipment and Software

Research estimates predict the creation of 1.2 million CAD operator positions by 1990. In response, educational institutions must incorporate CAD into the industrial arts curriculum; therefore, the question is not "whether to buy", but rather "what to buy." The purchase of a CAD system is not, by any means, a simple process. Vendors often confuse the client with conflicting claims of system capabilities. The following purchasing strategy is not all inclusive, but rather a sound beginning in the selection and purchase of a computer aided design system.

Research the Basic Concepts of CAD

Before the embarking on the journey to find a system, it is advisable to know the basics of what you are searching for. Locate and subscribe to journals such as Commline, Technical Education News, Industrial Education, School Shop, CAD/CAM Technology, Computer Aided Design Report, CAD/CAM Digest, Industrial Engineering, and other journals that you see dealing with CAD. Articles on developing CAD technology give a feel for the importance of CAD in industry.

Conferences and workshops on CAD abound at the university level; these are extremely helpful in answering technical questions as well as implementation questions. Don't go into the purchase blind.

Have a Clear Rationale for the Purchase

Although many administrators have jumped on the CAD bandwagon in support of their program, there are still going to be questions. "Why do we need it?" "Can't you use existing computers?", "Won't industry supply you with something?", etc. Make sure your stance reflects industrial needs, and the objectives given for the CAD system are compatible with the level of your learner and the mission of your department.

Selection Committee

Once approval for the purchase has been given, don't be solely responsible for the selection of a particular system. It is better to have a committee to back you up: Consider an administrator, computer faculty, a representative from industry and/or a nearby university, and the industrial arts faculty members who will be using the system.

Selecting a CAD System

Before talking to vendors, develop an evaluation chart to compare essential features among different CAD systems. These are dependent upon the desired level of skill development your students need. Are the students being trained for industry standards or as a general orientation. As a rule, due to cost, educators use simulation equipment. Features to be looked include:

1. Automatic dimensioning
2. Layering capability
3. Grouping
4. Cross hatching
5. 3-Dimensional capability
6. Mixing line types on a layer
7. Help functions (user-friendly)
8. Dynamic dragging
9. Maximum size of drawing
10. What peripherals are needed
11. Potential expandability
12. Multitasking capabilities

Considerations when dealing with vendors include:

1. What courseware is available?
2. Are software updates included in the cost?
3. Is there a maintenance contract? What does it cover?
4. Where does the system for repair?
5. Is there a training course for teachers? Cost?
6. Does the price include everything needed for operation? (cables, interfaces, operators manual)
7. Can backup copies of the software be made?
8. Does the vendor have any educational affiliations?
9. Is the vendor financially stable?
10. Does the sales representative have drafting background?
11. Are other customers happy with their service?
12. Does the local division vendor take care of all service?
13. Is there a local application specialist?
14. Is there an emergency hotline?

Negotiate the Price

Once the systems and vendors have been researched, negotiate with different vendors. Computer prices are flexible, especially for larger purchases made by a school system or district.

