A Curriculum Model: Engineering Design Graphics Course Updates Based on Industrial and Academic Institution Requirements

R. A. Meznarich.
R. C. Shava
University of Nebraska at Kearney

S. L. Lightner
Western Kentucky University

ABSTRACT

Engineering design graphics courses taught in colleges or universities should provide and equip students preparing for employment with the basic occupational graphics skill competences required by engineering and technology disciplines. Academic institutions should introduce and include topics that cover the newer and more efficient graphics techniques and technologies developed through research by academic institutions and professional organizations as well as information obtained from experienced engineering design graphics practitioners. This paper presents the systematic approach used at the University of Nebraska at Kearney (UNK), Department of Industrial Technology (ITEC), to update and improve its existing multidiscipline engineering design graphics course.

Twenty five engineering design graphics course syllabi, all from programs accredited by either the Association of Technology, Management, and Applied Engineering (ATMAE) or the Accreditation Board for Engineering and Technology (ABET), were reviewed in this study. A review of the course syllabi identified 20 of the most commonly taught engineering design graphics topics. The 20 topics were used to develop a survey instrument subsequently sent to the top 10 employers of ITEC students majoring in Construction Management, Industrial Distribution, and Telecommunications Management. The results obtained from the employer survey were analyzed and used to update the introductory engineering design graphics course at UNK so that engineering design graphics topics taught are consistent with academia and kept current and relevant to the needs of industry.

Introduction

In his article, "Towards a working philosophy of adult education," Apps indicates that we are not all agreed on what is to be taught (Apps 1973). Things are little different within the design engineering graphics field. What is to be taught continues to be the subject of continued research.

Many introductory engineering design graphics courses are designed to be "one size fits all" and that is the case within the Department of Industrial Technology (ITEC) at the University of Nebraska at Kearney (UNK). The engineering design graphics course, part of the "core" curriculum, is designed to meet the needs of ITEC's four programs, Aviation Systems Management, Construction Management, Industrial Distribution, and Telecommunications Management. Students typically take the course in their freshmen or sophomore year.

There have been many important developments in the field of engineering design graphics. One of the most significant has been the unprecedented shift from manual drafting to computer-aided design and drafting (CADD) techniques in producing engineering drawings. The engineering drawing is the traditional communication link between the design and manufacturing processes.

How to best update the existing course and to ensure it continues to meet the diverse needs of four different disciplines is the focus of this paper. Any changes to the course content must continue to meet the requirements and practices of industry in the 21st century and specifically meet the needs of those companies that hire our graduates.

Determining the content, or change in content, of an engineering design graphics course presents two challenges. What should the course contain to prepare students to be successful going forward into more advanced coursework? How in-depth should the course be and yet be useful to students not planning on advanced coursework? Identification of common course topics is necessary when developing or updating a multi-discipline engineering design graphics course.

Development or improvements of any engineering design graphics curriculum revolves around three major criteria. First, students must have a hands-on experience of drafting techniques, drafting standards, conventions and a thorough understanding of 2D CADD. Second, the curriculum should expose students to practical engineering graphics skills and knowledge about how various design components and systems relate and work together on any given project. Doing so will better prepare students for employment. Students are expected to develop problem solving skills and the ability to think, see, create and model 3D visual images in space or on paper from 2D blueprints using CADD or other forms of media. Carkhuff (2006) reported that instructors believe most students learn spatial visualization concepts better through parametric modeling technology first before orthographic projection. And third, students should be exposed to emerging trends in technical graphics, developments in industrial technologies and advancement in computer technology (Bradford, Simms, Chip, Ferguson, & Birnberg, 2006).

To arrive at what should be taught Barr (1999) expressed the need for a nationally based curriculum development team of highly motivated engineering design graphics faculty to establish the content and methodology for teaching engineering design graphics. He presented 32 topical areas to be taught from most to least importance. Meyers (2000) also addressed Barr's list of 32 topical areas in his discussion of a first year engineering graphics curricula in major engineering colleges. The topical areas noted by both Barr and Meyers compares favorably with the 20 topical areas identified and studied in this paper.

