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Content and Strategies for Teaching Computer Aided Drafting

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Today computer-aided drafting (CAD)—a refinement of manual drafting techniques—is widely used in industry and its future use will no doubt increase. However, the question arises whether students in vocational, technical and engineering education are receiving the training they will need in order to be prepared for future employment. Norwood (1986), for example, argues that increased use of CAD in industry means that secondary school programs should emphasize computer graphics if they wish to prepare students to use contemporary technology. Similarly, Pedras and Hoggard (1985) emphasize that technology educators cannot continue teaching without adjusting the curriculum to encompass new developments, and they regard CAD as a medium to bring new technology into the classroom.

However, the case for teaching CAD is not clear cut. "Many industrialists approach CAD with a great deal of reluctance. The argument that we should throw out our drafting tables and stop teaching traditional drafting because 100 different vendors offer CAD systems is foolish at best," Schwendau (1986, p. 11) suggests. Secondary classroom teachers have expressed similar concerns. Although opinions do vary, many feel that traditional methods of teaching drafting should be taught concurrently with CAD.

Certain problems are inherent in the move toward teaching CAD. Holloway (1987) observed that a lack of appropriate occupational experience, technical expertise, and funding was the most common. Effective CAD education for teachers also became a current problem as the demand for CAD users increased. According to Flechsig and Seamans (1987), despite a wealth of exciting predictions (i.e., widespread use of CAD) and reports of successes in the literature, the best way to apply computers to teaching drafting is still unknown.

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Goetsch (1985) saw great promise of a bright future for technology education—if professionals in the field responded effectively and used innovations such as CAD. To encourage the use of technology, according to Nelson (1985), teacher educators must develop and provide courses, both on campus and in-service to the schools, as well as technical assistance programs to help teachers upgrade the computer content of their classes. Only when teachers are convinced that some form of CAD is here to stay will they prepare themselves to use it as a method of teaching drafting. Despite a recognized need for CAD instruction, no agreement on method or emphasis for teaching CAD has been established. Suggestions in the literature are based on personal opinion rather than research.

**Purpose**

The primary purpose of this study was to determine whether selected drafting content should be taught using traditional methods, computer-aided methods, or both at the secondary level. The secondary purpose was to reach consensus on the teaching strategies appropriate to the content. A national panel of experts was selected to ascertain areas of agreement. Their consensus provided an information base valuable to educators in implementing a current drafting communication curriculum which used CAD instruction. Statements generated by the panel of experts reflected content, strategies, and time allotments necessary for teaching both manual drafting and CAD. Nevertheless, the focus of this study was directed to the teaching of CAD.

**Methodology**

The methodology used in conducting this study was the Delphi research technique. It is a method of forecasting that "uses a panel of experts within a field to gather consensus on future alternatives, expected breakthroughs, future opportunities, and value judgment" (Somers, Baker & Isbell, 1984, p. 26). The Delphi technique consists of a series of questionnaires to be answered by experts consisting of statistics from previous questionnaires. A three-round Delphi was adopted as the research method, using procedures that have been identified in the literature (Delbecq, Van de Ven, & Gustafson, 1975).

An extensive nomination procedure was used to select the panel of experts in this study. According to Jones and Twiss (1978), the selection of the panel of experts is one of the most critical steps in the success of the Delphi study. Jones and Twiss also recommended that panels be composed of from 12–20 experts. The panel size used for this study consisted of 15 experts.
Panel Selection

In an attempt to reduce bias in selecting a panel of experts, several steps were used. The first step was to ensure a large enough sample size. To achieve this goal, five states where the most current and innovative in CAD practices at the secondary level were employed had to be identified. The following criteria for judgment were used in selection: (a) most up-to-date CAD facilities (i.e., computers, digitizers and plotters), (b) most progressive CAD curriculum (i.e., using over 50% CAD in the curriculum), and (c) most effective teaching strategies (i.e., successful student learning). Fifty state coordinators for Industrial Arts/Technology Education (IA/TE) were asked to nominate five states on the basis of these criteria. As experts in the field, the coordinators were qualified to make these selections. The responses of the 50 state coordinators were ranked in terms of frequency of listing. Because 71% of the state coordinators responded, there was no need for follow-up. The five states they selected were New York, Virginia, Utah, Illinois, and Wisconsin.

The second step in selecting the panel required each of the state coordinators of the five nominated states to recommend the six most qualified and innovative individuals teaching CAD in Technology Education. These six nominees did not have to be from the nominated states. The individuals recommended by the state coordinators were used as the population of potential panel members.

The final step in selecting the panel was to use a stratified method of sample selection. This process consisted of subdividing the nominees into strata according to geographic location and state prior to sampling. This would ensure approximately equal representation by each state in the study. Three members from each stratum and state were selected using the random selection process to complete the panel of 15 experts.

