MANUAL DRAFTING AND CAD TEACHING TECHNIQUES FOR THE REQUIREMENTS OF THE CURRENT STCW

RODGERS POLLARD JOHN

California Maritime Academy, USA

ABSTRACT

Current STCW requirements require manual and CAD skills in mechanical drafting, which presents a unique set of challenges for Marine Engineering Technology programs that seek to prepare their students for licensure. Limited by a compressed academic schedule, how can a large engineering technology program provide its students with comprehensive training for such a diverse set of hands-on skill in such an unfamiliar area? The MET department at the California Maritime Academy has developed a distinctive mechanical drafting program that provides comprehensive training in manual drafting and CAD skills, for STCW requirements, in just one semester. This program has successfully prepared up to 100 students a year for STCW licensing and for the robust challenges of the student’s future Marine Engineering career. The purpose of this presentation is to outline the structure, methods, and pedagogical techniques implemented in this program.

Keywords: MET, 3D, CAD, SolidWorks, drafting course.

1. INTRODUCTION

The teaching of a maritime academy cadet machine drafting using either manual drafting or CAD skills within one semester, in their freshman year, is a full challenge. The majority of incoming students do not have any previous drafting experience during their high school education. Cursive writing techniques are no longer taught in the high schools. Without this type of experience, without fine motor skill and hand-eye coordination required for manual drafting, the incoming maritime academy cadet is in for a difficult challenge. The teaching and exposing of CAD techniques to the students is also a large task. However, with the proper tools, techniques and approaches, the overall task can be accomplished in a way that is meaningful and appreciated by the student and the instructor. This paper discusses the outline of the course. It discusses the challenges, pitfalls, and costs of the course as well as the grading and assessing of the students work. The purpose of this paper is to give insight into these difficulties and provide teaching techniques that develop and improve the Cadet’s manual drafting and CAD skills, both for the purpose of STCW requirements and for the Cadet’s marine engineering career opportunities and challenges.

The topics covered will include:

- Our unique project-based curriculum
- Materials and costs
- Text books
- Skills-based learning
  - Manual drafting techniques
  - Fine motor skills, line quality
  - Lettering
  - Software training
- Overcoming common difficulties
- Implementation of technology in the classroom
- Assessment and grading

2. PROJECT-BASED CURRICULUM

Because of the short timeframe of the course, the drawing projects need to progress to the drafting of identifiable, tangible objects, from the start of the course. Therefore, basing the course around an object or project that is realistic and not abstract is the key goal.

The main body of the course focuses on the drafting of three pieces of equipment. These are:

- A machinist clamp, using manual drafting techniques.
- Parts of an angle drive reduction gear unit, using CAD techniques.
- A piece of equipment or a tool, using scale, manual drafting. The class discusses and chooses the piece of equipment and it must be a piece of equipment or a tool that has a specific purpose, either on the training ship, T/S “GOLDEN BEAR”, on the California Maritime Academy campus or in the local community.

These three drawing exercises focus on teaching the basic techniques of manual drafting and of CAD, during the progress of completing the drawings. The Cadet thus learns basic manual drafting and CAD procedures as the Cadet draws the object and sees the results of producing a tangible piece of equipment, a tool or a machinery part.

1.2. The Machinist Clamp

The machinist clamp is the first drawing the Cadet attempts. It represents a recognizable machine shop tool that can be drawn easily full scale on “A” size paper, i.e., 8-1/2” x 11” paper. The Cadet is given the dimensions of the clamp parts. The clamp drawings consist of threads, rounds and machined surfaces and angles.
See Figure No. 1. Orthographic or multi-view drawings are made of the clamp jaws and screws on two drawing sheets. This teaches centering of the drawing, line drawing technique, drawing of threads, use of full scale and measuring, use of a circle template, dimensioning and arrows, lettering and inking technique. See Figures No. 2 and 3.

Figure 1

Figure 2

The third drawing sheet is of the assembled clamp. This teaches drawing of the assembled clamp to full scale, using all the given dimensions. It teaches the use of sectional cross-hatching. It teaches the use of item numbers and leader lines. See Figure 4.

Figure 3

Figure 4

2.2 Parts of Angle Drive Reduction Gear

The CAD program SolidWorks is used to draw parts of an angle drive reduction gear unit. The instructor gives basic instruction on the drawing tools and features of SolidWorks. The class of Cadets is then divided into teams and each team is assigned one part of the reduction gear unit. Each team works as a group and, using the text book as a guide, produces both a drawing of the part and a written procedure of the keystrokes to complete the part. The teams then present their drawings and procedures as class presentations. In the presentations, the SolidWorks drawing tools and procedures are discussed by the Cadets. See Figure Nos. 5, 6 and 7.

