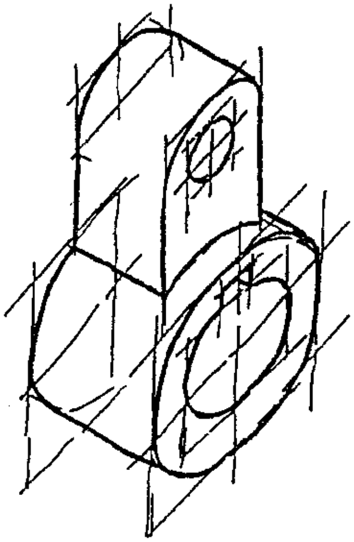
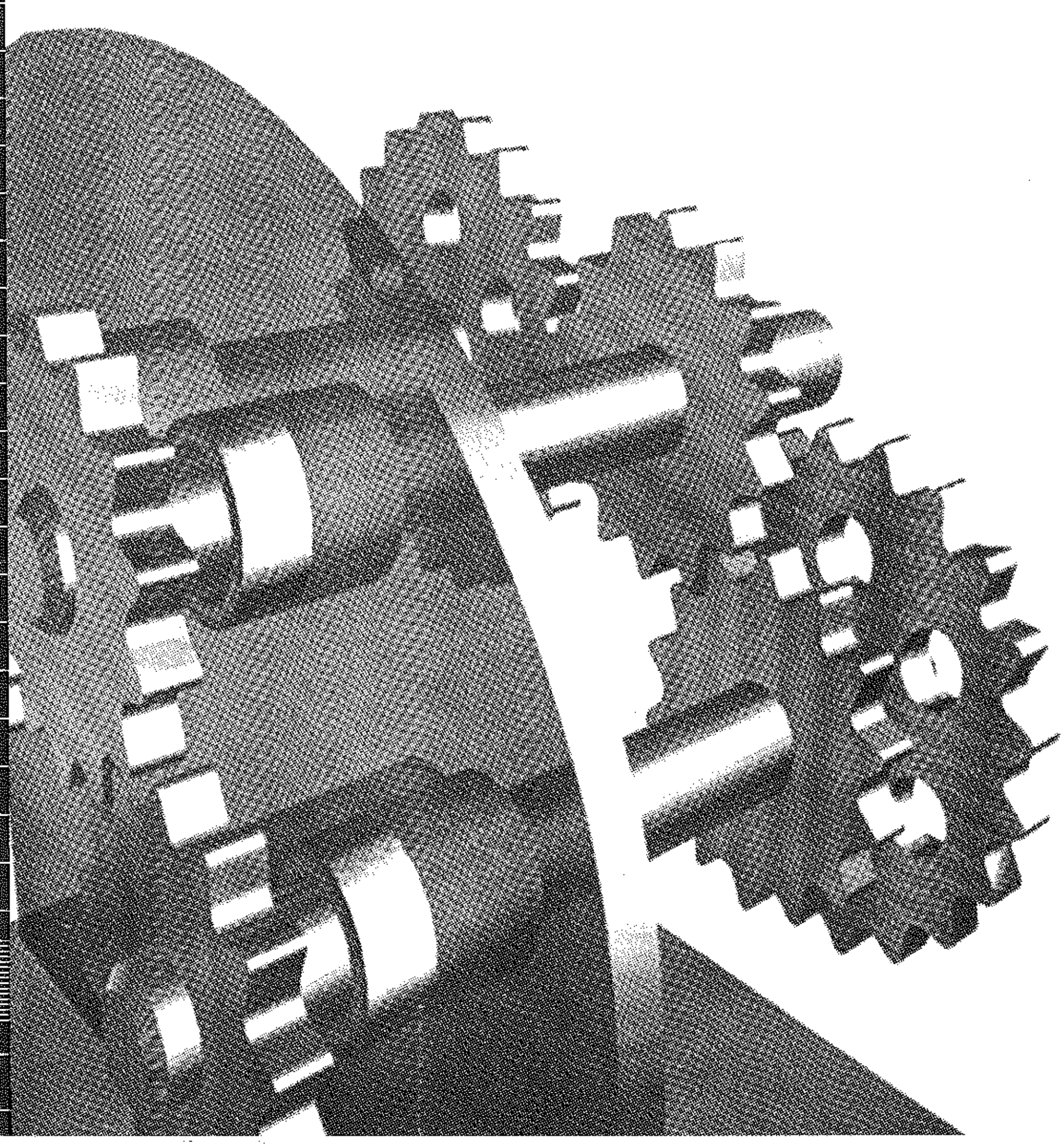
Spring 2000



The Engineering Design Graphics Journal

Volume 64 · Number 2



Engineering Design Graphics Division

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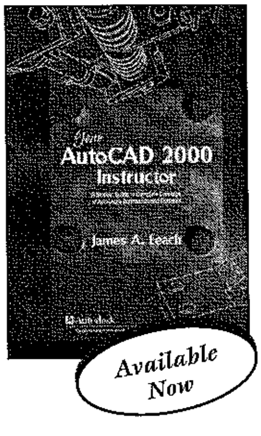

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James A. Leach, *University of Louisville*
1150 pages / ISBN 0072347619

AutoCAD 2000 Instructor covers all of the new capabilities of AutoCAD 2000 including multiple open drawings, partially loaded and partially open drawings, Polar Snap, Polar Tracking, Object Snap Tracking, Lineweight object property, Object Properties Window, AutoCAD DesignCenter, Layout tabs, Plot style, Find, and Quick dimensions.

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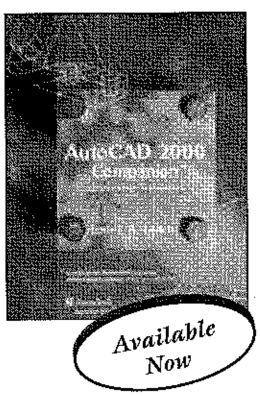
Visually-Oriented Design: uses over 1500 illustrations to support concepts, command usage, system variable settings, and procedures.



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The
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The Engineering Design Graphics Journal is the official publication of the Engineering Design Graphics Division of ASEE. The scope of the Journal is devoted to the advancement of engineering design graphics, computer graphics, and subjects related to engineering design graphics in an effort to 1) encourage research, development, and refinement of theory and applications of engineering design graphics for understanding and practice, 2) encourage teachers of engineering design graphics to experiment with and test appropriate teaching techniques and topics to further improve the quality and modernization of instruction and courses, and 3) stimulate the preparation of articles and papers on topics of interest to the membership. Acceptance of submitted papers will depend upon the results of a review process and upon the judgement of the editors as to the importance of the papers to the membership. Papers must be written in a style appropriate for archival purposes.

ISSN 0046 - 2012

Engineering Design EDGD Graphics Division

From the Editor

Dear Members:

I'll breathe a big sigh of relief after turning over this last issue of the Journal *to the printer. My three-year term as editor has come to an end. It was a lot of work but I always felt I had the support of the membership.*

I want to thank all the division members who have contributed to the Journal's *success.*

Members of the publication committee—Sue Miller my Technical Editor, who did a great job supervising the review process—Clyde Kearns, Circulation Manager who has served the Journal *diligently for many years—and Mark Bannatyne, Advertising Manager, who has spent many hours on the phone on behalf of the* Journal.

I also want to thank all the members of the review board who served during my term. Through your efforts, the Journal *remains a quality publication.*

Finally, thanks to all the contributing authors, for without you there would be no Journal. *I'm glad to report that recently, the number of papers being submitted for publication has increased. We all need to keep publishing to keep the* Journal *strong.*

Congratulations and good luck to the new publication team. Sue Miller will assume the duties of Journal *Editor. I've agreed to stay on as Sue's Technical Editor. David Kelley, who will join us at Purdue this Fall, will be the new Advertising Manager. Clyde will stay on as Circulation Manager but hopes to start training someone new for the job soon!*

See you at the Mid-year in San Antonio!

Judy Birchman

Cover illustration by Professor Bill Ross

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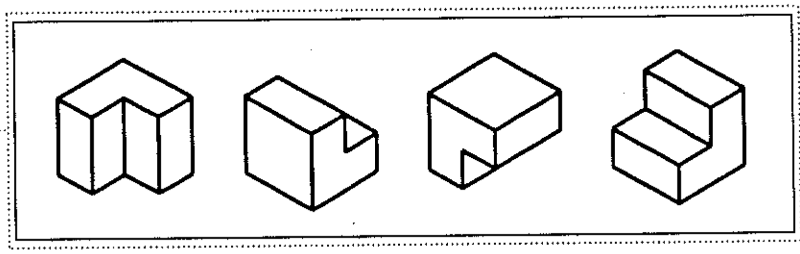

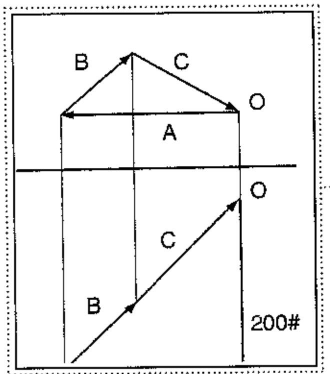

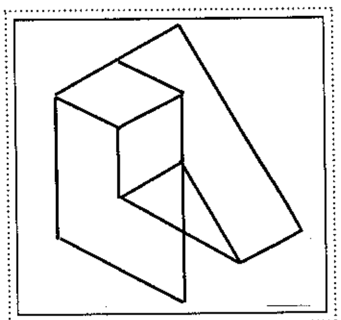

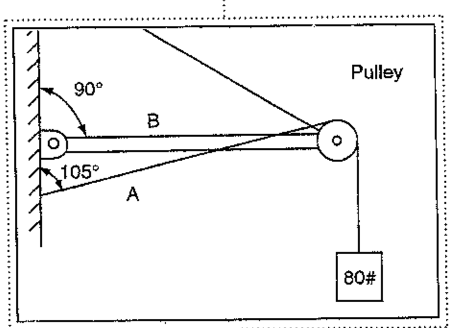

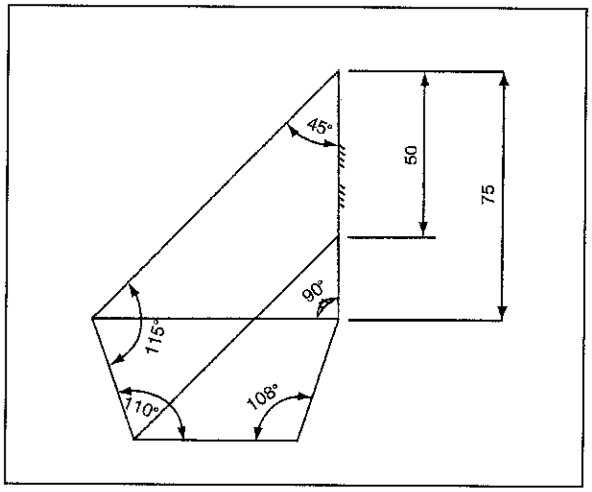

Figure 9 - *Constrained wireframe for loads in modified truss.*

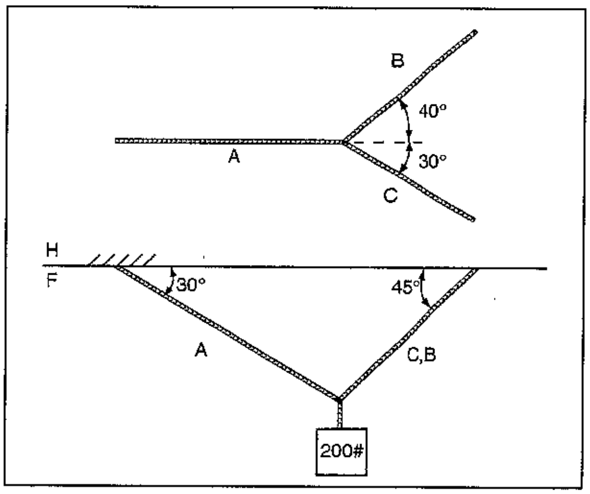

Figure 10 - *Space diagram of a concurrent non-coplanar force system - special case.*

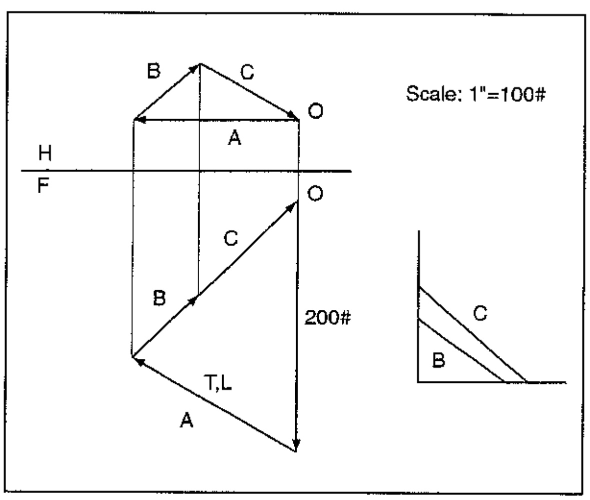

Figure 11 - *Vector polygons - traditional approach.*

and tail are aligned between the top and front views. Complete the top view of the vector polygon by placing vectors B and C parallel to their directions.