Instrument Development

The initial instrument—the survey developed for the Delphi panel and sent to the panelists—was comprised of lists of selected drafting components such as line quality, orthographic projection, and isometrics and was sent to the panelists.

These components were determined from a curriculum study that used CAD (Everly, 1984) and a textbook used in secondary school drafting (French & Svensen, 1985). These components established a framework of specific content for each panel member to assess. The instrument was left open-ended to give the panel of experts the opportunity to incorporate additional content items they deemed important. In addition to content components, the instrument also included sections for the identification of strategies for teaching each drafting component. Also, since the drafting
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Curriculum must be taught within a certain time frame, the instrument included a time allotment section for each component. The time allotment consisted of a typical secondary school year (36 weeks). Delphi Rounds Two and Three were developed by condensing the Delphi responses from the previous round in the manner recommended for Delphi studies (Delbecq, et al., 1975).

Procedures

The panel of experts was initially asked to identify whether the drafting components (included in the Round One instrument) should be taught using traditional methods, computer-aided methods, or both, and to identify strategies that could be used to accomplish this. The panel was also asked to indicate a time allotment for each component.

The Round-One instrument generated a list of 86 statements by the panel of experts, which included statements about both manual and computer-aided drafting. The focus of this study, however, was concerned with CAD content. All statements were left in the study but were not included in the results. All statements were numbered and grouped according to selected headings to aid in the organization of the instrument. The time allotments for each drafting component from Round One were averaged and documented on the Round-Two instrument.

In Round Two, the panel of experts indicated on a 5-point Likert-type scale the degree to which they agreed or disagreed with each statement. The scale ranged from (1) disagree to (5) agree. Where applicable, they were asked to indicate a time allotment for each statement.

The Round-Three instrument was developed from the suggestions from panel members in Round Two. Modal responses to statements from Round Two by the participants were indicated on the Round-Three instrument. In Round Three, the panelists were asked to compare the modal response and their own response from the previous round for each statement. If a change were needed, they were asked to make the revision.

Consensus in this study was achieved when 75% of the panelists' responses were within 1 interval of 5 on a 5-point Likert-type scale. Delbecq, et al., (1975) report that 75% consensus is considered appropriate for a Delphi panel.

Analyses

Several descriptive statistics were calculated for use in this study. The mean was used on Round One to determine the time allotments for drafting components. Likert-type scales were used to determine consensus for statements on Round Two and Round Three. The mode was used on
the Round-Three instrument to determine frequency of response on statements by the panel.

Results/Findings

Content for Teaching

Consensus was reached on 38% of the statements generated by the panel of experts on how selected drafting content should be taught. Table 1 depicts the statements on which the panel did reach consensus. On statements number 7, 45, and 47, consensus was reached, but it was a consensus of disagreement.

Table 1

Statements by the Panel That Reached Consensus

1. All drafting students should be taught CAD.
3. The knowledge and techniques used in traditional drafting are very important and will be needed using CAD.
7. CAD and traditional drafting should be taught consecutively rather than concurrently, with CAD being taught first.
9. The student-to-computer ratio should be 2:1 (students:computers).
10. "Open-lab" (extra time for students to use CAD outside of class) is very important for students learning CAD systems because of the time required.
15. All students learning CAD should be familiar with the various types of input devices (mouse, keyboard, digitizing pad, etc.).
16. Drafting students should learn to work on team projects.
17. Students learning CAD should know the concepts of customizing a system through generation of libraries, macros, etc.
20. Sketching should be taught using traditional drafting.
21. Students should learn to sketch to proportion.
22. Students should learn to sketch real objects, not just shapes.
26. Students should learn traditional methods of measurement (Arch., Mech., Metric, etc.) using scales.
27. Students should learn unit manipulation and limits relationships using CAD.
37. CAD should be used to stress modification, manipulation of dimensions.
39. Orthographic projection should be taught using both traditional drafting and CAD.
40. Visualization of objects should be stressed when teaching orthographic projection.
43. The concepts of pictorial drawings (axonometric, oblique, and perspective) should be taught using traditional lecture, demonstration, and sketching.
45. There is no need to teach traditional methods of pictorial drawings because the computer can do a better job.
47. The concept of revolutions should be taught using sketching only.
50. Various types of sections should be taught.
57. Gears & cams should be taught using CAD.
66. Shop processes should be taught using traditional lecture, readings, and discussions.
70. Students should use traditional methods to learn the use of measuring tools.
Table 1 - continued

71. Architectural drafting should be taught using both traditional and CAD methods.
72. Architectural, piping, structural, and electrical drafting is best taught using CAD because each requires respective tasks.
73. Logging in/out is taught when students first sit down at the CAD workstation.
74. The disk operating system (DOS) is important for students to learn because it controls file operations, formatting, etc.
75. Proper file operations are very important because if not properly performed they can destroy files and harm the system.
76. Software operating commands can be learned only through experience using CAD.
77. Digitizer types, techniques to use, and care of equipment are important for students to learn.
78. Plotting can be simple or complex (depending on the system), but all students should learn how to plot drawings.
79. Care of CAD hardware and software should be taught to all drafting students.
80. Microcomputers will become more commonplace for Design/Drafting.
81. Geometric Dimensioning and Tolerancing are vital to drafting.
82. Complex sheet metal layout (developments) should be taught using both traditional and CAD methods.