Figure 5

Figure 6

Figure 7

Because of the time constraints of the semester, the overall goal of using a 3D CAD program, such as SolidWorks, is not to complete the reduction gear unit.
The purpose is to give the Cadet confidence in learning and mastering an advanced CAD program.

2.3 Scale Project Drawing

The scale project drawing consists of drawing a piece of equipment that is to be used in the operation of the training ship T/S “Golden Bear”. Or the item may be used on the California Maritime Academy campus or in the local community. The drawing is then used by the Advanced Welding or Machine Shop Class and the item is fabricated and installed for use. An example of a successful scale project is a “Training Valve Rack” that was designed for the Power Lab of the T/S “Golden Bear”. See Figure No. 7 and 8.

3. MATERIALS AND COSTS

Materials and costs required for teaching the manual drafting and CAD course are significant. Careful consideration of drafting tools, manual drafting techniques and also the choosing of a CAD program is critical to the overall success of the course.

3.1 CAD Materials and Costs

The major cost of conducting this course is having a computer classroom to conduct the CAD portion of the class. At the California Maritime Academy, four sections of the course are taught in the fall semester and each section has a total of approximately 20 to 25 Cadets. A classroom of 25 computer stations is used for the course. The next major cost of the course is securing a CAD program yearly subscription. The computer classroom computer stations will each require “stand-alone” programs. Educational subscriptions for stand-alone CAD programs may be purchased at large discounts. However, a yearly subscription cost of a 100 seat CAD program, the educational version, will be approximately $3,000 USD, minimum.

3.2 Manual Drafting Materials and Costs

The drafting tools for conducting the manual drafting portion of the class are:

- Compact Drawing Board, 11” x 12”, with drawing mat surface
- Compact T-Square, 12” blade and 9” head
- 30/60 Triangle, 6”
- 45/90 Triangle, 8”
- Architect Scale, triangle type, 12”
- Circle Template, 1/16” to 1-1/2”
- Compass, small, type that allows a ball point pen to be used.
- Soft Eraser, white plastic type or rubber type
- No. 2 pencil
- Pencil sharpener
- Ball Point Pen
- Typing paper, 8-1/2” x 11”
- “White-Out” correction fluid

Typically, a suitable compact drawing board is not available from any supplier. See Figure No. 9.
The cost of the mat is approximately $3.50 USD per board. The cost of the T-square is $7.50 USD. The mat and T-squares are purchased from the Hearlihy Company, a division of the Pitsco Education Corporation. The remainder of the drafting tools are required to be purchased by the Cadet and may be easily purchased at the Academy Bookstore or a local art store.

4. TEXT BOOKS

The choice of text books for the course must be narrowed by choosing books that are reasonably priced for the benefit of the Cadets as well as being suitable for the course objectives. The two text books chosen have notably realistic drawings of equipment or tools and are notably void of abstract examples. The two text books that are required for the course are:

- **Instructional Workbook for Drafting, 4th Edition**, by Paul Wallach and Dan Hearlihy, Cost - $8.95 USD
- **Beginner’s Guide to SolidWorks 2013 – Level 1**, by Alejandro Reyes, Cost - $34.00 USD

5. SKILLS-BASED LEARNING

Using realistic drawing examples, in lieu of abstract drawing examples, and having a project-based curriculum, keeps the course moving and keeps the attention of the Cadet. Using skills-based learning also helps focus the Cadet to constantly improve his drafting skills. It can be compared to teaching carpentry. If you have the student carpenter build a saw-horse or a birdhouse, they learn the skill required to handle the lumber, use each tool, measure, saw, hammer a nail, etc. The same approach is used in teaching the drafting course, and the focus is to ever improve the Cadet’s skills.

5.1 Manual Drafting Technique, Line Quality, Lettering, Drafting Skill

The manual drafting technique employed for the course is a unique and simple method. It uses a readily available No. 2 pencil and a common black ball point pen. This method was chosen due to the fact that drafting pencils and inking equipment is difficult to find and expensive. The use of traditional drafting pencils and inking equipment is time consuming. The method that is employed is easy to learn and fast to produce a drawing. It produces a drawing that is professional looking and clear to read. A drawing, using this method, produces an 8-1/2” x 11” drawing that can be copied, faxed, scanned, mailed or readily exchanged person to person.