4. Project the point of intersection of vectors B and C in the top view to the front view to separate these vectors.
5. Measure the tension in cable A in the front view of the vector polygon where vector A is true length (T.L.). Construct the true-length diagram shown in *Figure 11* to determine the tensions in both cables B and C. Each of the true lengths is obtained by transferring the vertical distance between the ends of the vector to the vertical leg of the true-length diagram, and the horizontal length of the vector in the top view to the horizontal leg of the true-length diagram.

3D CAD Approach

1. Construct a triangular wireframe shown in *Figure 12* that represents the front view of the vector polygon. The wireframe is constrained by the equilibrant (200) with a vertical ground and the angles between the equilibrant and cables (60° and 45°).
2. Extrude the triangular wireframe into a solid. The thickness of the extrusion can be randomly selected. Repeat this step if the thickness is too small, which can be easily detected at the end of next step.
3. Attach a coordinate system to this solid at one of its upper corners as depicted in *Figure 13*. Sketch the second triangular wireframe, which represents the top view of the vector polygon, on Y-Z plane of the coordinate system. *Figure 14* represents the isometric and top views of the completed wireframe. The angles between cables (40° and 30°) in addition to the width of the solid are used to determine the shape and size of this wireframe.

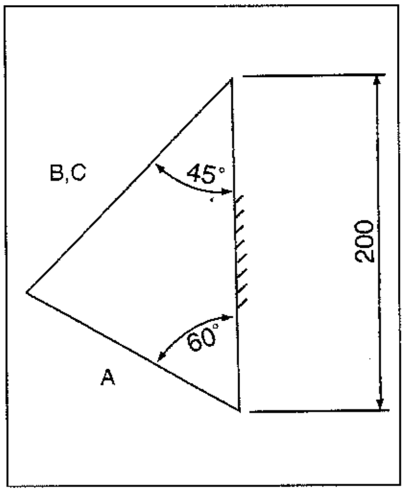

Figure 12 - Constrained wireframe - 3D CAD approach.

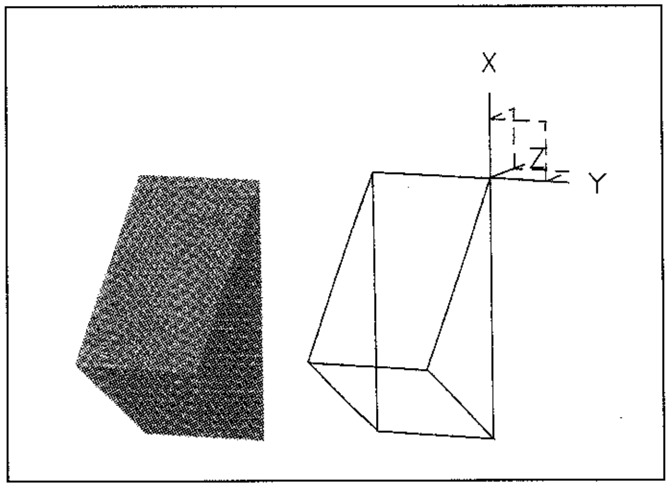

Figure 13 - Solid extruded from constrained wireframe.

4. Extrude the second wireframe by intersection to obtain the final solid shown in *Figure 15*. Measure the edges as labeled to find the tensions in cables.

Discussion

When examining the design alternatives for a non-coplanar system using 3D CAD, all the changes can be carried out by applying the "history tree" command that is ideal for quick modification of a solid. The history tree displays the sequence of commands used to model a solid part. One just has to retrieve the wireframes and change their dimensions to modify the shape and size of a solid. *Figure 16* represents such a modification. The changes include (a) the equilibrant decreases from 200 pounds to 150 pounds, (b) the angle between cable A and the ceiling in the front view increases from 30° to 40°, and (c) the angle between cables B and A in the top view increases from 40° to 45°.

Concurrent Non-Coplanar Structural Analysis: General Case

Figure 17 represents a problem of general

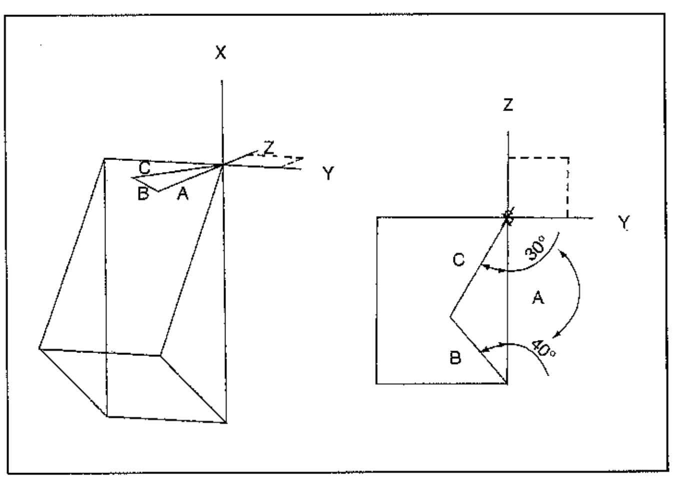

Figure 14- Constrained wireframe sketched on Y-Z plane of a coordinate system.

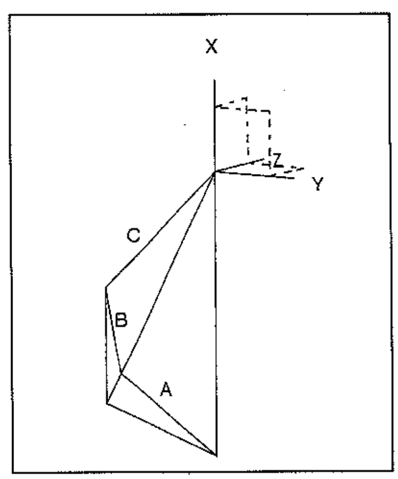

Figure 15 - Final solid model with edges representing tensions in cables.

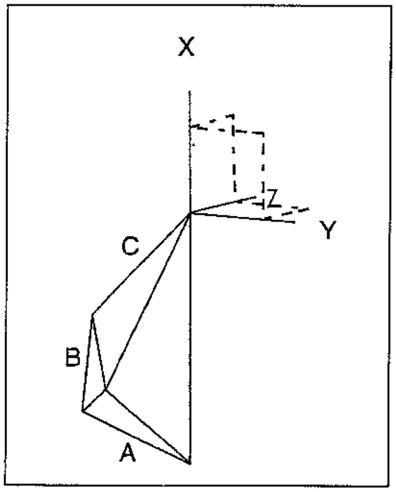

Figure 16 - *Solid model with modified dimensions.*

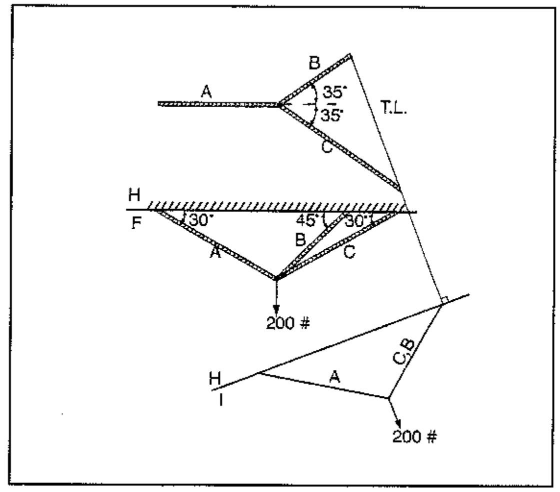

Figure 17 - *Space diagram of a concurrent non-coplanar force system - general case.*

case that doesn't have the overlapping of cables in either top or front view. Find the tensions in all three cables if they support a load of 200 pounds.

Traditional Approach

1. In order to limit the unknowns to two (instead of three), combine two of the three cables (B and C) as depicted in the primary auxiliary view of the space diagram in *Figure 17*. This can be achieved by obtaining the edge view of a triangle that includes any two of the three cables.
2. The procedure required next is similar to steps 1 to 4 of the traditional approach in the previous problem. The only difference is that the vector polygon must be constructed based on the top and primary auxiliary views as shown in *Figure 18*, instead of the top and front views of the space diagram.
3. Construct the true-length diagram to determine the tensions in all three cables.

3D CAD Approach

1. Construct the 3D space diagram using the "3D point" and "3D line" commands. Display the top view of the space diagram as shown at the upper left of *Figure 19* using the "display of top view" command.
2. Revolve this space diagram about the X-axis of the work-plane (in dotted line) by 90 degrees, so cables B and C would appear overlapping in this new position represented on the bottom left of *Figure 19*.

