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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