In a study by Branoff, Hartman, & Wiebe (2003) of companies in Raleigh, North Carolina, the highest ranked topics were assembly modeling, constraint-based modeling, modeling strategies, 3D geometric primitives, and orthographic projection. Cumberland & Miller (2001) report-

ed that engineering graphics programs should include the topics of macro programming, data translation, file and data management, CAD standards, constraint-based solid modeling, web technologies, simulation and animation, internships, collaboration, and a study of current trends and issues. Clark & Scales (1999) reported that 3D parametric modeling was the most important future trend identified by respondents. In a subsequent study Clark & Scales (2001) reported that 3D and 2D CAD dominates with over 50 percent of respondents to their study indicating that CAD/CAM is being taught at their institutions. Animation was being taught at over 25 percent of the institutions surveyed. Croft (1998) discussed if there was a need for descriptive geometry in a world of 3D modeling. His opinion was a resounding YES! Croft stated, "Descriptive geometry using CAD techniques requires an even greater command of spatial relationships than what is required for traditional projective geometry." Feedback received from our advisory committees, especially within the Construction Management program, substantiate Croft's and others findings. Although Croft feels there is a continuing need for descriptive geometry, it seems fewer and fewer university programs in the country include the topic (Clark & Scales, 2001).

Engineering design graphics drafting and drawing standards continue to change as a direct result of trends in manufacturing and construction methodologies as well as accreditation requirements. Some drafting standards are unique to particular fields. For example, drafting standards in the construction industry may vary considerably from those in automotive or manufacturing areas. In the construction industry, standards may describe how a company may assemble a set of plans; stipulate all the details they want to show on the plans, how they show them, and where they can be found on the set of blueprints. However, there are some drafting standards that are common to most engineering and technology areas of specialization.

In order to eliminate communication ambiguities, it has become imperative that industry engineers, designers, scientists and technologists come up with methods to standardize the characters of the graphics language (Dygdon, Hill, Giesecke, Mitchell, Novack, & Spencer, 2003). Most countries have either completely or partially adopted with minor changes the standards established by the International Organization for Standardization (ISO) Technical Subcommittee 10 (TC 10). In the United States, the American Society of Mechanical Engineers (ASME) is the governing body that establishes engineering drafting and design standards through its ASME Y14 committee (Jensen, Helsel, & Short, 2002).

The American National Standards Institute (ANSI), working together with the ASEE and the Society of Automotive Engineers (SAE), sponsored and prepared the American National Standard Drafting Manual-Y14 (Dygdon, Hill, Giesecke, Mitchell, Novack, & Spencer, 2003). Members of the ASME Y14 also serve on the ISO TC 10 subcommittee. The UNK engineering design graphics course exposes students to a variety of drafting and design standards established by ASME Y14/ANSI together with other specific professional or trade standards. This helps students appreciate the need for the class and the importance of having a working knowledge of engineering drafting and design standards.

A number of academic institutions offer engineering design graphics courses common to all engineering and technical programs. The challenge is how best to identify those common drafting standards/topics common to most engineering and technology disciplines and how they can be taught to develop basic occupational design graphics skill competencies. Once the common drafting standards and topics are identified it is possible to develop an engineering design graphics course that can be taught within multi-disciplined engineering and technology programs.

Employers of ITEC graduates expect a certain level of engineering design graphics proficiency from new employees. And they expect educational institutions to adequately prepare students

with basic knowledge. It appears, from a review of the published literature discussing engineering design graphics curricula, that most of us seem to be more or less on the same page with what should be taught in a freshman entry level engineering design graphics course.

Existing Introductory Engineering Design Graphics Course

The engineering design graphics course taught at UNK introduces all ITEC majors (Aviation Systems Management, Construction Management, Industrial Distribution and Telecommunications Management) to the fundamentals of engineering design graphics and different sets of drafting standards used by engineering and technology disciplines. The course seeks to fuse basic and contemporary principles of CADD together with traditional and newer engineering drawing and modeling concepts for the purpose of solving technical problems. Application of graphics knowledge is one of the main methods of "thinking" that designers use to solve and communicate ideas. Students then move to more advanced and specific engineering graphics courses in their areas of specializations.