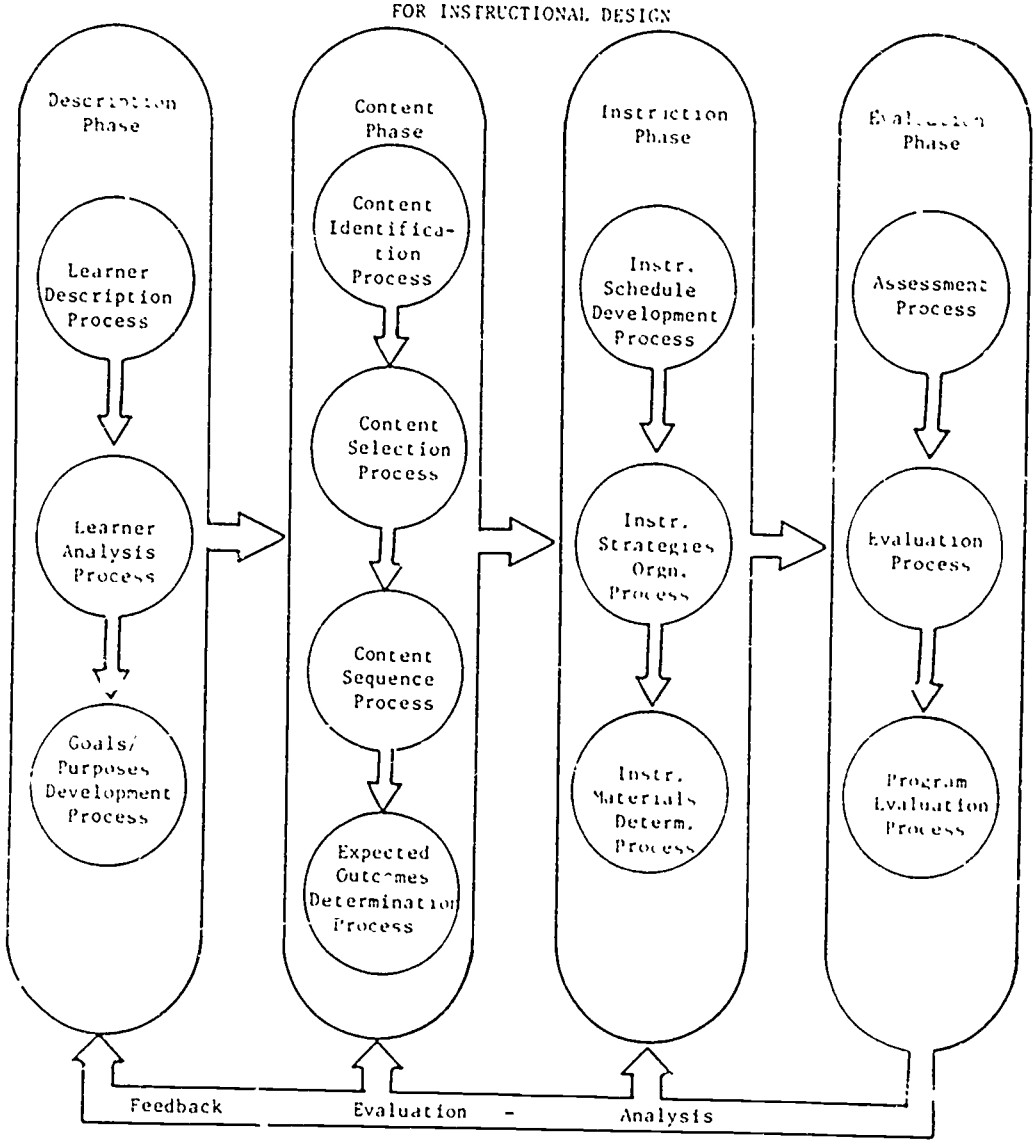
CAD SOFTWARE VENDORS

COMPANY/SOFTWARE	EQUIPMENT/COST
Autodesk, Inc. Autocad 2320 Marinship Way Sausalito, CA 94965	IBM PC and compatibles Cost: $1000 - $2000 The most popular package Excellent capabilities
BG Graphics System, Inc. Drawing Processor 824 Stetson Avenue Kent, AW 98031	IBM PC and compatibles Cost: $1000
Chessel Robocam CAD-1, CAD-2 111 Pheasant Run Newton, PA 18940	Apple IIe & II+ Cost: $1095-$1790 Excellent package, also adaptable for CAM
Datagraphics CAD Master 7011 Biscayne Milford, MI 48042	IBM PC Cost: $1,100-$1,800 Excellent drafting capability
Metasoft Corporation Benchmark 6509 West Frye Road Chandler, AZ 85224	IBM PC and compatibles Cost: $600 Introductory Package
Micro Control Systems Cadkey 27 Hartford Turnpike Vernon, CT 06066	IBM PC and compatibles Cost: $1,895 ($495 ea., min 8)

Micrographix PC-Draw 1701 North Greenville Richardson, TX 75081	IBM PC and compatibles Cost: $250 Very basic package
Milwaukee Area Technical College MATC-CAD 1015 North 6th Street Milwaukee, WI 53203	Apple IIe Cost: $700 (first time, $200 per copy thereafter) Good educational package
Personal CAD Systems CADplan and CADdraft 15425 Los Gatos Boulevard Los Gatos, CA 95030	IBM PC and compatibles Cost: $500-$1,300 Entry level or introductory package
T & W Systems VersaCAD, CadApple 7372 Prince Drive Suite 106 Huntington Beach, CA 92647	Apple II and IBM PC and compatibles Cost: $490-$1,500 Excellent entry level package

FOUR PHASE MODEL

FOR INSTRUCTIONAL DESIGN



(figure one)

PREPARING STUDENTS FOR COMPUTER AIDED DRAFTING

THIS COURSE IS INTENDED FOR HIGH SCHOOL BEGINNING MECHANICAL DRAWING STUDENTS. IT IS INTENDED TO PREPARE THEM FOR ENTRY INTO ADVANCED SYSTEM SPECIFIC COMPUTER AIDED DRAFTING CLASSES. IT CAN ALSO SERVE AS AN INTRODUCTORY UNIT FOR ADVANCED TRADITIONAL DRAFTING COURSES. NO PREVIOUS DRAFTING NOR COMPUTER EXPERIENCE IS REQUIRED AS A PREREQUISITE.

(figure two)

COURSE: PREPARING STUDENTS FOR C.A.D. PAGE: 1

TITLE	CONTENT	REFERENCE	ASSIGNMENT	EVALUATION
FREE HAND SKETCHING AND DRAWING	1. PENCIL POSITION 2. HORIZONTAL LINES 3. VERTICAL & SLANTED LINES 4. GEOMETRIC FIGURES 4.1 SQUARES 4.2 RECTANGLES 4.3 CIRCLES 4.4 IRREGULAR CURVES 5. FLAT LAYOUT	GIACHINO & BEUKEME PP. 7-21	(YOUR CHOICE)	(DETERMINED BY YOUR OBJECTIVES)
MEASUREMENT AND SCALE	1. SIZE 2. PROPORTION 3. MEASUREMENT 4. SCALE	HANKS & BELLISTON PP. 44-50		
ALPHABET OF LINES	1. VISIBLE LINES 2. HIDDEN LINES 3. CENTER LINES 4. CUTTING PLANE LINES 5. SECTION LINES	GIACHINO, ET. AL. PP. 26-32		
GEOMETRIC CONSTRUCTION	1. BISECTING LINES 2. BISECTING ARCS 3. BISECTING ANGLES 4. DIVIDING LINES 5. DRAWING TANGENTS (CONTINUED ON NEXT PAGE)	GIACHINO, ET. AL. PP. 115-121		

(figure three)