Teaching Techniques in Computer-Aided Design

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Abstract

This paper discusses common concerns about and various techniques for the teaching of Computer-Aided Design (CAD). One of the concerns raised will be related to how engineering technology students can acquire the necessary CAD skills for use in their design projects. Also discussed will be the relative advantages of different approaches, such as having CAD as a separate course, making CAD a part of design or graphics courses, and allowing students to acquire the skills on their own. Classroom lectures for the teaching of CAD software are examined and compared with self-learning by students. Another aspect to be addressed is project assignments. In addition to regular CAD drawing exercises, practical CAD design projects as well as traditional question-and-answer homework are assigned to students to enhance their understanding of the subject and to improve their CAD skills. Also, the proper mixture of CAD theory with hands-on experience, as well as the proper levels of general guidelines and specific instructions, is reviewed. In addition, the paper discusses the degree of complication that freshman CAD projects can have without overwhelming students and examines the introduction of practical exercises, such as machine parts with correct dimensioning and scale, early in the curriculum. Quizzes, written exams, and term projects are evaluated as to their usefulness in assessing the amount of understanding and skill that students have attained. Finally, the paper gives examples of the relative merits of different CAD software packages in an educational setting and raises other issues such as modern teaching equipment and the proper time to be given for the completion of projects.

Should CAD Be Included in Engineering Technology Curriculums?

Along with its fast development, CAD has virtually replaced traditional hand drafting and blueprints. Some schools even eliminated the conventional drafting boards, replacing them with regular large-sized desks. CAD courses are now required in many engineering technology programs that offer associate degrees. Since CAD software is a drafting tool, some schools do not offer a CAD course. Yet they still require students to complete their assignments or projects using CAD software with the assumption that students either have already learned CAD from somewhere else or can easily grasp it on their own. One high school teacher once said to me that

his graduates were in a disadvantageous situation at college because they had not learned CAD in high school, while some others had.

Since CAD has become a necessary skill for engineering technology majors, it should be included in a required graphics or drafting course if not as a stand-alone required course. The combined graphics and CAD course has the advantage of balancing theory and practice. It can be a lecture and laboratory course in which students not only learn drafting theory and techniques, but also practice CAD skills. One of the new approaches is to include CAD in a freshman design course which teaches fundamentals of engineering design, engineering graphics, and oral and written communication skills [1].

In the past decades, developments in computer hardware and software have caused an information revolution and made significant changes in our society and economy. Applications of information technologies have also contributed to developments in all engineering fields. Not long ago, in the seventies, many academic journals did not accept articles on software developments and applications. Now, John A. Pople, who developed "computational methods in quantum chemistry," shared the 1998 Nobel Prize in Chemistry [2]. His computer program "is now used by thousands of chemists in universities and commercial companies the world over." Application software, including CAD, will continue to make more and more improvements to engineering technologies. CAD should be a required skill for the new generation of engineers and technicians. It should be included in engineering technology curriculums.

Hands-on v. Theory

It is unrealistic to teach every CAD package available on the market. Sometimes, we see some of our graduates come back to take a CAD course simply because the same CAD course they took several years ago used an earlier version of the CAD package. Some students cannot use a new CAD package even though they already took a CAD course using a different CAD package. My explanation for this phenomenon is that these students only learned how to use CAD, but did not understand its theory. The issue here is how we teach the CAD course. In my view, we should teach both CAD theory and skills so that students can apply it to real world industries and be able to adapt to new versions as well as other similar packages.