The ITEC Department draws from both the Association of Technology, Management, and Applied Engineering (ATMAE), previously known as the National Association of Industrial Technology (NAIT), and the Accreditation Board for Engineering and Technology (ABET) accreditation standards in the development of its engineering design graphics course. To demonstrate a level of professionalism and proficiency, the industrial technology programs at UNK that utilize the engineering design graphics course are all accredited by ATMAE.

The rationale behind the course is to assure that upon successful completion, students will have acquired the ability to think and communicate graphically; a skill that promotes the creative use of the computer for technical problem solving. The ability of an individual to effectively create and read blueprints is critically important to any building contractor, sub-contractor, manufacturer, material supplier, sales representative, quantities estimator, machinist and many others involved in any project. An understanding of working drawings, the main goal of the course, helps control cost in many ways and also serves as an effective communication tool in today's competitive global economy (Neumann, 2006). The 14 key student outcomes for the course are shown in Table 1.

Student Outcomes
Interpretation and Use of Blueprint Reading
Apply Computer Science Applications
Utilize Drafting/Mechanical Drawing
Apply Personal Computer Skills
Demonstrate Technical Expertise
Comprehend the Latest Technology
Understand Geometric Tolerancing
Apply High Technical Skills
Apply Knowledge of Drafting and CAD
Use Appropriate Vocabulary
Communicate in Technical Terms
Understand and use Appropriate Product and Performance Standards
Utilize the Computer as a Tool for Daily Tasks
Distinguish between Various Computer-Based Design Techniques and Systems

Table 1

Methodology

A committee comprising seven faculty members representing the four ITEC programs, through a series of brainstorming sessions, reviewed the existing engineering design graphics course with the goal of providing recommendations for its improvement. Faculty discussions were focused on determining if the existing course was consistent with what other academic institutions were teaching in their beginning engineering design graphics course and if it was consistent with the requirements of those companies who recruit students from our programs.

The outcome of these discussions was a faculty proposal to conduct a study of academic institutions teaching engineering design graphics along with a study of requirements of those companies that hire ITEC students. The study involved reviews of course syllabi from different academic

institutions offering similar programs along with surveying companies who recruit ITEC students on the UNK campus. The goal was to solicit as much information as possible on common course topics, areas taught and company requirements.

Once course syllabi from academic institutions were reviewed and the most common topical areas being taught were identified, a survey instrument was developed and sent to employers who hire and/or offer internship programs to students in the Department. Information was sought on what employers believe the Department should be teaching based on syllabi topic preferences identified from academia. Identified topics that satisfy basic occupational skill competencies preferred by employers as well as contemporary topics offered by academic institutions were to serve as the basis for updating the existing multi-discipline engineering design graphics course.

Syllabi Review – Academic Institutions

Syllabi from 25 academic institutions offering industrial technology or engineering technology programs were reviewed to determine which engineering design graphics topics/areas were being emphasized and most commonly taught from the hundreds of individual topics listed in course syllabi. All selected academic institutions in this study had their programs accredited by either ATMAE or ABET. The top 20 key engineering design graphics introductory topics/areas (Table 2) identified in the syllabus review served as the basis for the survey instrument sent to employers who hire and/or offer internship programs to students in the Department.

Employer Survey

The 20 most popular engineering design graphics topics identified through syllabi reviews (Table 2) were used to generate a survey instrument that was sent to the top 10 employers in each of the programs within the Department with the exception of Aviation Systems Management. The Aviation Systems Management program currently has a limited number of students as well as potential employers.

The Construction Management program at UNK prepares students with a strong technical and managerial foundation in residential and light commercial construction techniques and processes. Companies completing the survey included national and regional residential and light commercial construction companies. Students taking employment with these firms are typically hired as construction project managers/engineers/superintendents.