The panel of experts agreed that the traditional methods used in teaching drafting are very important and will be needed in teaching CAD. The panel also determined that CAD was similar to traditional content and consisted of basic drafting components. Consensus (statement 7) was reached that drafting students should be taught traditional drafting and CAD concurrently. In addition, when teaching CAD, the content should include a knowledge of CAD hardware and software.

Strategies for Teaching

The panel members agreed that the drafting curriculum at the secondary level is in transition between the use of traditional methods and CAD. However, they reached no consensus on strategies for teaching drafting, whether using CAD or traditional methods. Lectures, demonstrations, discussions, worksheets, and problems/practice were the strategies suggested. Less emphasis was placed on line quality and lettering skills. It was agreed that more emphasis should be placed on learning concepts such as orthographic projections and pictorial drawing.

Time Allotments for Teaching

The panel of experts reached consensus that “open-lab” (extra time for students to use CAD outside of class) is very important for students learning CAD systems because of the time required in the initial learning of the process. They did not reach consensus on any other statements about time allotments for teaching traditional drafting or CAD.
The level of agreement by the Delphi panel for various drafting components concerning time allotments, content, and strategies was wide ranging. The Delphi results reflected differences in student objectives and program goals.

Conclusions

The following conclusions were drawn from the panel's consensus ratings on the content of CAD:

1. CAD and traditional drafting are complementary in current drafting programs.
2. In a drafting program, whether teaching traditional drafting, CAD, or both, the basic components of drafting were taught.
3. Experts from programs with extensive CAD facilities used more CAD in instruction, while those from programs with limited CAD facilities taught more traditional drafting.
4. When teaching CAD, traditional lecture, demonstration, discussion, and problem/practice were all effective if the instructor properly incorporated them.
5. Identifiable differences in strategies for teaching traditional drafting and CAD were discovered. These differences related to the use of the computers and software versus using traditional drafting instruments. The panel reached consensus that CAD instruction should stress concepts and know-how rather than quality of motor skills.

The panel did not reach consensus on a number of statements. The following conclusions were drawn from their lack of consensus on time allotments for teaching various components of CAD:

1. On time allotment, variations in the times recorded showed that there still is no general agreement on the times necessary to master CAD skills. For example, the estimated time needed to teach orthographic projection ranged from 5 hours to 100 hours.
2. Drafting programs at the secondary level appear to have little in common either in content or equipment.
3. The goals of secondary drafting programs were not common. Some programs were general in focus; some were preparation for advanced curriculum; and others were vocationally oriented.

Discussion

The present study suffers from typical constraints of Delphi research. The study does not lend itself to precise analytical techniques, and, as with any interactive process, information must be deciphered.
Secondary drafting programs traditionally have used manual methods of instruction with little emphasis placed on CAD. The results of all rounds of the Delphi research indicate that manual drafting and CAD should be taught concurrently. This impacts directly on secondary technology teacher education programs in that programs should emphasize more CAD instruction.

Of particular note, 92% of the panel of experts indicated that the knowledge and techniques used in traditional drafting are very important and necessary for users of CAD. Traditional lettering, sketching, measuring, and drafting media were valued as necessary in drafting curriculum. From a program planning perspective, these traditional drafting techniques will benefit (a) by indicating the type of equipment that must be present in the drafting curriculum (i.e., manual drafting equipment and CAD equipment) and (b) the methodology to use when developing the curriculum.

The panelists unanimously agreed that computer use will become more commonplace for design/drafting. Secondary technology teacher education programs, therefore, must continue to update and purchase new equipment to stay abreast of the continuing changes in CAD. This will enable students to get the exposure to compete in their desired areas. However, with CAD technology changing very rapidly, knowledge of hardware, software, and methodology must be continually updated for successful technology transfer by students and faculty alike.

The greatest variation found in program design suggests at least three priorities: (a) Because the curriculum represented by the experts in various secondary drafting programs varied so much, a curriculum study to identify a model program for utilizing CAD in drafting should be developed; (b) Because changes in industrial CAD practices are occurring continuously, there is a need for frequent validation of the content and strategies appropriate for a CAD curriculum; and (c) With facilities in drafting programs varying so greatly, research is needed to establish the optimum hardware and software needed to teach CAD, with program objectives and level as variables.

References