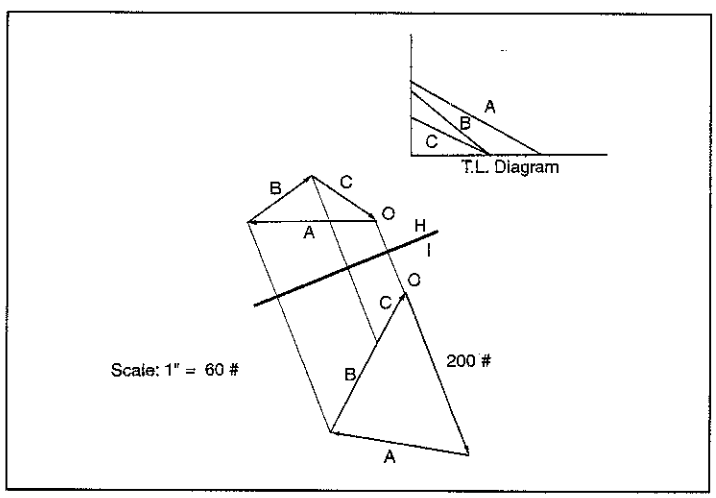

Figure 18 - *Vector polygons - traditional approach.*

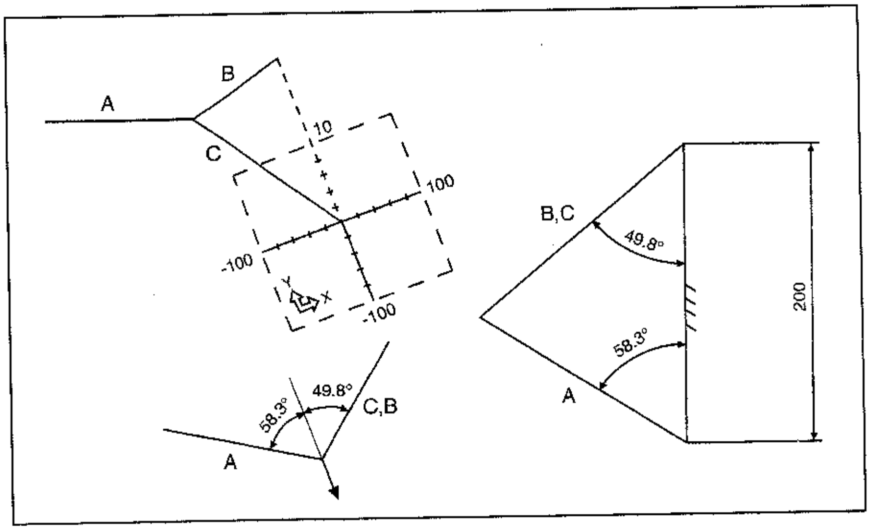

Figure 19 - *3D CAD approach to determine angles for constrained wireframe.*

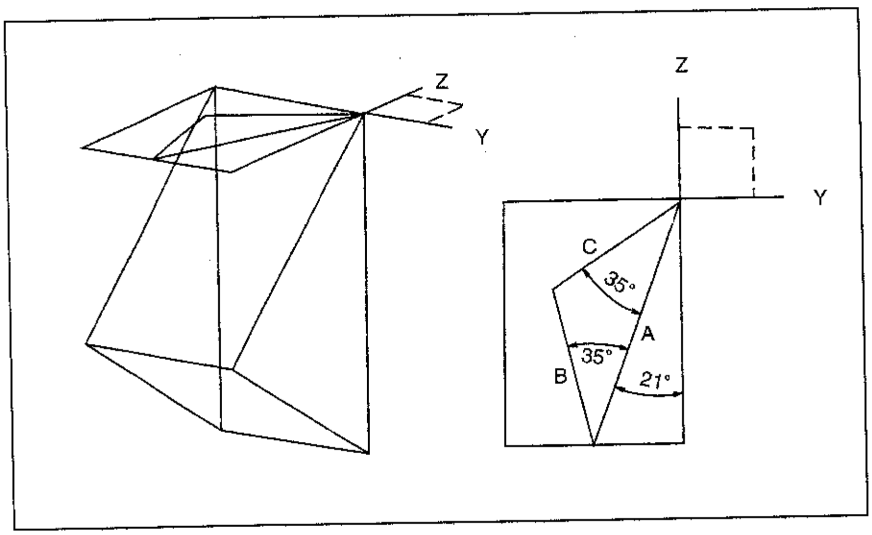

Figure 20 - *Constrained wireframe sketched on Y-Z plane of a coordinate system.*

3. Translate the work-plane that serves as a sketch-pad to the point of application (not shown), so the new position of the cables can be traced on the work-plane. The purpose is to determine the angles between the cables and the equilibrant in the primary auxiliary view (58.3° and 49.8°) as shown on the bottom left of *Figure 19*. Use these two angles in addition to the equilibrant to construct a constrained wireframe that is then extruded it into a solid.

4. Construct a second wireframe using 35° and 21° angles in the top view of the space diagram (21° is the angle between cable A and the folding line dividing the top view and the auxiliary view). *Figure 20* depicts how this second wireframe would be sketched on the Y-Z plane of a coordinate system. *Figure 21* represents the final solid model as a result of the extrusion by intersection. The tensions in cables can be found by measuring the edges of this solid.

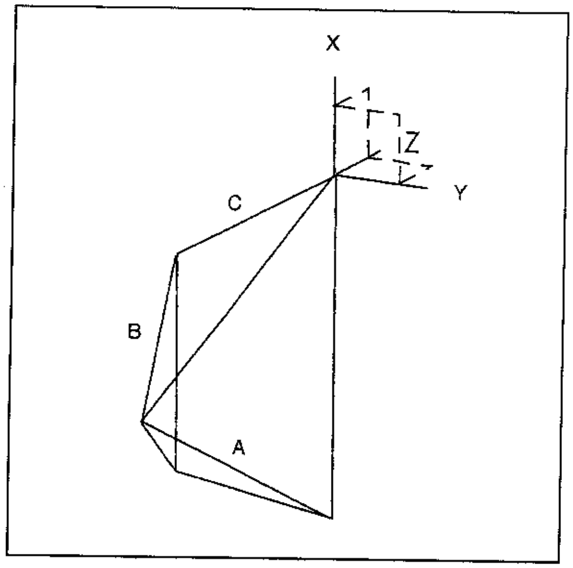

Figure 21 - Final solid model with edges representing tensions in cables.

Discussion

A concurrent non-coplanar structural analysis of "general case" requires a little more CAD work than that of "special case", because of the addition required in step 1. The key of 3D CAD approach for "general case" basically depends on how soon one can determine the angles between the members and the equilibrant (such as 58.3° and 49.8° from the above problem). In general, the use of 3D CAD for a general case still save a significant amount of time as compared to the manual drafting required for the traditional approach due to CAD's high performance.

Conclusion

The problems presented in this paper demonstrate that 3D CAD approach is much more effective in dealing with the concurrent coplanar or non-coplanar structural analysis versus traditional approach. In each of these problems, 3D CAD is less time-consuming yet more accurate, because it just requires the application of proper CAD commands instead of manual construction of scaled vector polygons. With 3D CAD approach, the analysis of other vector quantities, such

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Introduction

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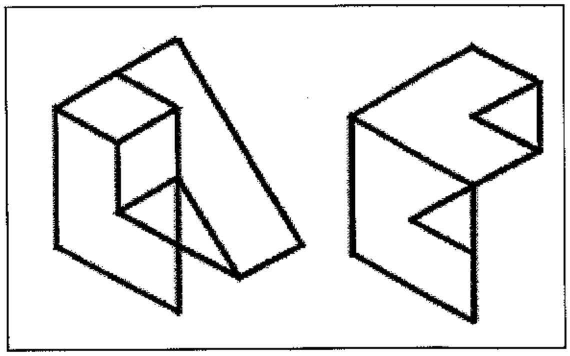

Figure 1 - 3-D objects or 2-D patterns?

like rectangularity and parallelism (Perkins, 1983). A problem occurs when perceived information can be interpreted in more than one way (Perkins, 1982). Lowe (1987) defined this as the detection condition. Perceived features must be constrained in a way such that accidental instances are unlikely to arise. One criticism of the PSVT is its use of isometric projections for the display of three-dimensional objects. In some cases, isometric projections of three-dimensional objects create accidental instances where the three-dimensional objects may be interpreted as two-dimensional patterns (*see Figure 1*). If an individual interprets the information being displayed as a two-dimensional pattern, the validity of the test must be questioned relative to assessing a person's ability to mentally manipulate the representation as a three-dimensional object. The researcher has concluded that a "missing piece" in research in this field is the testing of whether the use of trimetric projections of three-dimensional objects on the PSVT allow for a more accurate assessment of 3-D spatial visualization ability than isometric projections (*see Figure 2*).

Methodology

Purpose of the Study

The purpose of the study was to determine whether the use of trimetric pictorials for items on the Purdue Spatial Visualization Test - Visualization of Rotations would be a more sensitive predictor of 3-D spatial visualization ability for students enrolled in technical graphics classes. Of key interest to the researcher were the concurrent validity and the reliability of the revised PSVT. Concurrent validity is the extent to which a person's score on a new measure corresponds to their score on an established measure of the same construct. Reliability is the extent to which a test yields the same results

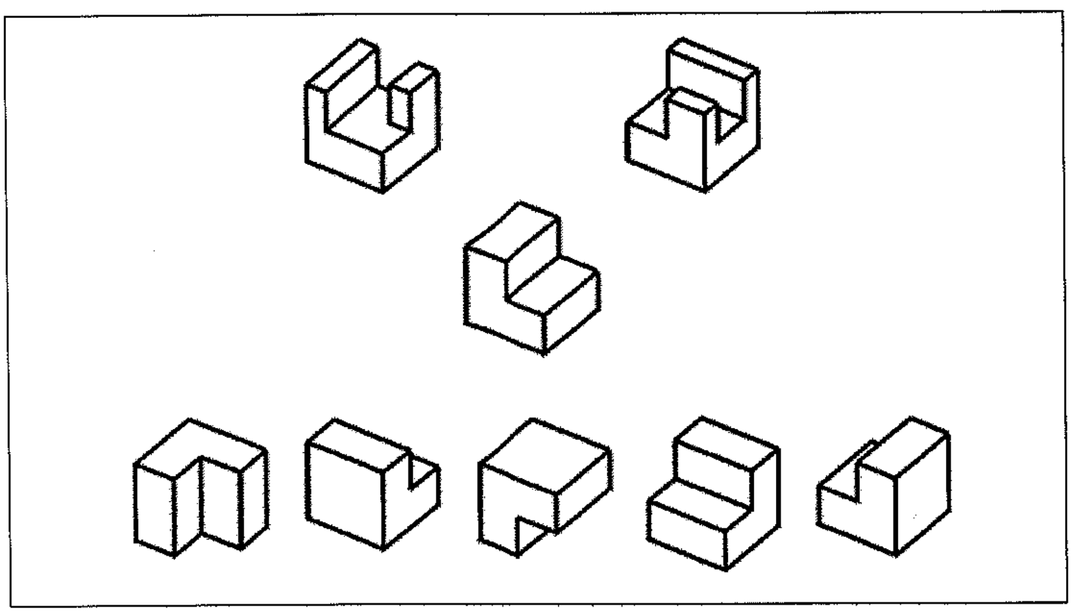

Figure 2 - Visualization of rotations test - revised with trimetric pictorials.

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Score on PSV
Score on MR
Time on PSV
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Experimental G
Score on PSV
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Table 3 - Mean

Means and Standard De
Table 3 displays the deviations for score and PSVT, score and respor and age for both the co tal groups.

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Time on PSV
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Time on MRT
Experimental G
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Score on PSV
Score on MR
Time on PSV
Time on MRT
Males
Score on PSV
Score on MR
Time on PSV
Time on MRT
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Table 4- Mean

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Discussion

Concurrent Validity

The purpose of the study was to examine whether the revised PSVT was as good a measure of a person's 3-D spatial visualization ability as the original PSVT. Several analyses were performed to examine the effectiveness of the revised test. First, mean scores and response times were compared for both the revised PSVT and the original PSVT. No significant difference was found between the control group (original PSVT) and the experimental group (revised PSVT) when examining mean scores (F=1.29, df=276, p=0.2575). There was a significant difference between the control and experimental groups when mean response times were examined (F=8.34, df=276, p=0.0042). This difference seems to be attributed to the fact that males in the experimental group completed the revised PSVT in significantly less time (12.59 minutes) than the males in the control group completed the original PSVT (14.87 minutes). It is possible that the trimetric pictorials in the revised test made the initial interpretation of the objects easier. Exit interviews revealed that some students in the control group were confused with the last several items in the original PSVT. Based on these interviews, the researcher concluded that most of the confusion resulted from the accidental instances or coincidental edges that occurred with isometric pictorials.

In addition to the analysis of variance procedures between versions of the PSVT, analyses were conducted to examine how the revised PSVT correlated with another measure of spatial visualization ability. Previous research suggests that the PSVT and the MRT have high construct validity in the area of 3-D spatial visualization ability (Guay, 1980). Pearson correlation coefficients of 0.67 and 0.65 were calculated for the MRT and original PSVT and for the MRT and the revised PSVT respectively. These values suggest good relationships between the MRT and the two versions of the PSVT.