The Industrial Distribution Program at UNK prepares students for careers in technical sales and management. Companies completing the survey included manufacturers and distributors of a wide variety of industrial product lines consisting of electrical, material handing, fasteners, electrical and electronics connectors, water and wastewater equipment, hydraulics and pneumatics, swimming pool supplies, building products, machine tools, cutting tools, power tools and MRO supplies. Students taking employment with these firms are typically hired as inside/outside technical sales representatives/account managers/management trainees.

The Telecommunications Management program at UNK prepares students to design, install, maintain, expand, and manage voice, video, and data networks. Companies completing the survey included telecommunications companies, printing companies, public school districts, municipalities and hospitals. Students taking employment with these firms are typically hired as network technicians/engineers/administrators.

Key Engineering Design Graphics Topics Taught in Academia
Technical Graphics (Importance of Technical Graphics & Drawing to Industry)
Design Process
Integrated Design (2D/3D CADD)
Manual Drafting & Design (Pen and Paper)
Spatial Visualization (2D/3D Drawings and Interpretation)
2D/3D Geometry (Point/Line/Area/Volume Concepts & Graphical Illustrations)
Boolean Operators (addition/subtraction/union of solids)
Multi-View Drawings (Orthographic Projections, including Auxiliary Views)
Axonometric (e.g. Isometric/Perspective/Oblique Drawings
Sectional Views
Limits, Fits & GDT (Geometric Dimensioning & Tolerancing)
Thread/Fastener/Spring/Gear (Graphical Representation/Language)
Rendering
General Dimensions/Text Styles
Computer Literacy & File Formats (Basic Hardware/Software knowledge as it pertains to CADD/Graphics)
Parametric Modeling (Creation of Intelligent 3D Virtual Solids/Components)
Import & Export CADD Files (On-Line, Collaboration, Interoperability)
Document Creation & Management (Engineering Graphics Documentation)
Printing/Plotting
Blueprint Reading (Knowledge of Basic Graphical Language: Standards, Symbols & other forms of detailing in compliance with ISO, ANSI, ASME, AIA, CSI, IEEE, ACCE, etc. requirements)

Table 2

Responses were received from 27 of 30 employers, a 90 percent response rate. The data was summed by industry specialization providing a picture of what employers in Construction Management, Industrial Distribution and Telecommunications Management perceived as important. Employer data, perceived importance, was then compared against the most popular engineering design graphics topics being taught at the 25 academic institutions with similar accreditation status as UNK. Topic preferences by employers and academic institutions were calculated as percentages and the results analyzed. This provided a picture of what academia thought to be important and what employers of ITEC students thought was important or unimportant.

Academia Preference vs. Employer Preference

Topics that most academic institutions were teaching were compared to cumulative employer preferences. To be classified as important fifty percent or more of the respondents needed to have selected the item. Results show that seven topics (Table 3) had higher topic preference percentages in academia over employer preferences indicating these topics are among the most popular in most engineering and technical fields. Due to continuous research and development in CADD at colleges and universities, academic institutions are eager to promote newer concepts such as Parametric Modeling to industry. With CADD becoming an ever more important tool in the teaching of engineering design graphics, competencies in computer skills have also become increasingly important.

Academia: Most Favored Topics	
Topic	Academia %
Integrated Design	90
2D/3D Geometry	95
Boolean Operators	79
Multi-View Drawings	84
Limits, Fits & GDT	63
General Dimensions/Text Styles	74
Parametric Modeling	59

Table 3

The results shown in Table 3 beg the question, is academia ahead of the curve and leading the way or are they out of touch with employer's requirements? This is an interesting question for further research to determine if the results of this study would be replicated by surveying different academic institutions and employers representing different industries. As this survey was answered primarily by industry executives in Construction Management, Industrial Distribution and Telecommunications Management, results could have been different if engineering practitioners rather than industry executives had been surveyed. However, the purpose of this study was to determine if UNK was in line with its employer's requirements. These results will be discussed with our advisory committees, which is comprised of both executives and engineering practitioners.

Industry executives were asked to select the most important topics, listed on the survey in-

strument, to be taught to Department students whom they ultimately recruit. When the data was tabulated considerable differences were found between academia and industry. Table 4 shows the employers most favored topics. Once again, to be classified as important, fifty percent or more of the respondents needed to have selected the item. These results indicate those areas graduates will be responsible for once they are hired. Students graduating from ITEC programs are often employed in industry as management trainees and not engineers or architects. This may have influenced our employers' preferences.

