Drafting the Basics

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Abstract

This paper outlines the work in progress undertaken by the School of Engineering Technology faculty to identify, assess, and develop a course to address the depth and breadth of drafting/plan preparation and plan reading skills required by the various engineering technology programs offered at Youngstown State University. The methodology used to establish course outcomes and the techniques proposed to accomplish the outcomes are identified. Metrics are developed to evaluate and assess the student's understanding and application of drafting basics.

INTRODUCTION

Most first-year engineering and engineering technology students enter college having had some training or a formal course in computer-aided drafting (CAD) in high school. When CAD courses were originally developed, they were being taught to students who had a background or knowledge in basic technical drafting. With most of the high schools and colleges having discontinued courses in basic drafting the majority of first-year engineering technology students have not taken a course in basic drafting. Studies have shown that in recent years 'courses involve extensive coverage of CAD commands even at the expense of fundamental concepts in engineering concepts' (Balamuralikrishna & Mirman, 2005). Due to this absence of basic drafting skills, the first year engineering and engineering technology students are lacking an understanding of layouts, standard drafting symbols, sectioning, standard nomenclature, plan reading and have poor spatial visualization skills.

Feedback from the members of the Industrial Advisory Boards (IAB) for the various engineering technology programs at Youngstown State

University (YSU), instructors of the engineering technology capstone courses and recent TAC of ABET program evaluations, raised concerns over the students' lack of basic drafting skills and their inability to read blueprints or construction/fabrication plans. To address these issues, the first year course STECH 1505 Introduction to Engineering Technology, was revised to include a module covering basic drafting layouts and dimensioning. This change has shown some positive impact; but more importantly, it sparked discussion among the department faculty to develop a drafting/plan reading course.

This paper outlines the work in progress undertaken by the School of Engineering Technology (ENTEC) faculty to identify, assess, and develop a course to address the depth and breadth of drafting/plan preparation and reading skills required by the various engineering technology programs offered at YSU. This basic drafting course will be required for all students who have not taken a basic drafting course prior to entering the engineering technology program.

DISCUSSION

To the engineer, designer, and drafter sketches and drawings are the basic elements of communication. Henderson (1999) states that the interactive use of sketches and drawings also blends together the engineer and people with shop expertise, such as welders and designers (p27). Jerz (2001) determined that, the most prevalent competency gaps in engineering graphics were: geometric dimensioning and tolerancing, blueprint reading and tying it to CAD, shape visualization and design for manufacture. For the engineering technology student to be able to design and draft, they are certainly at a disadvantage when they lack the ability to visualize a two-dimensional drawing and read blueprints or plans. How can the student communicate with the craftsperson or workers in the trades, if they cannot sketch and visualize themselves?

IAB's have raised concerns regarding the students' depth and breadth of understanding and abilities to communicate graphically. IAB's noted that recent engineering technology graduates that they have hired are lacking in their abilities to read blueprints/plans, in their knowledge of the standard symbology used on drawings, and knowing and understanding the components that comprise a set of blueprints. Within the Civil and Construction, Electrical, and Mechanical Engineering Technology programs at YSU, the instructors have commented that many students do not understand how to prepare a simple sketch to graphically convey their ideas. The students lack the necessary training, skills, and abilities to visualize the three-dimensional reality based on two-dimensional drawing.

The student's ability to "manipulate an object in an imaginary 3-D space and create a representation of the object from a new viewpoint" is known as spatial visualization (Strong & Smith, 2002). Studies by Sorby (1996) and McGee (1979) emphasize the correlation between an individual's visualization skills and with success in engineering and mathematics (pp 13-20 & 889-918). With the continual upgrading of engineering graphic software (e.g. solid modeling, building information models, etc.), the impact of the student's visualization abilities will be even greater. Engineering design instructors noted that the students trained on CAD systems consistently made identical errors by leaving out critical lines in electronic renderings of manufactured parts (Henderson). Recognizing that students' are entering engineering technology programs lacking the basic drafting knowledge, and that these skills are needed to succeed in college and in their professional careers, the introductory CAD course has been divided into two modules. The first module, Drafting and Design Technology (DDT) 1503 – AutoCAD 1, is the two dimensional CAD component of the course. The second module is DDT 1504 – Drafting and Plan Reading (Figure 1). This module is designed to improve the students' ability to visualize spatially which, as pointed out by Yue (2002), is a fundamental requirement to comprehend graphics and drawings. Students are required to take DDT 1503 and DDT 1504, concurrently.