In CAD classes, when we teach students how to use a command, we should also discuss with them the design, concept, and user-friendness of a CAD command. For example, the isometric circle in AutoCAD is under the *ellipse* command. We can guide students in discussing the advantages of grouping all isometric entities into one access method, just as *dim* mode does, instead of keeping them apart. Another example is AutoCAD's *fillet* command (the *chamfer* command has similar problem), which requires two accesses to complete a fillet. After the radius is set for a fillet, the *fillet* command exits. One must reenter the command to create a fillet. To simplify the process, it is better to complete the fillet in one access, for example:

Command: *fillet*
(TRIM mode) Current fillet radius = 0.5000
Polyline/Radius/Trim/<Select first object>: *r*

Enter fillet radius <0.5000>: *0.25*
Polyline/Radius/Trim/<Select first object>: *(Select one object)*
Select second object: *(Select another object)*

Many students are taught to use AutoCAD's *mvsetup* as the first step to create a new drawing. The *mvsetup* is in general a useful command to setup a drawing in tiled model space. It can set units and scale. But without a full understanding of scaling, some students still do not know which scale factor to use when assigned projects of drawing prototype objects. The frame showing up on their printed drawings when they use *mvsetup* to setup their drawings puzzles some students. Others are confused about which print scale to use in order to obtain a print with correct scaling. In traditional hand sketching, a draftsman must determine the scale factor between a prototype object and the drawing size on a selected sheet, then use an appropriate scale to draw the object. With CAD, the "true" size of any object can be drawn with its desired view shown on the screen by zooming in or out. The scale factor between a prototype object and a hard copy can be controlled easily by the print scale in CAD. With a good understanding of the scale relationship, students are able not only to set the scale factor in *mvsetup*, but also to use other methods, such as the command *limits*, to setup a drawing.

Step-by-Step Instructions v. Outlines

Many textbooks provide step-by-step instructions in great detail. Step-by-step instructions are certainly necessary in examples to help students, especially new users, to understand and use any software. However, I have found that when step-by-step instructions are provided everywhere in assignments and projects, students develop dependency on them and do not try to understand concepts and theory. It is not uncommon for even experienced students to be unable to begin a new drawing. They often ask me for setup parameters and commands. The problem of setting up a new drawing is so common that some schools are forced to simply provide students with preset templates to use. In one of my introductory CAD courses, one student followed the instructions in the textbook step-by-step. He typed in all the commands and values as instructed without even raising his head to look at the screen. Finally, after completing all instructions, he saw a scrambled drawing on the screen and complained that the instructions were wrong. In this extreme case, he did not try to learn how to use CAD to create a drawing, but simply followed instructions. Any wrong keystroke or mouse-click could cause a drawing error. No matter how many CAD drawings a student has completed, he may still not know how to draw if he merely follows instructions without understanding CAD concepts and how a CAD package works. It makes more sense to provide students with outlined instructions for assignments and projects, letting them figure out details. It is also a good practice to encourage students to try different approaches and methods for completing a project. This will provide opportunities and challenges for students to broaden their knowledge and have a better understanding of a topic after they fulfill basic requirements.

Once students become dependent on step-by-step instructions, they also have difficulties adapting to other CAD packages. They may even have a hard time using a newer version of the same CAD package that they learned not long ago. With new releases coming out at a rapid pace, a CAD course should train students not only in the use of a particular CAD package, but

also in the ability to adapt to new releases and other CAD packages. This again boils down to the issue of teaching students the fundamental theory of CAD.

Lecture v. Laboratory

As I have stated earlier, we should teach students not only the skills of using a CAD package, but also the concepts and techniques of CAD. An appropriate and balanced combination of both lecture and laboratory is necessary. For example, an introductory CAD course of 1-2-2 (lecture hours-lab hours-credits based on a semester system) is offered at Essex County College. The mandated lab hours allow direct communication and problem solving between the instructor and students. Usually, additional open lab hours with the attention of lab technician or assistant should also be arranged so that the students can obtain help and complete their assignments or projects. Many software companies have teamed with publishers to offer student versions of CAD packages through campus bookstores at discount prices. It is recommended that students acquire a copy of the software so that they can work on their assignments at home and better manage their time.