Employers: Most Favored Topics	
Topic	Employer %
Technical Graphics	57
Design Process	57
Computer Literacy & File Formats	71
Blueprint Reading	71

Table 4

Tables 5 and 6 show the correlation between academia and employer responses on key topics. For Blueprint Reading, employers hiring UNK graduates generally concur with academic institutions on the need for this emphasis. Table 6 shows disparities between academia and employers on the topics listed in the table. Academia placed a much higher emphasis on these topics then did the employers. This seems to indicate that our graduates will not need to be as proficient in these engineering design graphics skills/topics as we once believed. However, these topics form the foundation for competencies employers are looking for. Hence they should be taught albeit with lesser emphasis.

Academic Institutions vs. Employers: Most Favored Topics Correlation		
Academia %	Topic	Employer %
53	The Design Process	57
74	Computer Literacy & File Formats	71
63	Blueprint Reading	71

Table 5

Employer Least Favored Topics (<25% selection) Comparison Between Academic and Employers		
Academia %	Topic	Employer %
90	Integrated Design	24
37	Manual Drafting & Design	24
80	Spatial Visualization	5
95	2D/3D Geometry	19
79	Boolean Operators	10
84	Multi-view Drawings	24
26	Axonometric	19
74	Sectional Views	19
32	Thread/Fastener/Spring/Gear	14
11	Rendering	24
59	Parametric Modeling	10

Table 6

The least favored topics were defined as those selected by less than twenty-five percent of the respondents of either academia or industry. There are several anomalies presented in Table 6 including a vast discrepancy for Spatial Visualization as employers seem to place little to no value on this skill. Given its important in the field of engineering design graphics (Carkhuff, 2006) this seems counterintuitive. The percentage results on this topic are being skewed by the Industrial Distribution employers who did not view this as a priority. Reasons for this are unknown, suggesting further research and discussion with the Industrial Distribution advisory committee.

Construction Management Employer Preference

Table 7 shows percentage preferences between employers who hire Construction Management students with the cumulative employers' percentages on each topic. A fifty percent selection rate by either Construction Management employers or all employers was used as the determinate to include or exclude a topic. There appears to be a thread of agreement between all the employers and the Construction Management employers as to what topics are important in an engineering design graphics course.

The strongest disagreement is the topic "Axonometric/Perspective/Oblique Drawings." Given the small size of the sample no statistical tests

were conducted to determine significance of this difference. While there is a correlation on four topics listed in Table 7, four other topics were least favored by all employers when compared to Construction Management preferences. This discrepancy could be attributed to the extensive use of these competencies in the construction industry compared to other industries. A greater level of engineering design graphics skills are required of construction students before they graduate compared to other ITEC programs.

Construction Management Employers vs. all Employers: Most Favored Topics		
Construction Management %	Topic	All Employers %
57	Technical Graphics	57
57	Design Process	57
57	Integrated Design	24
86	Axonometric	19
57	General Dimensions/Text Styles	38
71	Computer Literacy & File Formats	71
71	Document Creation & Management	38
100	Blueprint Reading	71

Table 7

Industrial Distribution Employer Preference

Table 8 shows percentage preferences between employers who hire Industrial Distribution students with the cumulative employers' percentages. However, for Industrial Distribution alone, two topics were above the 50% response rate level with most of the topic preference percentages below the 30% mark. This negatively affected cumulative employer preference percentages overall.

The Industrial Distribution program is a hybrid program of technical and business subjects focused on training students for technical sales positions within the wholesale distribution industry. Given its sales and business focus, and that executives responded to the survey, this may account for the results. None-the-less, the data is consistent with regularly repeated comments from Industrial Distribution industry personnel and the advisory committee. In addition to sales skills, employers of Industrial Distribution graduates want a focus on computer literacy, business financials and blueprint reading. Since most engineering design graphics documents are created, printed and transmitted electronically, Industrial Distribution graduates need the necessary skills to import and export engineering design graphics CADD documents/files to and from various clients as they work in the industry.