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ability. Relationships between the revised PSVT and the spatial ability section of the Differential Aptitude Test, the Purdue Spatial Visualization Test - Visualization of Views, and the Purdue Spatial Visualization Test - Visualization of Developments need to be examined.
2. The study needs to be replicated at other universities with similar populations to verify the generalizations made regarding the effectiveness of trimetric pictorials.
3 The study needs to be replicated with a different target population to verify the effectiveness of the revised PSVT. Trimetric pictorials may influence scores and response times differently for high schools students or undergraduate, non-engineering students.

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First Year Engineering Graphics Curricula in Major Engineering Colleges

Frederick D. Meyers
The Ohio State University

Abstract
There is a great variance in the amount of time devoted to basic graphics instruction and in the content of the courses among American engineering colleges. Nine universities were visited, classes attended, and syllabi reviewed with faculty. The commonalities and differences are analyzed and possible directions for graphics programs presented.

Introduction

There is a great variety in engineering graphics courses offered in engineering colleges and in the content of these courses. Graphics instruction in major engineering colleges has been reduced, and in some cases eliminated, as we have moved from practice-based engineering taught in the first half of this century to science-based engineering which has dominated the last half of the 20th century.

This revolution began in the 1920's and '30's as European educated engineers became engineering professors in the United States. They noted the lack of mathematics and science in engineering curricula in American universities (Seely, 1999). World War II further demonstrated the need for a more analytical approach and the Grinter report, published in 1955, gave impetus to the adoption of science-based curricula (Grinter, 1955). The Grinter report called for more basic science and mathematics courses and fewer "skill" courses. However it did not specifically target graphics - usually cataloged as "engineering drawing" at that time. Item 6 of the implementation called for "a high level of performance in the oral, written and *graphical* communication of ideas." (italics by this author) Almost fifty years later ABET Criteria 2000 call for "an ability to design...", "an ability to communicate effectively", and "an ability to use techniques, skills, and modern engineering tools necessary for engineering practice (Phillips, 1997)." Despite the efforts of executives of the EDGD, ABET has not specifically mentioned graphic communication as an important ability. Seely states that the key to the push for more science in curricula was military research funding: "schools seeking to grow had to develop graduate programs to support the fundamental research programs, and emphasize engineering science. But the goal was not to save industry, rather to attract federal research funds (Seely, 1999)."

The engineering faculty members and administrators of today have been educated and worked in university environments so dominated by the call for grant-funded research in engineering colleges that practice-based engineering is almost forgotten. Few engineering faculty have had experience in an economy-based commercial organization where design must result in a salable product or service. Much of what is taught as design is not a comprehensive study of the design process but only that portion which uses mathematical tools for analysis. The process of design follows the structure of the scientific method and has been outlined similarly by many authors; one comprehensive outline by Bertoline is given below; he notes that the three overlapping areas can all share the same 3-D CAD database (Bertoline et al., 1995).

Ideation
- Problem Identification
- Preliminary Ideas
- Preliminary Design

Refinement
- Modeling
- Design Analysis
- Design Visualization

Implementation
- Servicing
- Financing
- Marketing
- Producing
- Planning
- Documenting

Clive Dym states in a recent paper "we have done a much better job over the last fifty years teaching analysis than we have done teaching design (Dym, 1999)." He notes there has been an increased interest in design in recent years and that we need to recognize that there are several "languages of engineering design: verbal or textual statement, graphical representations, mathematical or analytical models, and numbers that represent design information." Analysis alone is not design;it is but one element in the iterative process of design.

In recent years we have had a great diversity among the papers presented to the Engineering Design Graphics Division of ASEE. Some still present methods for solving descriptive geometry problems with hand tools while others present projects describing advanced computer animations. My own institution, where graphics has been taught in various forms for over 100 years, now has three different options for beginning engineers to learn graphics (and related topics). We have been conducting surveys of our alumni and their employers and modifying curricula in an effort to better prepare our students for professional careers (Meyers et al., 1993). After discussing these variances and needs it seemed appropriate to visit some major institutions and learn first-hand what is happening in beginning graphics education.

The Visits

Nine universities were selected because of their reputation, or knowledge of a welcoming colleague, or being in the path of a projected tour. Universities included are:

- Arizona State (2 campuses)
- Colorado (2 campuses)
- Colorado School of Mines
- Iowa State
- Ohio State
- Pennsylvania State (State College)
- Purdue (West Lafayette)
- Texas (Austin)
- Worcester Polytechnic Institute

Engineering graphics, in some form, was required in the beginning engineering programs in all but one of the campuses visited. (How do you present design without graphics?) Two of the largest institutions house graphics instruction in a School of Technology, where it is taught as a service course to the College of Engineering. Some Colleges do not require a course in beginning graphics, but do include a required intermediate or advanced course (assuming that the students arrive with some knowledge of graphics - a beginning course is provided as an option). Most of the institutions visited do provide beginning and advanced courses in graphics. The two technology schools within major universities have departments which are offering comprehensive four year curricula with specialization in various sub-disciplines of graphics.

Graphics is taught within departments that specialize in this discipline, or within a department granting engineering degrees, or as a service by one degree-granting department to other departments. It may be required in all engineering degree programs or by only selected programs: typically, mechanical and industrial engineering would require it and electrical and computer engineering may not. The topics included vary widely - affected by the amount of time allotted to the subject, the orientation of the faculty, and the demands of other departments within the institution. The spreadsheet (*Figure 1*) summarizes the major topics included at each campus in the beginning graphics course or the beginning engineering course in which graphics is included.

	Ohio State University			Arizona State	U of Colorado		Colo Mines	Iowa State		Penn State	Purdue	U of Texas	WPI
	Engineering Graphics		Engineering College	Technology	Mech Engr	Arch Civil		Ag/Env Engr	Civil Engr	Engr Design	Tech	Mech Engr	Mech Engr
	EG 166	Honors	2 quarters	ETC 100			EPICS			ED&G 100	CGT 155	ME210	ES 1310
TOPICS													
Visualization	X	X	X X	X	X		X	X	X	X	X	X	X
3-D Modeling - CADD	CADKEY	CADKEY	CADKEY	AutoCAD	AutoCAD	AutoCAD	AutoCAD	AutoCAD	AutoCAD	SilverScreen	AutoCAD	AutoCAD	CADKEY
Orthographic Views	X	X	X X	X	X	X	X	X	X	X	X	X	X
Pictorial Views	X	X	X	X	X		X	X	X	X	X	X	X
Section Views	X	X	X	X	X	X	X		X	X	X	X	X
Dimensioning	X	X	X	X	X	X	X	X	X	X	X	X	X
Fits & Tolerances	X	X	X	X				X					X
G D & T	X	X											
Fastening & Welds	X			X	X						X		X
Working Drawings	X	X	X		X	X	X	X		X		X	X
Space Geometry	X						X	X				X	X
Charts & Graphs	X	X	X		X		X			X			
Spreadsheets/Solvers			X		X		X			X		X	
Hands-on Labs		X	X X				X	X		X		X	X
Team Projects		X	X X				X	X		X			X
Other Topics			PowerPoint	WWW			Build 3-D model		Topo map	WWW Ind'l project		FEA Prototype	
	Advanced courses required	Advanced courses required	Advanced courses available	Advanced courses required	Advanced courses required	Advanced courses required		Advanced courses available		Advanced courses available	Advanced courses available	Advanced courses available	Advanced courses available
TOOLS													
Sketching	X	X	X	X	X	X	X	X	X	X	X	X	X
Triangle & Compass				X			X			X		X	
CADD	X	X	X	X	X	X	X	X	X	X	X	X	X

Figure 1 *- Major topics in Engineering Graphics curricula 1998-99 academic year.*

Score:		Score:	
5.00	Developing 3-D Visualization Skills	3.13	New Computer Lab Development
4.44	Parametric Modeling	3.06	Drawing Standards & Codes
4.38	3-D Solid Modeling	3.00	Threads, Tolerancing, etc.
4.38	Manual Sketching	2.94	Auxiliary Views
4.00	New Generation of Teaching Materials	2.94	Rapid Prototyping
3.81	Team Projects in EDG	2.94	Computer Animation/Simulation
3.75	Design Process Stages	2.88	Mass Properties Analysis
3.69	Orthographic and Multiview Projection	2.88	Hardware & Software Skills
3.63	Dimensioning	2.69	Finite Element Analysis
3.50	Sections	2.63	Color Rendering & Visual Realism
3.50	Pictorials	2.63	Charts & Graphs
3.44	Use of WWW in EDG Instruction	2.38	Computational Geometry
3.44	Use of Multimedia in EDG Instruction	2.25	Descriptive Geometry
3.31	2-D CADD	2.13	Virtual Reality
3.31	Reverse Engineering	1.81	Manual Construction Using Instruments
3.19	Surface Modeling	1.75	Lettering

***Figure 2** - Survey results from curriculum planning session - Barr.*

Topics are listed in an order which includes the most common topics near the top of the list and the topics not so universal in the lower part of the list. "Tools" have been separated from "topics" to emphasize the idea that we do not teach tools - we use different tools as a means for learning about the topics. The course offered at Penn State and the introduction to engineering at Ohio State include beginning graphics and also hands-on laboratory projects which require teamwork and report writing. The pertinent course at the Colorado School of Mines is a beginning design problem course - graphics is not in the title, however the students learn graphics as they present their solutions to the given design problems.

Two recent papers have listed topics most likely to be included in an engineering graphics course: Barry Crittenden of Virginia Polytechnic Institute presented "Requirements for Successful Completion of a Freshman Level Course in Engineering Design Graphics" in 1995 (Crittenden, 1996) and Ron Barr of the University of Texas at Austin who has been pursuing curriculum issues for several years presented the findings of his most recent workshop in a paper entitled "Planning the EDG Curriculum for the 21st Century: A Team Effort" in 1998 (Barr, 1999). Comparing the topical areas found in this study with their work shows that about half of the topics listed in Barr's summary *(Figure 2)* were covered in the beginning courses and that most of the topics covered were noted by his panel. Crittenden's respondents (*Figure 3*) included most of the topics with the exception of those found in the introductory engineering courses as distinguished from the beginning engineering graphics courses, such as spreadsheets and solvers, hands-on labs, and team projects. (This author has not attempted a comparative statistical analysis of the topics covered: the sample, while representative of major institutions, is too small for a statistical study.)

The CADD packages used for beginning courses are the ones found in the usual discussions of CADD: AutoCAD, CADKEY and Silver Screen. Some institutions have used packages which are more often used for

descriptive geometry	intersections	sectional views
developments	kinematics	sketching
dimensioning	lettering	software use
drafting skills	mathematics	solid modeling
geometric construction	orthographic projection	threads and fasteners
geometry	reading engrg. drawings	tolerances
graphing	scales	visualization

Figure 3 *- Major topics covered in freshman level graphics courses - Crittenden.*

intermediate or advanced courses: SDRC: Ideas, Pro-Engineer, and Solid Works.

Conclusions

There is a wide diversity in the offerings at different institutions, however topics of visualization, orthographic views, pictorial views, section views, dimensioning and working drawings appear in all the curricula. Beyond these topics there is diversity depending upon the predominant discipline in charge, time available, the availability of complementary advanced courses and the orientation, whether it be toward graphics only or toward a first course in engineering experiences. The technology schools at Purdue and Arizona State offer complete 4-year curricula, while a degree-granting department at Arizona State requires no graphics.