In preparing the material to be covered in DDT 1504 – Drafting and Plan Reading, three primary course objectives were identified. First, to expose the engineering technology students to the various components which make up a standard set of plans. Students learn and recognize these various components which will help them see the necessity to have an understanding of the other engineering disciplines, outside of their major, in order to communicate with each other in the professional realm. Second, students learn to distinguish and understand standard drafting symbols used in various engineering disciplines, so that they can better understand all types of drawings. Lastly, students learn to be proficient in reading a set of building plans so that they see the big picture when they look at a set of plans. These objectives are in line with the national trends that were found in industry and education and that should be covered in introductory courses, such as our DDT 1504, namely; visualization, dimensioning, multi-views, working drawings, section

Figure 1: DDT 1504 Drafting & Plan Reading Syllabus

DDT 1504 - DRAFTING & PLAN READING

CLASS SCHEDULE

Week	Topic
1	Drafting: Principle views & Orthographic & Isometric Projections
2	Drafting: Principle views & Orthographic Projections – cont'd
3	Dimensioning, Line types & weights, drafting scales, tolerances
4	Section Views / Details, Standard drafting symbols (applied to mechanical, civil and electrical **Quiz #1**
5	Drafting standards: Title blocks / borders
6	Drafting standards: Grading & Contours (considering civil, mechanical, & electrical)
7	Drafting standards: Grading & Contours – cont'd.
8	Drafting standards: Foundation layout & drafting (structural considerations, plumb ing, & electrical stub-ups)
9	Drafting standards: Foundation layout & drafting – cont'd. **Quiz #2**
10	Drafting standards: Building layout & drafting (structural, mechanical, & electrical)
11	Drafting standards: Building layout & drafting – cont'd.
12	Drafting standards: Floor plans, mechanical & electrical plan views, elevation views, wall sections **Quiz #3**
13	Plan reading – putting it all together (civil/structural, mechanical & electrical)
14	Plan reading – putting it all together (civil/structural, mechanical & electrical)
15	Plan reading – putting it all together (civil/structural, mechanical & electrical)
Final	**Final Exam**

and auxiliary views (Branoff, Hartman & Wiebe, 2001).

DDT 1504 – Drafting & Plan Reading

Fatzinger (2004) notes that plans or blueprints serve two purposes: to establish a picture of the structure or design element in one's mind; and to show the necessity for coordination between the various trades so that the structure can be finished with fewest problems and the most cooperation (preface). The engineer lacking a graphics background will struggle to communicate across the engineering fields. As noted by Hansberry and Lopez (2005), graphics is the universal language that unifies the engineering professions. Graphics is a universal language for communicating among applied and research engineering, engineering technology, designers, drafters and technically trained people worldwide.

The best way to learn how to read drawings is to learn how to prepare drawings. In a report published by The Spanish Ministry of Science (2004), in conjunction with the European Union, it was stressed that the development of visualization skills, or the ability to picture three-dimensional shapes in the mind's eye, is one important objective of engineering graphics basic courses. Understanding that students who lack the basic drafting skills and visualization ability are at a tremendous disadvantage, the first third of the semester focuses on these basic skills. Therefore the first set of outcomes the students gain, are the understanding and ability to:

- Learn the difference between orthographic and isometric projections.
- Draw the principle views in an orthographic project.
- Draw an isometric view.
- Proper dimensioning
- The different types of tolerance fits and dimension a tolerance fit
- Draw sections and details
- Recognize standard drafting symbols.

How will the students gain this basic drafting knowledge? In-class lecture will utilize existing drawings that have been professionally prepared for actual projects, which will serve as visual examples for the students. Homework assignments will consist of drawing orthographic and isometric projections, dimensioning of various parts, dimensioning a tolerance fit, drawing section views and details, and placing drafting symbols on existing drawings.

Once the basics of drafting are covered and the students are able to visualize simple sketches/drawings, instruction focuses on the various types of drawings that are used in business.