Industrial Distribution Employers vs. all Employers: Most Favored Topics		
Industrial Distribution %	Topic	All Employers %
29	Technical Graphics	57
43	Design Process	57
57	Computer Literacy & File Formats	71
71	Blueprint Reading	71

Table 8

Telecommunications Management Employer Preference

Table 9 presents topic preferences by employers who hire Telecommunications Management graduates in comparison to cumulative employer preferences across all programs. Five topics thought to be most important by Telecommunications Management employers have selection rates above 50 percent. The Printing and Plotting topic showed lower percentages over other topics Telecommunications Management employers preferred important. The topics listed in Table 9 indicate that engineering design graphic skills are paramount to graduating candidates wishing to be employed in the telecommunications field. As noted in Table 9, Blueprint Reading shows a preference of 43 percent. We expected this topic be rated much higher, as it is with Industrial Distribution and Construction Management employers. This will be a topic of discussion at the next Telecommunications Management Advisory Committee.

Telecommunications Management vs. all Employers: Most Favored Topics		
Telecommunications Management %	Topic	All Employers %
86	Technical Graphics	57
71	Design Process	57
86	Computer Literacy & File Formats	71
86	Import & Export CADD Files	43
57	Printing & Plotting	29
43	Blueprint Reading	71

Table 9

The Overall "Big Picture"

Table 10 shows all 20 topics and percentage preferences by employers in each discipline, cumulative topic preference responses from the 25 colleges and universities, and cumulative topic preferences for all employers across all program areas. It is the "Big Picture" upon which all data presented in this paper is based. As shown in this table the only topic that reached the fifty percent threshold across all three groups of employers and academia was "Computer Literacy and File Formats." The Computer Literacy and Blueprint Reading topics (with the exception of Telecommunications Management) stand out for all three programs surveyed. The remaining topics are more closely aligned with each industry and their perceived importance of the topic. The Construction Management industry has a higher percentage preference – 10 topics - compared to the other two ITEC programs. The considerable disparity of topic preferences among industries makes the job of trying to teach a "one size fits all" engineering design graphics course all the more difficult.

Conclusions and Recommendations for Curriculum Change

Results from the study convinced the faculty there are topics that needed to be added, deleted, or otherwise increased or decreased in emphasis in the entry level engineering design graphics course. Some topics were preferred by academic institutions but not by employers and visa versa. It should be noted there were considerable differences among employers in the industry segments surveyed. Given the three different industries surveyed, no consensus was reached on what changes are necessary.

It is important to point out that industry professionals are not educators. Industry is more concerned with training and the bottom line – making a reasonable profit. Educators on the

The Big Picture					
Topic	Const. Mgt %	Ind. Dist. %	Telecom Mgt %	Acad. %	All Employer %
Technical Graphics	57	29	86	42	57
Design Process	57	43	71	53	57
Integrated Design	57	0	29	90	24
Manual Draft & Design	14	43	14	37	24
Spatial Visualization	14	0	0	80	5
2D/3D Geometry	14	14	29	95	19
Boolean Operators	14	0	14	79	10
Multi-view Drawings	43	14	14	84	24
Axonometric	43	0	14	26	19
Sectional Views	86	14	29	74	19
Limits, Fits & GDT	43	14	14	63	43
Thread/Fastener/Spring/Gear	14	29	0	32	14
Rendering	43	14	14	11	24
Gen. Dimensions/Text Styles	57	29	43	74	38
Computer Literacy & File Formats	71	57	86	74	71
Parametric Modeling	14	0	14	59	10
Import & Export CADD Files	29	14	86	32	43
Document Creation & Mgt.	71	0	43	16	38
Printing/Plotting	29	0	57	32	29
Blueprint Reading	100	71	43	63	71

Table 10

other hand are more concerned with "educating" students, teaching the basics behind a discipline, so students can develop and apply reasoning skills to solve problems as they arise. In the end, after discussions between the faculty and the advisory committees in each of the Department's programs, the faculty determined that it would be appropriate to make changes to the course.