It is essential for a CAD lab to have an adequate number of PCs or workstations. The idea number is under twenty so that the instructor can provide necessary attention to every student. With local-area networking or distance learning equipment, the instructor can also have remote communications with students. This, however, is not as effective as direct face-to-face discussions. It is preferable to have big screen monitors that can display more details of CAD drawings. Although digitizing tablets with either a puck or stylus are popular devices used by many CAD specialists in work places, it is not an essential device for an introductory CAD course. A mouse usually satisfies the need for a pointing device in schools. A projector-type device, such as Datashow, that can project the image on a computer screen onto a big board is very helpful in CAD teaching. By just lecturing or illustrating on the marker board, it is hard to demonstrate some CAD features. With a Datashow, the instructor can demonstrate many sophisticated CAD features and various approaches to complete a drawing. Nowadays, with an Internet connection, students can also communicate with students at other schools. It can be helpful to exchange information during teamwork and competition.

One problem during lecturing is that some students try to follow each step that the instructor is demonstrating, or merely draw incomplete projects or other things on their computers. Unless demonstrating simple drawing features, it is almost always necessary to have students look at the projection screen in the front. In this way, students can catch what the instructor is doing and participate in the discussion. Letting students repeat every step is very time-consuming. Students usually complete each step in different speeds. Faster students will get impatient. Slower ones will panic after getting stuck due to wrong keystrokes or mouse-clicks. The worst problem is that when students do something else on their computers, they completely miss the discussion. I had an interesting experience when organizing a computer workshop. The presenter requested a computer room without students' computers in order to avoid distractions. There are better ways to handle this type of problem. For example, some local-area network software or hardware can allow the instructor to disable students' computers or show the

instructor's screen on their computers. This is a good way to deliver an effective lecture or demonstration, and get students' attention and participation as well.

Assignments and Projects

Traditional assignments, such as multiple choice questions and open-ended problems, are still applicable to CAD courses. In addition, practical projects should be assigned to students regularly to enhance their understanding of the concepts and improve their CAD skills, accuracy and speed. Without adequate practice, a student will not be able to use CAD. The projects should also be comprehensive and involve engineering applications. At Essex County College, about twenty comprehensive weekly projects are assigned each semester [3, 4]. These projects cover various features of CAD and engineering application fields.

Comprehensive CAD projects are time-consuming. Lab hours during class are often not enough to complete the projects. I always emphasize that point to my students in the first class meeting. Some students assume that the lab hours in CAD classes are the only time they need to practice and work on their assignments and projects. Thus, when they are unable to complete their assignments on time, they think the assignments are too many and too hard. As with homework assignments in other college courses, students must spend out-of-class time on CAD assignments. Lab hours in CAD classes are designed to provide direct discussions and help to students by the instructor, not to be used for completing assignments. Students should be aware that they need to spend a lot of time to work on CAD projects, either in the open lab, or at home if they have a computer and the software. On the other hand, due to the time-consuming nature of CAD projects, we should allow a relatively long time period for students to complete them. Usually, I give my students a week to complete each CAD project.

Assessment

The assessment of a CAD course should be different from other theoretical courses. The concepts and theory of CAD are important. However, it is equally important for students to acquire CAD skills and be able to produce professional CAD drawings. Quizzes, tests, and exams are still necessary in assessing students' achievements. Practical and comprehensive CAD projects should also be used as an important part of assessment. In my CAD classes, I usually assign a comprehensive term project. In advanced CAD courses, students have to choose their own term projects in their fields. Then, they present their proposal in front of the class and collect comments and feedback from their classmates and instructor. The proposed project should include advanced CAD features that they have learned in class, be of reasonable difficulty, and include a suitable number of drawings. After the instructor's approval, students start work on their term projects about mid-term. At that point, they have learned many CAD skills from class. Usually, many discussions and modifications are needed to complete the project. Finally, students present their completed term projects in class. Many students prepare a term project portfolio and bring them to job interviews. I grade all the weekly projects as well as the final term project and consider them an important portion of the final grade.

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