Because this course is a required to be taken by all of the engineering technology students, the second set of outcomes incorporates the basic format of a drawing as well as the various types of drawings as follows:

- Drawing borders and title blocks
- Contours and grading drawings
- Foundation layouts
- Site development

How will these outcomes be accomplished? By studying, in-class, actual drawings of the various types the students will understand each type of drawing and the basic layout of a drawing. The students will also be given homework working with the various types of drawings. With the in-class work and homework assignments the students will become more proficient at the basics of drafting while learning the different types of drawings included in a set of plans.

Students will complete the semester by putting it all together, which is the third and final set of outcomes for the course, these being:

- Interpret building/facility layout (structural, mechanical, and electrical)
- Interpret structural plans
- Interpret floor plans (including mechanical and electrical plans)
- Interpret elevation and wall sections

In-class the students will utilize existing drawings as examples to complete in-class assignments as well as by completing a simple project, which will incorporate outcomes from the entire semester. This is accordance with the findings of Hansberry and Lopez (2005) that working plans and prints are a very effective way to provide students with practical experience in reading and making plans. After completing this module of DDT 1504 the students will have the basic necessary drafting and plan reading skills, as well as the ability to prepare a readable set of plans. Hansberry and Lopez go on to state that, "The exceptional engineer possesses the ability to make, read, and interpret plans." At the 2000 International Millennial Conference on Engineering Education it was noted that the visual communication language that engineering graduates need in order to be prepared for professional practice are; visual science, projection, space perception, standards for technical drafting, drawing techniques, sketching, and CAD (Ostrogonac-Seserko, Torralba, Inelmen & Pletenac, 2000).

ASSESSMENT

To determine whether DDT 1504 – Drafting and Plan Reading is effective an assessment skills test was developed (Figure 2). This instrument is given at the beginning of the semester and again at the end, to determine how well the students have grasped the course content. Figures 3, 4, and 5 are rubrics used to assess the outcomes that the students are expected to gain throughout the semester. Information from the assessment tests and rubrics will be used to determine whether any changes in course content or pedagogy are necessary. As these students progress, longitudinal assessment will be performed by administering additional instruments in upper level courses to see if the inclusion of the DDT 1504 course improves the students' abilities in other courses. Feedback from employers and various IABs will also be used to assess the impact of these changes on graduates' knowledge of drafting and plan reading skills.

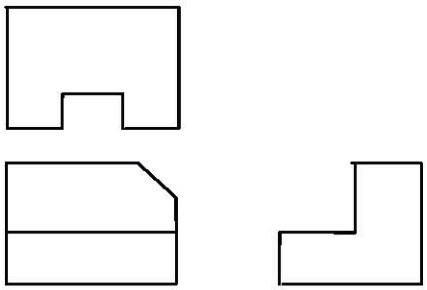
CONCLUSION

This curriculum change has recently been implemented by the Engineering Technology programs at YSU. The changes are the result of the continuous improvement process encouraged by the TC2K self-study that is part of the TAC-ABET program accreditation process. Achieving a higher level of competency in visualization and plan reading has been identified as an important outcome. Development and implementation of DDT 1504 – Drafting and Plan Reading is an important step in achieving that outcome. The assessment instruments and follow-up evaluation of results will provide evidence regarding the effectiveness of this strategy.

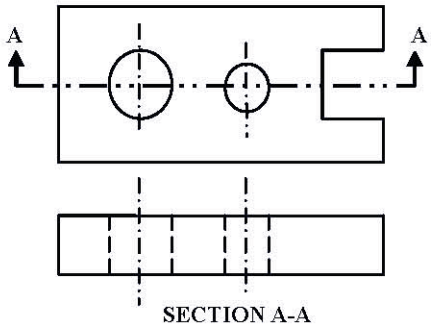
Figure 2: Examples of Assessment Skills Test

1) Draw the line types listed below:
   a) Hidden line:
   b) Centerline:
   c) Break line:
   d) Phantom line:

2) Drafting: Fill in the missing lines in the drawing below.



3) In the drawing below, complete the sectioned view.



4) Dimension the following drawing for fabrication.