As we evaluate these programs and our own we must focus on the "customer". Who is the customer? This author believes that the student is the primary customer and that downstream faculty, future employers and society, as a whole, are secondary customers. The student may not be in a position to know what she/he needs downstream; we know from evaluations by employers and downstream faculty what they perceive as strengths and weaknesses of our graduates. The pertinent areas we can impact include: communication skills, ability to read drawings, teamwork, use of commercial CADD packages, and use of spreadsheets and data bases (Meyers et al., 1993). Depending upon the goals and degree programs of our students we can prepare them with "straight" engineering graphics courses and leave other communication skills to other courses, or offer them introduction to engineering courses which include other communication and teamwork skills, or prepare them to be technical specialists in the fast moving world of computer graphics with virtual reality, animations, and web site design. Whichever course we take the one thing certain is change.

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Design Graphics in Idaho, A 1999 Industry and Academic Benchmark

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Abstract

This paper is based in part on a 1998-99 benchmark study of Idaho industries that either design and manufacture products, or design and construct facilities. It is also based in part on a concurrent study of engineering and technical graphics programs in Idaho. These studies were sponsored by an Economic Development Administration (EDA) grant. Additionally, it is based on an independent, select national sampling of engineering, engineering technology, and technical graphics programs. The purpose of the EDA sponsored studies was to develop a strategy for improving the computer-integrated design and manufacturing infrastructure for the state's industries and higher-education institutions. This paper focuses on those portions of the studies specifically relating to Engineering Design Graphics (EDG). It compares what is being taught in Idaho's colleges and universities to what is being done in the state's industries. Also, Idaho's academic programs are compared to a select national sampling of like programs. Idaho's economy, which has traditionally been agrarian based, is now in an era of rapid high technology growth. It's EDG education needs to respond to this change. A set of recommendations is made for adjusting Idaho's EDG programs to better accommodate changing industry needs and to better reflect national trends in EDG education.

Introduction

Idaho's tradition is of a rural state whose economy has been rooted in agriculture, ranching, mining, and timber industry. The decline of mining and timber has been followed over the last two decades by rapid development of high-technology industries, especially at populous centers in the state. A recent newspaper article reported Boise, the state's capital, as being the third fastest-growing high-tech city in the country and among the top 25 cities based on its share of products made by high-tech industries (Edwards, 1999). These new industries in Idaho center on computers and electronics.

In times past engineering design graphics in Idaho was most often used in support of facilities design. Examples are the design and layout of highways, dams, irrigation systems, hydroelectric plants, electric power grids, mines, railroads, and sugar beet and potato processing plants. Civil engineering had a leading role with mechanical and electrical in a supportive role. With the rise of today's new high-tech industries electrical, electronic and computer engineering predominate. In support of the growing urban population and expanding manufacturing there is still a significant amount of facilities design, though. Generally, mechanical engineering is still in a supportive role for the other disciplines, although there are strong indications this is changing due to an increasing emphasis in product design.

That the economy of Idaho has been rapidly expanding over the last decade to include more and more industries related to the design and manufacturing of products is well-established (State of Idaho, 1998). During this same period computer based software and hardware that facilitates design, manufacturing, and construction has changed dramatically. Trying to keep pace with this change, and utilize this technology infrastructure to remain competitive, has been a major challenge for industry. From the site visits and professional contacts made in the Boise Valley by the authors during 1997 and 1998 it was concluded that strategic use of computer technology in this valley was sporadic, but evolving. Further, there was seen to be a growing need for infrastructure development in computer-integrated design and manufacturing. The authors developed a hypothesis that this same need for infrastructure development existed statewide.

An Economic Development Administration (EDA) grant was then obtained to determine the current state of computer-integrated design and manufacturing in Idaho industries, and further to develop a strategy for improvement where needs were observed. Concurrently, a similar activity was undertaken at institutions of higher education. Additionally, one of the authors was able to make an independent, select national sampling of engineering, engineering technology, and technical graphics programs while attending a National Science Foundation (NSF) sponsored workshop at Central Michigan University. These studies all took place during 1998 and 1999. This paper focuses on those portions of the studies specifically relating to Engineering Design Graphics (EDG). It compares what is being taught in Idaho's colleges and universities to what is being done in industry. Also, Idaho's academic programs are compared to the national sampling. And lastly, a set of recommendations is made for adjusting Idaho's EDG programs to better accommodate changing industry needs and to better reflect national trends in EDG education.

Study of Industry

Three sources were utilized to search out companies that met the criteria of either being in engineering design, manufacturing, or construction, or some combination thereof. These sources were: a Department of Commerce manufacturing census of some 3500 companies throughout Idaho, the 1998 Greater Boise Employer Directory, and the 1998 Boise Valley Telephone directory. Some 1200 companies were identified and sent industrial questionnaires; of these, responses were received from 146 companies. In an effort to better understand the pattern of software utilization those 146 companies were divided into 11 categories depending on the type of products they produce and customers they serve. *Table 1* gives the breakdown of these categories (column 1) and how many companies were in each (column 2). It also gives five categories of software applications (columns 3 through 7): drafting, solid modeling, computer numerical control (CNC), finite element modeling (FEM), and simulation. The integer values in columns 3 through 7 indicate the number of companies in each industry category using that particular application. The values in parentheses are the percent of companies using that application. Predictably, obvious differences were observed between industry categories as to relative usage of software. Drafting software had the highest utilization in every industrial category with an overall average of 80% - All other software had significantly less overall utilization. Solid modeling software had a 27% overall utilization with the product manufacturing industries having an average of 36%. Overall CNC software had utilization of 21% with the machining and molding categories at the high end with 69% and 55% respectively. FEM software had the lowest overall utilization at 10%, while simulation software was somewhat higher at 16%.

Table 2 gives a breakdown as to the most significant brand representation in each category of software application. Interestingly,

Number of Companies & Percentage that Reported Using a Given Type of Package						
Industry Category	Number of Respondents	Drafting	Solid Modeling	CNC	FEM	Simulation
Food Processing/Sales	6	5 (83%)	1 (17%)	0	1 (17%)	4 (67%)
Agricultural & Food Processing Equipment	11	9 (82%)	4 (36%)	0	1 (9%)	2 (18%)
Computers Chips & Computer Equipment	11	9 (82%)	5 (45%)	2 (18%)	1 (9%)	3 (27%)
Consumer Products	23	15 (65%)	9 (39%)	6 (26%)	2 (9%)	3 (13%)
Industrial Products	22	19 (86%)	7 (32%)	4 (18%)	4 (18%)	4 (18%)
Mobil Equipment	10	8 (80%)	3 (10%)	2 (20%)	3 (30%)	1 (10%)
Machining/Welding/ Fabricating	13	10 (77%)	2 (15%)	9 (69%)	0	0
Plastics/Metal Molding	11	8 (73%)	4 (36%)	6 (55%)	0	1 (9%)
Facilities/Plant Design	15	12 (80%)	2 (13%)	1 (7%)	1 (7%)	2 (13%)
Architect/Civil Consult	15	15 (100%)	0	0	0	1 (7%)
Electric/Mech. Consult	9	7 (78%)	3 (33%)	0	1 (11%)	2 (22%)
TOTAL # & AVERAGE %	146	117 (80%)	40 (27%)	30 (21%)	14 (10%)	23 (16%)

Table 1 - Response of Idaho industry by category to types of software usage.

a multitude of different software brands was reported in each category though most were reported only once. For example, 27 different software packages for drafting were reported. The Autodesk product, AutoCAD, had the majority usage at 58%; no other package came close to this value. For solid modeling another Autodesk product, Mechanical Desktop, had the highest reported utilization at 30% - ProEngineer and SolidWorks were next at 17% each. The Autodesk product had the plurality here, but not the majority. In all, 15 different solid modeling packages, 17 different CNC packages, ten different FEM packages, and 20 different simulation packages were reported. No one package dominated in any of the CNC, FEM, or simulation categories.

Two recent articles about national trends in usage of computer-aided design software by industry shed light on the information in the categories of drafting and solid modeling reported herein. The first article was based on a survey of 159 discrete manufacturing companies in North America. (Tan, 1998). Fifty-three percent of the respondents in the national survey were using solid modeling as their main form of design as opposed to 36% for Idaho consumer and industrial product manufacturers. These figures seem to indicate Idaho is lagging the national trend towards solid modeling for product design. The second article reports that taken as a whole in U.S. industry there are six 2D drafting seats for every solid modeling seat (Rendell, 1999). Here a ratio of seats is being compared, not percentages of companies using a type of software. The Idaho survey did not determine how many seats of a particular category of software a company was using, just whether they were using it or not, and if they were what brand(s). Some companies reported using more than one brand in a particular category, and some reported having drafting packages as well as solid modelers. Forming the ratio of companies reporting at least one 2D (drafting) software, 117, to companies reporting at least one solid modeling software, 40, gives a value to 3 to 1, that is, three 2D seats per one solid modeling seat.

Number of Companies & Percentage Using a Given Brand of Software for **Drafting**	
Software Brand	**Number & percentage**
AutoCAD	80 (58%)
MicroStation	9 (7%)
CADkey	5 (4%)
SolidWorks	5 (4%)
Pro-Engineer	4 (3%)
Cadence Allegro	3 (2%)
(21 other brands)	31 (23%)

Number of Companies & Percentage Using a Given Brand of Software for **Solid Modeling***	
Software Brand	**Number & Percentage**
Mechanical Desktop	14 (30%)
SolidWorks	8 (17%)
Pro-Engineer	8 (17%)
CADkey	3 (7%)
Solid Edge	2 (4%)
MicroStation	2 (4%)
(9 other brands)	9 (20%)

Number of Companies & Percentage Using a Given Brand of Software for **CNC Machining***	
Software Brand	**Number & Percentage**
BobCAD	6 (18%)
SurfCAM	5 (15%)
Virtual Gibbs	4 (12%)
SmartCAM	4 (12%)
MasterCAM	3 (9%)
(12 other brands)	12 (35%)

Number of Companies & Percentage Using a Given Brand of Software for **FEM***	
Software Brand	**Number & Percentage**
ANSYS	3 (21%)
COSMOS	3 (21%
Pro-Mechanica	2 (14%)
(7 other brands)	7 (44%)

Number of Companies & Percentage Using a Given Brand of Software for **Simulation***	
Software Brand	**Number & Percentage**
Working Model	4 (18%)
ADAMS	2 (8%)
CADSI-DADS	2 (8%)
(17 other brands)	17 (68%)

** Some companies use more than one brand.*

***Table 2** - Significant brand representation in each category of software application.*

The above ratio seems highly unlikely for two reasons. First, the 3:1 ratio is not based on seats so it is not directly comparable to the national 6:1 value. Second, the Department of Commerce database did not include engineering consulting companies. So, whereas data from all other categories was based on an exhaustive statewide survey, data about the consulting companies was based only on a localized sampling in the Boise Valley. Thus, although the relative magnitudes of data within the consulting company categories are thought to be representative, the actual magnitudes (weights) within each dimension (drafting, solid modeling, CNC, FEM, simulation) are undoubtedly low with respect to the same dimensions in the other categories. The work of the consulting companies is tied closely to the state's traditional economic infrastructure and this work is still a significant portion of engineering activity as stated in the Introduction. Thus, if the true weight of consulting categories data was available it is believed the total 2D usage reported would be much higher and the 3:1 ratio would be closer to 6:1 or higher.

The last point above raises a question as to just how closely the respondent data sample actually reflects the state's industrial population taken as a whole, especially in light of the response rate. As previously stated the selection of consulting companies was weighted towards the Boise Valley since the authors only accessed information about this geographic region for that category. Also, as respondents were promised a reporting of the survey results, it is likely that companies more actively involved in using computers and different kinds of software, and interested in seeing how they compare to other active users, were more apt to respond than those who were not. In any event, every effort was made to obtain a fair sampling for each of the 11 industrial categories. Conclusions drawn from this database reflects some 12% of the state's design, manufacturing, and construction companies, but since virtually all of the largest employers are included, the economic value of these companies may approach 75% or more of the industries benchmarked.