The technique is simple. The drawing is first sketched out, very lightly, using a sharp, No. 2 pencil. Lines are drawn, dimensions are drawn, lettering is completed, all using the lightest pencil lines, with the lightest of touch, to complete the drawing. A ¼ inch width border is drawn around the drawing and a title block, ¾ inch, is drawn at the bottom of the drawing, all with light pencil lines. Drawing, in light pencil this way, allows the Cadet draftsperson to make and correct any errors. It allows the Cadet to draw and use guide lines and reference lines, and to layout and space lettering, all without worry or wasting time. Lastly, when the pencil drawing is correct and to the satisfaction of the Cadet, it is then “inked”, using a ball point pen. The best pen to use is the least expensive, most common, and with a black ink. This is the type found in stores, such as a “Bic” pen. Having a drafting surface “mat” under the drawing sheet is important, as it helps the pen ball point “glide” and produces an even line quality. If the “mat” drawing surface is not installed on the board, then two sheets of blank paper, underlying the drawing, may be used with roughly the same benefit.

In inking the drawing, a constant pressure is applied when making the lines and the line is made with a continuous motion, with the pen held at a constant angle. The pen ball point is kept a slight distance away from the straight-edge, by holding the pen at a slight angle to the straight-edge. This keeps the ball point “rolling” and does not allow the ball point to catch or blot. The ball point pen is wiped of excess ink, before each line is made. The ball point should be “warmed up” before using, by making lines or “doodles” on a piece of scratch paper. Doing this prevents excessive ink blotting on the drawing and improves the drawing quality.

Making different line width is accomplished by changing the pen angle to the straight edge. Then a second or third pass is made over the line, as the width of the line requires. There are basically two line “weights” required. A “heavy” or wide line is used for object lines, border lines and title block lines. A “light” or narrower line is used for dimension lines and item leader lines. Lettering and dimension arrows are made, using the same pen, using a “heavy hand” pressure. Lettering and arrows, done properly, may be done with single strokes or passes of the ball point. Finally, when all inking is completed, the drawing is gone over with a white plastic or rubber eraser, removing all pencil lines, smudges and dirt marks. A clean, “inked” drawing emerges.

Inking errors may be corrected or drawing modifications may be made on the drawing by using “White-Out” correction fluid. Another method is to blank out the drawing portion not wanted, using a blank paper insert, taped to the drawing. The drawing and blank paper insert is then photo-copied. The photo-copy edition then becomes the drawing and the correction or modification is made to the photo-copy edition. The scale of the photo-copy edition is 99% accurate and well within drafting tolerances.

The use of this method of manual drafting requires practice by the Cadet to prefect his or her skill. It requires fine motor skill, hand eye coordination, and a level of focus. However done with proper training and done properly, it produces a clear and professional appearing drawing that the Cadet takes pride in and appreciates a new skill learned.

5.2 Software Training

The teaching of a 3D CAD program, such as SolidWorks, within a short time period is a difficult event, unless done properly and with preparation.
However, the majority of Cadets come with an advantage. They have pre-disposition to computers and are natural computer operators and self-learners. They naturally take to the challenge of learning the CAD program. They take up the challenge of learning the CAD program and proceed to take instruction from the text book. They proceed to complete the drawing and do so with appreciation. Choosing an inexpensive, hard copy text book that is project and skills-based is key to their rapid learning.

Choosing which CAD program, SolidWorks, AutoCAD, Sketch-UP, Visio, etc., is based on the Instructor’s preference and experience. The choice of an advanced CAD program, such as SolidWorks, for the CMA drafting course, was made based on the fact that by learning and mastering the SolidWorks program, it teaches the Cadet the confidence that allows the Cadet to master any CAD Program.

6. OVERCOMING COMMON DIFFICULTIES

Because manual drafting and lettering is most foreign to the majority of the Cadets, the most difficulty occurs in the manual drafting portion of the course. Difficulties in the CAD portion of the course are of less frequency. It is therefore important to make the manual drafting knowledge, a prerequisite to the CAD knowledge that the Cadet learns. Proper teaching techniques, grading, and the teaching pace of manual drafting knowledge is very important and must be done with care to make the Cadet confident and have pride in his or her drawing skill and work.