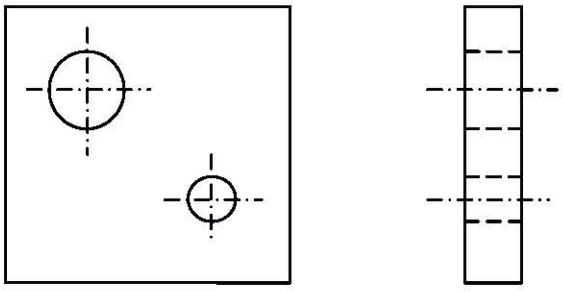


Figure 3: Basic Drafting Outcomes Assessment

Quiz 1 – First set of outcomes

Outcome a. – An appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines

Metric & Weight (W)	Unacceptable (Score, S=0)	Marginal (Score, S=1)	Acceptable (Score, S=2)	Exceptional (Score, S=3)	Points (P) P = W*S
1) Demonstrate ability to detail, dimension, & specify tolerances on engineering drawings. (W=2)	Does not understand how & when details are required Poor at applying dimensioning requirements in drafting Poor ability in incorporating & specifying tolerances on drawings.	Understands how & when details are required, but unable to complete detail views. Good at applying dimensioning requirements in drafting Understands & good at incorporating & specifying tolerances on drawings.	Comprehends & very good at applying how & when details are required. Very good at dimensioning requirements on drawings. Comprehends & very good at incorporating & specifying tolerances on drawings.	Excellent at understanding of when details are required & how to create detailed drawings. Excellent at dimensioning drawings. Excellent at incorporating & specifying tolerances in drawings.	
2) Utilize and apply the principles of sections to draw sectional views. (W=2)	Does not understand the principles of sections & drawing of sectional views.	Understands the principles of sections & can draw simple sectional views.	Comprehends the principles of sections & is very good at drawing sectional views.	Excellent understanding of the principles of sections & drawing sectional views.	
3) Understand & ability to draw principle orthographic views. (W=1)	Does not understand the principles of primary auxiliary views.	Good understanding of principles of primary auxiliary views.	Understand very well the principles of primary auxiliary views.	Excellent understanding of the principles of primary auxiliary views.	
4) Understand the standard engineering symbols & prepare engineering diagrams (W=2)	Does not understand standard engineering symbols & preparation of engineering diagrams.	Good understanding of standard engineering symbols & preparation of engineering diagrams	Very good comprehension of standard engineering symbols & preparation of engineering diagrams.	Excellent comprehension of standard engineering symbols & preparation of engineering diagrams.	
Total Points (TP=ΣP)					

Overall Performance Criterion: TP≥11	Unacceptable 0≤TP≤4	Marginal 5≤TP≤10	Acceptable 11≤TP≤16	Exceptional 17≤TP≤21

Figure 4: Drawing Types Outcomes Assessment

Quiz 2 – Second set of outcomes

Outcome a. – An appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines

Metric & Weight (W)	Unacceptable (Score, S=0)	Marginal (Score, S=1)	Acceptable (Score, S=2)	Exceptional (Score, S=3)	Points (P) P = W*S
1) Demonstrate understanding of the contents of a title block. (W=2)	Does not understand what is contained within the title block	Able to list some of the items contained within a title block	Ability to list most of the items contained within a title block.	Excellent understanding of what is contained within a title block.	
2) Understands and ability to interpret grading & contour plans. (W=2)	Does not understand & inability to interpret grading & contour plans	Understands & can somewhat interpret grading & contour plans.	Comprehends and can most of the time interpret grading & contour plans.	Excellent understanding & ability to interpret grading & contour plans.	
3) Understands and ability to interpret bldg. foundation plans. (W=1)	Does not understand & inability to interpret bldg. foundation plans.	Somewhat understands & can interpret bldg. foundation plans.	Comprehends and can most of the time interpret bldg. foundation plans.	Excellent understanding & ability to interpret bldg. foundation plans.	
4) Understands and ability to interpret site development plans (W=2)	Does not understand & inability to interpret site development plans.	Somewhat understands & can interpret site development plans.	Comprehends and can most of the time interpret site development plans.	Excellent comprehension & ability to interpret site development plans.	
Total Points (TP=ΣP)					

Overall Performance Criterion: TP≥11	Unacceptable 0≤TP≤4	Marginal 5≤TP≤10	Acceptable 11≤TP≤16	Exceptional 17≤TP≤21