Survey of Academia

All eight of Idaho's engineering and pre-engineering programs responded to the academic questionnaires and so did three of four technical graphics programs. Then, in June 1999 one author attended a National Science Foundation (NSF) sponsored workshop on problem solving in design graphics along with 27 other attendees from all parts of the United States. Five attendees from technical graphics programs and ten attendees from engineering and engineering technology programs voluntarily completed the academic questionnaires used in Idaho. Idaho's technical graphics programs were compared with like program respondents from the NSF workshop, and its engineering programs were compared to engineering and (non-graphics) engineering technology programs from that workshop.

The questionnaires for the engineering programs and technical graphics programs were identical except for a variation in the first question. For engineering the question centered on an introductory course in engineering graphics, whereas for technical graphics the question centered on courses (plural) in technical graphics.

Respondents then estimated the percentage of the course(s) devoted to nine graphics topics. *Table 3* lists these topics along with the minimum response and maximum response, and then the average of responses

Introductory Course in Engineering Graphics						
	Idaho Schools			National Schools		
Topic %	Minimum	Maximum	Average	Minimum	Maximum	Average
Sketch	0	20	11	0	30	11
Manual	0	30	8	0	50	7
Des. Geo.	0	10	7	0	35	7
GD&T	0	15	5	0	20	6
2D CAD	20	100	56	0	50	21
3D Wire	0	25	5	0	30	11
3D Solid	0	20	6	0	30	10
3D Constr	0	5	1	0	60	18
Other	0	10	1	0	38	10
Groupings						
Non-CAD			31			30
2D CAD			56			21
3D CAD			11			39
Other			1			10
Courses in Technical Graphics						
	Idaho Schools			National Schools		
Topic %	Minimum	Maximum	Average	Minimum	Maximum	Average
Sketch	4	12	8	3	20	11
Manual	10	35	22	5	17	14
Des. Geo.	4	5	5	5	50	9
GD&T	1	7	3	0	20	9
2D CAD	35	44	40	15	25	23
3D Wire	3	10	8	0	13	6
3D Solid	1	4	3	5	20	16
3D Constr	0	0	0	0	16	6
Other	0	35	12	0	35	7
Groupings						
Non-CAD			38			42
2D CAD			40			23
3D CAD			11			28
Other			12			7

Table 3*- Topic percentages in graphics – Idaho versus national.*

Engineering, Pre-Engineering, and Engineering Technology Programs						
	Idaho			National		
	NCI*	WCI*	Sum	NCI	WCI	Sum
Solid Modeling	1	7	8 (100%)	0	10	10 (100%)
Finite Elements	2	3	5 (63%)	0	5	5 (50%)
Motion Simulation	1	3	4 (50%)	1	5	6 (60%)
Manufacturing	1	0	1 (13%)	1	4	5 (50%)
Facilities Design	1	0	1 (13%)	1	2	3 (30%)
Other	1	1	2 (25%)	0	1	1 (10%)
Technical Graphics Programs						
	Idaho			National		
	NCI	WCI	Sum	NCI	WCI	Sum
Solid Modeling	1	2	3 (100%)	0	5	5 (100%)
Finite Elements	0	0	0	0	2	2 (40%)
Motion Simulation	0	2	2 (67%)	1	2	3 (60%)
Manufacturing	0	0	0	0	3	3 (60%)
Facilities Design	0	2	2 (67%)	0	1	1 (20%)
Other	0	1	1 (33%)	0	0	0

** NCI - Available with No Class Instruction , WCI - Available with Class Instruction*

***Table 4** - Number of schools that offer CAD/CAE/CAM applications.*

for each topic. Comparisons of note can be seen when comparing groupings of topics. [Non computer aided design (Non-CAD) includes sketching, manual drafting, descriptive geometry, and geometric dimensioning and tolerancing (GD&T). Three-dimensional (3D) CAD includes 3D wireframes, 3D static solid modeling, and 3D constraint based solid modeling. The "Other" topic generally involved design projects and presentations for engineering. For technical graphics "Other" included ANSI dimensioning, general theory, and mechanical design.] One of the most obvious differences in comparing Idaho's academic programs to national programs, both engineering and technical, are in reference to these groupings. National schools had a much higher ratio of 3D CAD to 2D CAD (39%:21% for engineering and 28%:23% for technical) as compared to Idaho (11%:56% for engineering and 11%:40% for technical). These ratios for Idaho show CAD topics are weighted in favor of facilities design, that is, an emphasis on 2D CAD. For engineering these ratios are just for the initial graphics course; Idaho schools compare more favorably when follow-on course work in solid modeling is benchmarked (*See Table 4*). The other obvious difference is that national engineering schools are much more apt to have a design project.

A recommendation has been made for an extension of the EDG curriculum paradigm to include analysis and prototype manufacturing (Barr & Juricic,1997). The second survey question dealt with the availability of software that would support such an endeavor and more, and whether it was available with or without classroom instruction. Table 4 lists software types considered along with responses. Solid modeling has a 100% universal availability, although not always with instruction in Idaho. All other software types were available to a lesser extent. The third question dealt with teaching GD&T, and whether the subject was integrated with

	Engineering Programs		Technical Graphics	
	Idaho	National	Idaho	National
Integrated Course	3	6	3	2
Separate Course	0	0	0	0
Both Kinds Of Courses	0	0	0	3
TOTAL	**3 (38%)**	**6 (60%)**	**3 (100%)**	**5 (100%)**

Table 5 - Number of schools that offer geometric dimensioning and tolerancing.

other materials or taught as a stand-alone subject. *Table 5* summarizes responses for this question. All technical graphics respondents were teaching this subject, engineering programs to a lesser extent with Idaho below the national average. Since engineers bear ultimate responsibility for product function and manufacturability that is encrypted in GD&T symbology, it seems logical that this subject ought to be universally introduced in engineering graphics courses, too.

Question 4 dealt with the types of auxiliary software that complement and complete an engineering design infrastructure, and question 5 dealt in a similar way with the hardware requirements. In a recent article about directions in the software industry (Connolly, 1999) it was suggested that the most exciting trends relative to CAD are use of the World Wide Web, product data management, data exchange standards, and collaborative engineering . Since much of the software and hardware covered in questions 4 and 5 are directly related to these trends, it would appear that these questions are relevant and important. *Table 6* lists software types and summarizes responses for question 4, and *Table 7* lists hardware types and summarizes responses for question 5. As can be seen from Table 6 access to the Internet communication and Web browser is universal for engineering programs and to lesser extent for technical graphics programs. It was not determined how much if any of the Internet/Web use was for CAD conferencing and model viewing. Database management and project management have a presence, but are not universally available in either engineering or graphics. *Table 7* demonstrates that personal computers are universally available, and that scanning, digitizing, video conferencing, printing, plotting, and faxing generally are widely available in all programs.

An extensive search for national surveys of engineering graphics and technical graphics courses and programs was undertaken using the Engineering Index of CompendexWeb. Although some surveys were located in the decade of the 1980's nothing could be located in the decade of the 1990's, let alone recently. Thus, a comparison of the national schools sampled against any other study was not possible. It is therefore unclear as to how representative the national sampling for this paper is of national schools taken as a whole. The national trend of emphasizing solid modeling over 2D graphics is thought to be accurate, though.

Comparison of Academia to Industry

A comparison of CAD instruction in academia with CAD usage in industry indicates Idaho schools tend to mirror the state's industries. That is, both place a heavy emphasis on CAD as a 2D drafting documentation tool. Comparatively, engineering programs place greater emphasis on solids modeling in support of product design industries than do the technical programs. And vice versa, technical programs place greater emphasis on 3D-wireframe modeling in support of facilities design. A diversity of products is used for solid modeling with no

Engineering Programs						
	Idaho			National		
	NCI	WCI	Sum	NCI	WCI	Sum
Word Processing	4	4	8 (100%)	5	5	10 (100%)
Spreadsheets	4	4	8 (100%)	3	7	10 (100%)
Internet	7	1	8 (100%)	7	3	10 (100%)
Web Browser	7	1	8 (100%)	5	3	8 (80%)
Database Manage	2	1	3 (38%)	5	2	7 (70%)
Project Manage	3	1	4 (50%)	2	1	3 (30%)
Presentations	4	3	7 (88%)	4	3	7 (70%)
Desktop Publishing	2	0	2 (25%)	3	1	4 (40%)
Graphic Design	1	0	1 (13%)	0	1	1 (10%)
Animation	1	1	2 (25%)	1	3	4 (40%)
Accounting	0	0	0	0	0	0
CNC Machining	0	1	1 (13%)	0	5	5 (50%)
Material Require	0	0	0	0	1	1 (10%)
Statistic Process	0	0	0	0	0	0
Store & Retrieve	0	0	0	0	0	0
Material Process	0	0	0	1	0	1 (10%)
Technical Graphics						
	Idaho			National		
	NCI*	WCI*	Sum	NCI	WCI	Sum
Word Processing	0	3	3 (100%)	3	2	5 (100%)
Spreadsheets	1	2	3 (100%)	3	1	4 (80%)
Internet	0	1	1 (33%)	3	1	4 (80%)
Web Browser	1	2	3 (100%)	2	1	3 (60%)
Database Manage	0	2	2 (67%)	1	1	2 (40%)
Project Manage	1	1	2 (67%)	1	0	1 (20%)
Presentations	1	2	3 (100%)	3	1	4 (80%)
Desktop Publishing	0	3	3 (100%)	1	1	2 (40%)
Graphic Design	0	3	3 (100%)	1	1	2 (40%)
Animation	1	2	3 (100%)	2	1	3 (60%)
Accounting	1	1	2 (67%)	1	0	1 (20%)
CNC Machining	0	0	0	1	1	2 (40%)
Material Require	0	0	0	0	0	0
Statistic Process	0	0	0	0	1	1 (20%)
Store & Retrieve	0	1	1 (33%)	0	0	0
Material Process	0	0	0	0	1	1 (20%)

Table 6 *- Number of schools that offer auxiliary software.*

Engineering Programs						
	Idaho			National		
	Avail.*	Req.*	Sum	Avail.	Req.	Sum
Personal Computer	0	8	8 (100%)	0	10	10 (100%)
Unix Computer	3	2	5 (63%)	2	1	3 (30%)
MacIntosh Comp.	1	0	1 (13%)	3	0	3 (30%)
Mainframe Comp.	2	0	2 (25%)	4	0	4 (40%)
Scanners	6	2	8 (100%)	5	4	9 (90%)
Digital Cameras	6	2	8 (100%)	4	3	7 (70%)
Video Conference	5	1	6 (75%)	5	0	5 (50%)
Printers	2	6	8 (100%)	0	8	8 (80%)
Plotters	3	5	8 (100%)	4	3	7 (70%)
Coordinate Measure	2	0	2 (25%)	1	1	2 (20%)
Rapid Prototyping	0	1	1 (13%)	1	0	1 (10%)
Internet Cards	5	1	6 (75%)	3	1	4 (40%)
Modems	3	2	5 (63%)	6	1	7 (70%)
Faxes	6	2	8 (100%)	6	1	7 (70%)
** Avail. (Available for students, Req. (Available for students, plus students are required to know.*						
Technical Graphics						
	Idaho			National		
	Avail.	Req.	Sum	Avail.	Req.	Sum
Personal Computer	1	2	3 (100%)	1	4	5 (100%)
Unix Computer	0	0	0	1	2	3 (60%)
MacIntosh Comp.	0	0	0	2	0	2 (40%)
Mainframe Comp.	2	0	2 (67%)	4	0	4 (80%)
Scanners	2	1	3 (100%)	5	0	5 (100%)
Digital Cameras	3	0	3 (100%)	5	0	5 (100%)
Video Conference	3	0	3 (100%)	5	0	5 (100%)
Printers	0	3	3 (100%)	1	4	5 (100%)
Plotters	2	1	3 (100%)	1	3	4 (80%)
Coordinate Measure	2	1	3 (100%)	3	2	5 (100%)
Rapid Prototyping	1	1	2 (67%)	1	0	1 (20%)
Internet Cards	1	0	1 (33%)	4	0	4 (80%)
Modems	2	0	2 (67%)	4	0	4 (80%)
Faxes	2	0	2 (67%)	5	0	5 (100%)

***Table 7** - Number of schools that have computers and computer peripherals.*

one brand dominating either industry or academia. AutoCAD is used by a majority of companies for facilities design, although selective interviewing has indicated companies with large-scale projects use the MicroStation product. Down-stream application of the CAD database for FEM and simulation is evident at about half of the schools in support of the relatively sparse usage of these applications by industry.