6.1 Manual Drafting - Lettering, line quality, arrows and proper dimensioning

The block lettering required for manual drafting is difficult for most Cadets to initially learn. It is important to start the Cadet practicing block lettering from the very first day of the semester and for the Cadet to keep practicing until perfected. Every letter stroke is important and should be checked by the instructor. Any poor quality lettering strokes must be called out and the instructor must insist that the Cadet correct any incorrect lettering. Line quality and proper dimension arrows must be taught carefully from the start and must be checked point by point by the instructor from the start of the Cadet’s learning process. Proper dimensioning and the drawing of arrows must be standardized using professional drafting standards, such as ASME/ANSI. Completing the Cadet drawing exercises in class, as much as possible, helps keep track of the Cadet’s progress. The Cadet appreciates the Instructor’s engagement in the learning process and the Cadet’s homework load is lessened. Also having the Cadet do the exercise in class, allows the Instructor to correct the Cadet’s drafting errors as they happen and not allow the errors to compound and collect in the Cadet’s drawing.

6.2 CAD Training Difficulties

CAD training difficulties consist mainly of finding a proper teaching technique and a proper CAD text book. Having adequate time to cover CAD techniques is also difficult due to the short timeframe. Having a hardcopy text book allows the Cadet to read the text book beside the computer and directly key in the strokes in the SolidWorks program, on the computer. Some training programs are computer and subscription based, but these are too complex to facilitate and require two computer monitors, per Cadet. Starting the manual drafting portion of the course, immediately at the start of the semester, allows more adequate time to complete the CAD portion of the course, with adequate time. Basically a half and half proportioning of the manual drafting and CAD is ideal for the course, and should be strived for by the Instructor.

7. IMPLEMENTATION OF TECHNOLOGY IN THE CLASSROOM

The class size of the course necessitates the use of a screen projector and screen. PowerPoint presentations are used to teach drafting subjects, such as orthographic and isometric projection, threads and dimensioning.

A major teaching tool for teaching of lettering and the manual drafting techniques is the use of a document projector. The Instructor uses an EPSON Model ELPDC11 Document Projector. See Figure Nos. 10 and 11.

The use of the EPSON Document Projector allows the Cadet to watch, on the classroom screen, the individual drawing strokes of the Instructor, as the Instructor demonstrates the manual drafting technique of pencil sketching and inking. This allows the Instructor to quickly teach the proper techniques to all of the Cadets in the classroom and teach proper techniques from the start of the Semester. The Instructor keeps the document projector in his possession and brings it into the classroom. The document projector also allows the Instructor to show Cadets the text book pages, good examples of Student Cadet work, etc. Tools and equipment such as the machinist clamp can be measured under the projector and all the class can see, on the
classroom screen, the Instructor’s measuring of the clamp.

8. **ASSESSMENT AND GRADING**

The grading of the Cadets performance in the course is broken down as follows:

- Weekly assignment, class exercises: 40%
- Quizzes: 15%
- Midterm Exam: 20%
- Final Project: 25%

The grading of the Cadet’s individual manual drafting exercise is divided into ten categories, each category worth a total of 10 points for a total of 100 points. These categories are:

- Drawing details, centering, and proper views
- Accuracy, squareness, and scale
- Line quality and weight
- Dimensioning and Arrows
- Lettering quality, strokes, slanting of letters, size of lettering
- Notes and symbols
- Neatness and drafting skill
- Borders, Title Block, Title, Name, Date
- Following directions
- Inking

Grading the drawing exercises, with such a standard of grading, keeps the Cadet striving for satisfactory or better than satisfactory work.

The quizzes and exams are multiple choice and fill-in-the-blank type questions. They may be supplemented by requiring the Cadet to complete a drawing exercise for the quiz or exam. The Cadets that are below satisfactory are warned at the mid-point of the semester and welcomed to seek individual tutoring either thru the Academy student tutoring programs or individual extra instruction from the Instructor.

9. **CONCLUSIONS**

The purpose of writing this paper was to give the reader insight into the awards and pitfalls of such a drafting course and to give the readers of this paper guidelines to setting up a drafting course for the purpose of STCW requirements. The students are starting the course as Freshmen Cadets. Their focus and maturity is not always to be counted upon. Having an efficient and quick-paced drafting course is key in relating to these new Cadets. The drafting course is given in the Fall semester, only. However teaching of the course is almost a year-round endeavour. The Instructor must strive to increase his or her skill level. This includes procuring and perfecting manual drafting techniques and drafting tools, as well as learning CAD programs and techniques. The pay-off to this “year-round” job is seeing a Cadet progress thru the drafting course and finish with a drafting and CAD skills “tool bag”. A skills “tool bag” that will serve the Cadet very well in the future and becomes a sense of pride for the Cadet.