Figure 5: Plan Reading Outcomes Assessment
Quiz 3 – Third set of outcomes
Outcome a. – An appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines

Metric & Weight (W)	Unacceptable (Score, S=0)	Marginal (Score, S=1)	Acceptable (Score, S=2)	Exceptional (Score, S=3)	Points (P) P = W*S
1) Demonstrate ability to interpret bldg/ facility layout (structural, mechanical & electrical). (W=2)	Does not understand & inability to interpret bldg. facility layouts w/ respect to structural, mechanical, & electrical.	Somewhat understands & can interpret bldg. facility layouts w/ respect to structural, mechanical, & electrical.	Comprehends & can most of the time interpret bldg. facility layouts w/ respect to structural, mechanical, & electrical.	Excellent comprehension & ability to interpret bldg. facility layouts w/respect to structural, mechanical, & electrical.	
2) Demonstrate ability to interpret structural plans. (W=2)	Does not understand & inability to interpret structural plans.	Somewhat understands & can interpret structural plans.	Comprehends and can most of the time interpret structural plans.	Excellent comprehension & ability to interpret structural plans.	
3) Demonstrate ability to interpret floor plans, including mech. & elec. (W=1)	Does not understand & inability to interpret floor plans including mech. & elec.	Somewhat understands & can interpret floor plans including mech. & elec.	Comprehends and can most of the time interpret floor plans including mech. & elec.	Excellent comprehension & ability to interpret floor plans including mech. & elec.	
4) Demonstrate ability to interpret elevation views & wall sections. (W=2)	Does not understand & inability to interpret elevation views & wall sections.	Somewhat understands & can interpret elevation views & wall sections.	Comprehends and can most of the time interpret elevation views & wall sections.	Excellent comprehension & ability to interpret elevation views & wall sections.	
Total Points (TP=ΣP)					

Overall Performance Criterion: TP≥11	Unacceptable 0≤TP≤4	Marginal 5≤TP≤10	Acceptable 11≤TP≤16	Exceptional 17≤TP≤21

References

Balamuralikrishna, R., & Mirman, C. (2005). Adopting a systems approach to design a freshman course in technical graphics – meeting the societal need for articulation. Proceedings of the 2005 American Society for Engineering Education Conference. Portland, Oregon.

Branoff, T., Hartman, N., & Wiebe, E. (2001). Constraint-based, three-dimensional solid modeling in an introductory engineering graphics course: Re-examining the curriculum. Proceedings of the 2001 American Society for Engineering Education Conference. Albuquerque, New Mexico.

Contero, M., Naya, F., Pedro C., & Saorin, J. (2004). Learning support tools for developing spatial abilities in engineering design. Spanish Ministry of Science and Education.

Fatzinger, J.A.S. (2004). Blueprint reading for construction. Ohio: Prentice Hall.

Hansberry, E., & Lopez, G. (Eds). (2005). Avoiding graphic illiteracy: Incorporating architectural graphics into the engineering curriculum. Proceedings of the 2005 American Society for Engineering Education Conference. Portland, Oregon.

Henderson, K. (1999). On line & on paper. Massachusetts: MIT Press.

Jerz, R. (2001). How CAD forces changes to engineering graphics education. Proceedings of the 2001 American Society for Engineering Education Conference. Albuquerque, New Mexico.

McGee, M.G. (1979). Human spatial abilities: Psychometric studies and environmental, genetic, normaonal, and neurological influences. Psychological Bulletin, 86, 889-918.

Ostrogonac-Seserko, R., Torralba, M., Inelmen, E., & Pletenac, L. (2000). Visual communication curricula for the global engineering. Proceedings of 2000 International Millennial Conference on Engineering Education. Philippines.

Strong, S., & Smith R. (2002). Spatial visualization: Fundamentals and trends in engineering graphics. Journal of Industrial Technology, 18 (1), 1-6

Sorby, S.A., & Baartmans, B. (1996). A course for the development of 3D spatial visualization skills, The Engineering Design Graphics Journal, 60 (1), 13-20

Yue, J. (2002). Spatial visualization skills at various educational levels. Proceedings of the 2002 American Society for Engineering Education Conference. Montreal, Canada.