Little instruction in the down-stream application of the CAD database for CNC in manufacturing was reported although there was significant activity reported in this area by Idaho's product manufacturing industries. If a prototype of a product part is built in Idaho, it is almost exclusively by CNC machining. For material-additive prototyping such as stereolithography or fused-deposition modeling, companies will go to an out-of-state service bureau. Just one company and one school are known to have their own material-additive prototyping equipment.

Just as for academia, Idaho's industries were surveyed about usage of auxiliary software and infrastructure hardware (Eggert and Tennyson, 1999). Highest reported usage of software, by 50 percent or more companies, was for word processing, Internet communication, spreadsheets, Web browsing, databases, and projects management. Except for databases and project management, instruction for the other software is given in all academic programs. Highest reported usage of hardware, by 50 percent or more companies, was for personal computers, printers, faxes, modems and plotters. All academic programs reported that students had access these devices.

Recommendations

This study has demonstrated conclusively that both facilities design and product design are prevalent in Idaho and each plays a vital role in the economy. Recognition of this has been made in developing the following recommendations for adjusting Idaho's EDG programs to better accommodate changing industry needs and to better reflect national trends in EDG education.

Introductory Engineering Graphics Courses

- The introductory course in engineering graphics should contain examples and assignments that illustrate application of EDG to both facilities design and product design. Each of these contains fundamental concepts students must grasp: visualization, imaging, geometry, and dimensioning. This is advocated for both the manual drawing and CAD portions of the course.

- The CAD package(s) should be capable of 2D drafting, 3D wireframe with surfacing, and explicit solid modeling. Two adequate software packages in the authors' experience are AutoCAD and SilverScreen (Tennyson, 1997). An advantage of incorporating SilverScreen is that the software is essentially free of charge to schools and students. An advantage of AutoCAD is commercial name recognition. SilverScreen has none yet and this concerns some students.

- An important task common to facilities design and product design in industry is using high-end CAD packages to create elaborate assemblies. Students can emulate this activity at an elementary level by extracting 3D entities from parts libraries to create simple assemblies.

- In the authors' experience the inclusion of an individualized, course-long design project has had broad student appeal. This activity also lends support to the Accreditation Board for Engineering and Technology mandate to integrate design across the curriculum.

Engineering Graphics, Electives

- The preponderance of new CAD capabilities today and into the foreseeable future for product design will be built on the solids modeling foundation. In recent years so-called "midrange" or "mainstream" solid modeling software has become popular with small and medium sized manufacturing companies, the predominant kind in Idaho. Currently, the two most highly recommended parametric solid modeling packages on the market for general application are Solid Edge and SolidWorks (Martin, 1998). An elective course at the junior/senior level is recommended in product design employing some such ìmainstreamî package as the CAD foundation. The assembly-modeling portion of the course should include an introduction to GD&T methodology. This course should also explore down-stream design integration involving a combination of FEM, simulation, and manufacturing packages.

- An innovative elective course at the junior/senior level is recommended for facilities design. Since such a vast array of different kinds of activities is associated with this type of design, numerous alternatives exist for organizing such a course. One option is to have a course-long design project incorporating multi-disciplinary teamwork. The team(s) would logically be composed of civil, mechanical, electrical, and graphics technology students. The software package should have 3D parametric capability and offer full associativity for updating changes throughout all part and assembly files. One good possibility for a software package is MicroStation.

- It is further recommended that these two elective courses incorporate, as so far as possible, current topics about the World Wide Web, collaborative engineering, product data management, and large assembly manipulation.

Technical Graphics

- Is the role of the technical graphics changing now that 3D CAD packages are automating more and more of the drafting documentation portion of CAD? It is estimated that 60% of the more than 2 million 2D CAD users today wish to adopt 3D CAD (Versprille, 1999). Thus, although a significant portion of companies will continue to employ people with 2D drafting skills, it is recommended that a larger share of the technical graphics core curriculum be devoted to 3D CAD in order to maintain currency with national trends.
- It is recommended a required course be developed that supports product design employing a ìmainstreamî parametric solid modeling package as was recommended above. Part creation, part drawings, assembly modeling, interference checking, GD&T, bill of materials, and other pertinent topics should be covered.

- It is recommended a required course be developed that supports facilities design and employs a software package like MicroStation. Again, just as for engineering, numerous alternatives exist for organizing such a course. One option would be for the course to run concurrently and interactively with the engineering elective. Then, all students involved would have the experience of integrating work between disciplines, thus emulating what their counterparts should be ideally be doing in industry.

- Further, just as for engineering, it is recommended that both these courses incorporate as so far as possible current topics about the World Wide Web, collaborative design, product data management, and large assembly manipulation.

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Guest Commentary

Most graphics textbooks tell us the Monge invented Descriptive Geometry. Dr. John Lienhard, Distinguished Professor of Mechanical Engineering and Technology History thinks otherwise. In two episodes of his national broadcast series "Engines of our Ingenuity" on the Public Broadcasting Radio Network, he talks about Albrecht Dürer's creation of modern descriptive geometry. Part I follows.

Albrecht Dürer

by John H. Lienhard

Today let's meet Leonardo da Vinci's northern counterpart. The University of Houston's College of Engineering presents this series about the machines that make our civilization run, and the people whose ingenuity created them.

Albrecht Dürer was born in Nürnberg in 1471 — 19 years after Leonardo da Vinci. He was to Germany what Leonardo was to Italy -- a great artist, humanist, and student of nature. Still, the two were not at all alike.

Dürer's greatest works were his marvelous prints. If you've seen nothing else, you've seen copies of his famous "Praying Hands." You find them in every curio shop. We could easily forget the remarkable conviction — and anatomical perfection — of the original, when we've seen a thousand versions in black velvet and bronze-painted plaster. Those indignities are matched only by the ones inflicted on Leonardo's "Last Supper."

Dürer was trained as a goldsmith. Behind his art was the mind of a superb technologist. Leonardo was more the scientist, and Dürer more the engineer. Both were powerfully curious about the nature of things; but Leonardo was more determined in getting-at-truth through direct observation. Dürer, on the other hand, had greater technical control of his art. Leonardo's soaring imagination was expressed in his marvelous ability to show us what his eye saw. Dürer's was expressed in the powerful combination of startling realism with the symbolic language of his time. Dürer was in the center of the intellectual life of his day — everything from the Protestant Reformation to mathematical analysis. He and Leonardo show us that subtle line between pure observation and analytical synthesis. They walked on different creative paths.

In 1505 Dürer went to Italy to study Italian advances in perspective drawing. He learned what the Italians knew. Then he came back and recast that art in the language of Euclidian geometry. His first volume was titled "*A treatise on Constructions with Compasses and Rulers*." An original copy in our library is hauntingly close to one of my old engineering texts. I see my old homework problems among his constructions. The second volume, titled "*Four Books on Human Proportion*," continues to exploit his fascination with, and his command of, formal geometry.

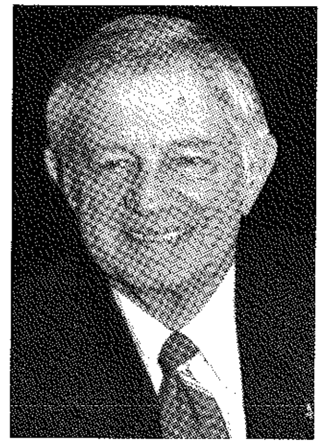
Dürer's full mastery comes clear in his late engravings. Our eye roams these pictures from detail to detail, through layers of symbolism, then back to the whole. The depth of field is astonishing. As our eye takes us into the picture, we feel we're physically walking through rooms. Our interest is carried from element to element the same way it's carried by a fine storyteller.

Dürer harnessed one of the really dazzling minds of the Renaissance to an engineer's clarity and analytical sense — with astonishing results.

I'm John Lienhard, at the University of Houston, where we're interested in the way inventive minds work.

Message from the Chair

Fritz Meyers
The Ohio State University
meyers.2@osu.edu



Division News

It seems like only yesterday that I wrote the first of these columns allowed to your Chair. I have enjoyed my year as Chair and am passing the "torch" on to our capable Vice-Chair, Jim Leach. The Engineering Design Graphics Division is a volunteer organization and I appreciate the service and support of all officers, chairs and other members. Thank you! By the time you read this each of the members should be wearing their EDGD recognition pin which was authorized by the Executive Committee and mailed this Spring. I hope you will wear it and feel a kinship with colleagues you see also wearing the pin.

Now that I am "emeritus" at Ohio State I find that I can't stay away from the classroom. Autumn quarter there were two classes of Honors graphics with 35 really intelligent and earnest young men and women in each class. Winter quarter we did take a vacation and in Spring I had one class of beginning graphics and another in design for manufacture using Solidworks - fun. Our vacation was a trip to New Zealand and Australia (mostly New Zealand) and I couldn't stay away from graphics: we stopped at the University of Canterbury near Christchurch. We were greeted warmly and invited to sit in on a course planning meeting. Same discipline - same great people: we have a lot in common with graphics professionals everywhere. Last Winter we visited eight other universities to learn about their graphics programs and were welcomed at each one (paper in this edition of the *Journal*).

My goal, since leaving industry and becoming a professor, has been to help people learn about graphic communication so that they can be productive citizens. I believe that all of my colleagues share the same focus: to help people learn to visualize, to communicate, to create. It is good to associate with friends who share this same focus. And like other Chairs before me, I shall not leave the Engineering Design Graphics Division - just work with my friends in a different role.

Fritz Meyers

Election Results

Congratulations to the newly elected EDGD officers!

Vice Chair - **Mike Stewart**

Secretary-Treasurer - **Tim Sexton**

Director of Publications - **Sue Miller**

Editor's Award

Congratulations!

2000 Editor's Award Recipient

for outstanding technical paper

published in Volume 63 of

The Engineering Design Graphics Journal

presented to

Sheryl Sorby

Michigan Technological University

for her paper

"Developing 3-D Spatial Visualization Skills"

Standards Corner

Y14.3 Multiview and Sectional Views – May 2000 Proposals

by Patrick J. McCuistion
Ohio University

In the last Standards Corner I discussed the two-dimensional nature of many of the drawing standards. The standard for orthographic views, Y14.3 Multiview and Sectional Views, is about as two-dimensional as they come. I was surprised to learn that two work orders had been submitted on this standard and that we would listen to two different proposals at the May 2000 meeting in St. Louis. Bruce Wilson from the Boeing Company referred to the concerns expressed in theses work orders at the annual ASEE conference.

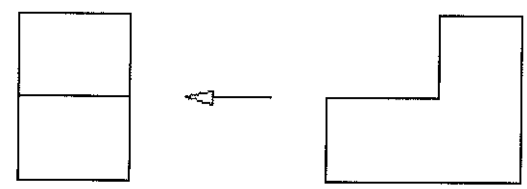


Figure 1 *- Proposed new projection system.*

Archie Anderson from Dimensional Control Systems reported that ISO is now considering what they call a new projection system. Archie is the chairman of Y14.5 Dimensioning and Tolerancing subcommittee and has been active in ISO drawing standards for many years. The projection system involves a combination of two opposing third angle projection views and a view direction arrow placed between the views that points to the main view. See *Figure 1.* While it seems very simple to me, for the people who usually use the ISO standard 1st angle projection system, it may be quite a change.