New technology necessitates additional topics to be added to the engineering design graphics course. Along with recommendations from our advisory committees the faculty determined the following topics should be added to the course:

- Parametric Modeling
- Electronic File Documentation
- Document Reproduction
- Introduction to the concepts of Computer Integrated Manufacturing.
- Introduction to the concepts of Rapid Prototyping (Creation of Intelligent 3D Virtual Solids/Components)

The need for increased computer and blueprint reading skills is one of the most often discussed issues in our advisory committees across all programs. As a result, topics to receive increased emphasis include:

- Computer Literacy & File Formats
- Blueprint Reading
- Technical Graphics
- Design Process
- Limits, Fits & GDT

Topics for deletion include most topics related to manual drafting, the use of pen and paper, use of triangles, squares, compass and the like. Clearly computerized systems have replaced these skills within industry. Further, topics being decreased in emphasis include Boolean Operators and 2D/3D Geometry. However, Parametric Modeling still requires students to understand the basic concepts associated with these topics.

As a result of the study the faculty, along with discussions with their respective advisory committees, recommended to the Department Chair that the instructors responsible for the engineering design graphics course proceed to make the changes noted above and have them implemented during the 2008-2009 academic year. An additional recommendation was to move the more advanced CADD/CAM topics from the lower level course to upper division classes. This would make class time available to more thoroughly teach Computer Literacy, File Formats and Blueprint Reading.

Feedback continues to be sought and received from our industry partners. This feedback leads to the engineering design graphics course, as well as other courses in the curriculum, to undergo continuous improvement consistent with industry requirements.

References

ABET Technology Accreditation Commission, Criteria for Accrediting Engineering Technology Programs, 2008-2009 Accreditation Criteria. http://www.abet.org/Linked%20Documents-UPDATE/Criteria%20and%20PP/T001%2008-09%20TAC%20Criteria%2011-30-07.pdf

Apps, J. W., (1973). Towards a working philosophy of adult education. *Publications in Continuing Education*, Syracuse University.

Barr, R. E., (1999). Planning the EDG curriculum for the 21st century; A proposed team effort. *Engineering Design Graphics Journal,* 63(2), 4-12.

Branoff, T. J., Hartman, N. W., Wiebe, E. N., (2003). Constraint-based, solid modeling: What do employers want our students to know? *Engineering Design Graphics Journal,* 67(1), 6-12.

Carkhuff, D., (2006). Teaching drafting 101:

What comes first? *Tech Directions,* Prakken Publications, Inc., Ann Arbor, MI., 65(7), 21.

Clark, C. A., Scales, A. Y., (1999). A barometer for engineering and technical graphics education. Presented at the *ASEE Annual Conference*, Charlotte, NC.

Clark, C. A., Scales, A. Y., (2001). Assessment practices in engineering / technical graphics. *Engineering Design Graphics Journal,* 65(3), 13-24.

Croft, F.M., (1998). The need (?) for descriptive geometry in a world of 3D modeling. *Engineering Design Graphics Journal,* 62(3), 4-9.

Cumberland R. R., Miller, C. L., (2001). The foundation of a progressive engineering graphics curriculum. Presented at the *ASEE Engineering Design Graphics Division*, Mid Year Meeting, Berkeley, CA.

Dygdon, J. T., Hill, I. L., Giesecke, F. E., Mitchell, A., Novak, J. E., and Spencer, H. C., (2003). *Technical drawing.* (12th ed.). New Jersey: Prentice Hall.

Jensen, C., Helsel, J. D., and Short, D. R., (2002). *Engineering drawing and design.* (2nd. ed.). New York: Glencoe McGraw Hill.

Meyers, F. D., (2000). First year engineering graphics curricula in major engineering colleges. *Engineering Design Graphics Journal*, 64(2), 23-29.

National Association of Industrial Technology, Accreditation Handbook 2006, http://www.NAIT.org/accred/2006accreditationhandbookcomp.pdf

Neumann, R., (2006). Working drawings: The blueprints for cost control. *SMA Operations Management, LLC.* Management Message of the Week.