The proposal is to include this method in Y14.3. Multinational companies like General Motors have expressed interest in using this method as an alternative to both the 1st and 3rd angle projection systems. It may relieve much confusion (save lots of money) for those employees who are responsible for reading drawings using both projection systems.

The second proposal deals with how software may present section views of solid geometry. The problem is that computer projection is too accurate. Kenny King from Lawrence Livermore Labs noted that in certain offset section applications single features appear more than once. See *Figure 2.* I'm not sure how much can be done about this situation, but we will ponder it. It seems to be a problem to report to CAD vendors with the suggestion that they provide alternative projection practices.

Another problem occurs when a cutting plane is passed through thin structural members like ribs, spokes, and webs. It is difficult for most CAD systems not to apply section lines to these areas. It may sound like a minor problem, but for gov-

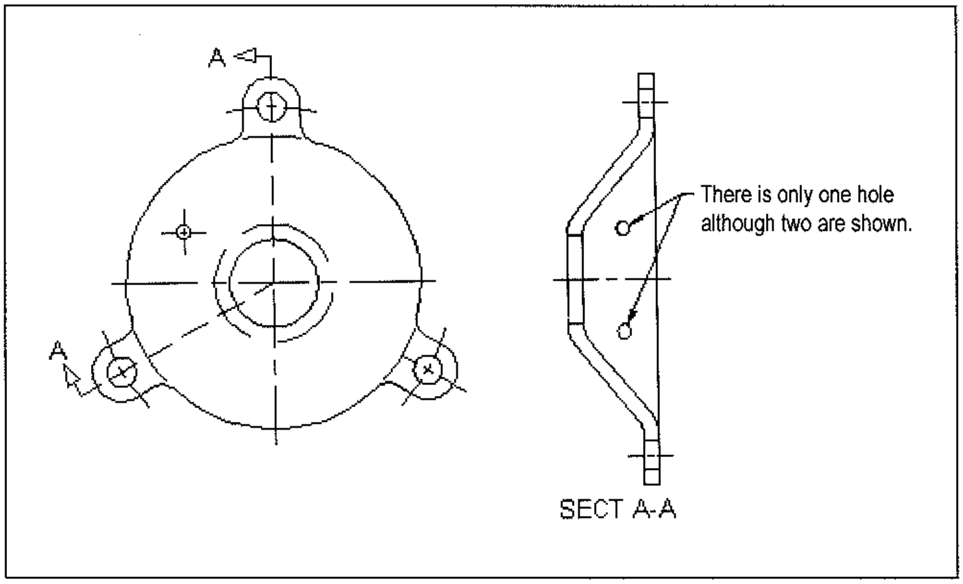


***Figure 2** - Accurate offset section.*

ernment agencies and their suppliers who strictly follow the standards, it's a real problem. To get the drawing accepted for production they may be forced to mask certain areas from hatching, which adds time to the drawing and makes it more complicated.

Both these proposals point to dilemma of creating a standard. In order to keep a standard from dying for lack of use, it must be maintained to keep up with the technology of the day, not of the future, and we hope not too far in the past.

Side bar

ISO and US standards have a long history of sharing standards ideas. Occasionally both groups adopt new standards, like the ISO proposed projection standard, almost simultaneously. Sometimes it takes much longer. The US adoption of the ISO datum symbol for geometric dimensioning took about 30 years to happen. Each group liked their own symbol. There were many friendly arguments about whose symbol was better. We finally realized the rules for the use of the ISO symbol were more flexible. Although we adopted the ISO symbol, they are still not quite the same – the triangular bases have different angles.

Calendar of Events

Division: http://www.east.asu.edu/edgj/edgd

55th Annual EDGD Mid-Year Conference

San Antonio, Texas
Dates: January 6-9, 2001
General Chair: Ronald E. Barr
Phone: (512) 471-3008
E-mail: rbarr@mail.utexas.edu
FAX: (512) 471-7683

56th Annual EDGD Mid-Year Conference

Berkeley, California
General Chair: Dennis K. Lieu
Phone: (415) 642-4014
E-mail: dlieu@newton.berkeley.edu
FAX: (415) 643-5599

57th Annual EDGD Mid-Year Conference

Indianapolis, Indiana
General Chair: Doug Acheson
Program Chair: Pat Connolly

58th Annual EDGD Mid-Year Conference

Arizona
General Chair: Jon Duff

2001 Annual ASEE Conference

Albuquerque, New Mexico
Dates: June 24-27, 2001

2002 Annual ASEE Conference

Montreal, Quebec, Canada
Dates: June 16-19, 2002

2003 Annual ASEE Conference

Nashville, Tennessee
Dates: June 22-25, 2003

2004 Annual ASEE Conference

Salt Lake City, Utah

WSCG 2000

The 8th International Conference in Central Europe on Computer Graphics, Visualization and Digital Interactive Media 2000

Pizen, Czech Republic

Dates: February 7-11, 2000
Web site: http://wscg.zcu.cz

The International Conference on Computer Graphics and Imaging 2000 (CGIM 2000)

Las Vegas, Nevada

Dates: November 19-23, 2000
Web site: http://www.iasted.com/conferences/2000/lasvegas/cgim.htm

EDGD

55th Annual EDGD Mid-Year Meeting

Annual EDGD Mid-Year Meeting
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Call for papers

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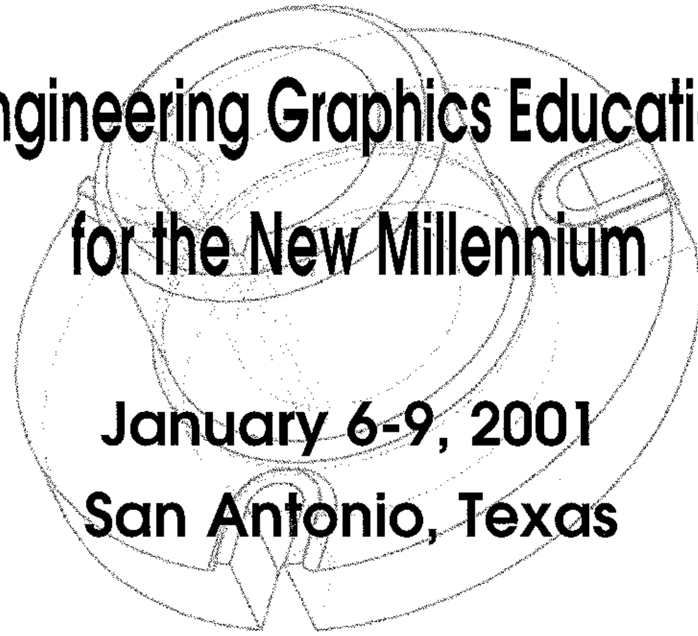

Engineering Graphics Education for the New Millennium

January 6-9, 2001
San Antonio, Texas

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Material submitted should not have been published elsewhere and not be under consideration by another publication. Submit papers, including an abstract as well as figures, tables, etc., in quadruplicate (original plus three copies) with a cover letter to:

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Cover letter should include your complete mailing address, phone and fax numbers. A complete address should be provided for each co-author. Use standard 8-1/2 x 11 inch paper, with pages numbered consecutively. Clearly identify all figures, graphs, tables, etc. All figures, graphs, tables, etc. must be accompanied by a caption. Illustrations will not be redrawn. All line work must be black and sharply drawn and all text must be large enough to be legible if reduced. The editorial staff may edit manuscripts for publication after return from the Board of Review. Upon acceptance, the author or authors will be asked to review comments, make necessary changes and submit both a paper copy and a text file on a 3.5" disk.

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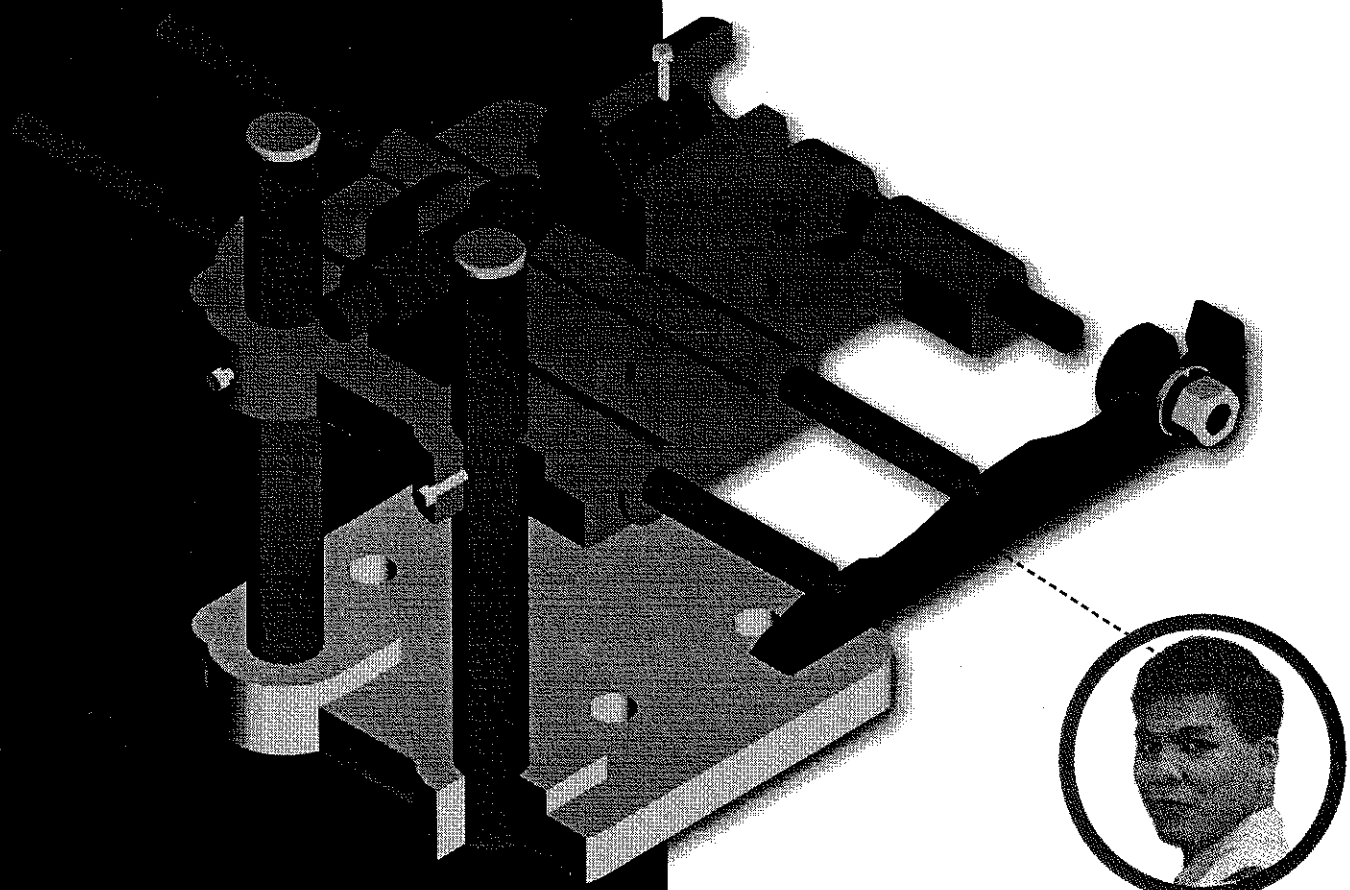

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