Session 3538

Developing the EDG Curriculum for the 21st Century: A Team Effort

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ABSTRACT

A Course, Curriculum, and Laboratory Instruction (CCLI) proposal was submitted to the National Science Foundation (NSF) in November 1998. The title of the proposal was "Engineering Design Graphics Summer School 1999: Planning the Engineering Design Graphics Curriculum for the 21st Century." The project proposes to establish a team of highly-motivated Engineering Design Graphics faculty who will work together and devise a plan that will serve as a modern curriculum guide for Engineering Design Graphics. The inaugural event will consist of a Summer School to be held in the Summer of 1999. At this school, participating faculty will convene to discuss major issues, form sub-committee teams with specific assignments, and return to their home institutions to work on their specific parts of the curriculum plan. Interaction amongst the committees will be conducted through email and internet, and ideas will be discussed and tested in the classroom setting. The group will then reconvene for short 2-day meetings in the 1999-2000 era to finalize the curriculum plan. The results will then be published in a Monograph in time for the year 2001. The monograph will serve as a comprehensive EDG curriculum guide, and will be distributed to all college faculty who are identified as teaching Engineering Design Graphics, as well as to all Engineering and Technology Deans.

Introduction

The field of Engineering Design Graphics (EDG) has been a cornerstone in engineering education for over a century. Courses in EDG are typically incorporated into the curriculum in either the freshman or early sophomore year, and in many cases it is a core requirement for all engineering majors. In the past, the academic focus for Engineering Design Graphics has been developing methodology for producing and reading engineering drawings, which were the traditional communication links between design and manufacturing. Within this academic focus, students of EDG learned how to sketch, to make drawings with manual instruments, and more recently to make drawings with Computer-Aided Design and Drafting (CADD) systems. If courses at both four-year universities and two-year community colleges are included in the tally, it is estimated that over 100,000 students annually study within this EDG discipline.

The field of Engineering Design Graphics has also experienced a long succession of dedicated faculty members who have both fostered and promoted the graphics discipline in engineering education. Most of these EDG faculty have worked cooperatively over the years through the Engineering Design Graphics Division of ASEE. One of the major examples of this cooperative effort was the long series of Summer Schools that the Division had conducted, beginning in the early 1930's. The most notable early Summer School was held after the war in St. Louis in 1946. Many of the pioneers in EDG education made presentations at the meeting, which resulted in a hardbound book [1] that charted the course for EDG education during the twenty-year post-war era. The seventh Summer School was held in 1967 in East Lansing, Michigan and it focused on integrating graphics more closely with the design process. The proceedings of that Summer School were published as a special edition of *The Engineering Graphics Journal* [2], and it served as a landmark document for the infusion of freshman design projects into EDG courses that were typical in the 1970's and 1980's. The last EDG Summer School was held in 1978, and it has now been twenty years without another one. It is the belief by many EDG faculty, and potential participants in this project, that time is overdue for another landmark EDG Summer School.

Statement of the Problem

The traditional process of product development, which was predominant in the United States for the past eighty years, could be generally described as a serial process. The task of designing a part or component would involve a design engineer to conceive its embodiment, a drafter to produce drawings of the part or component, and a manufacturing engineer to guide its production. The current EDG curricula in a majority of engineering programs still reflect this serial approach to product development by relying on engineering drawings for design representation. The students may be using Computer-Aided Drafting systems and even 3-D geometric models, but they still learn skills of a designer/detailer and end up producing engineering drawings that are useful only in the traditional design process. There is a major need to conduct a nationally-based curriculum development project to establish the content and methodology for teaching Engineering Design Graphics in the 21st Century. This proposed project is based on the premise that 2-D drafting is no longer the central focus of the Engineering Design Graphics discipline. Instead, modern engineering students need to develop new 3-D visualization abilities and computer skills that nurture and expand their creative engineering design talent. It now appears that a new paradigm, along the lines of Concurrent Engineering [3,4], would be the natural future paradigm for Engineering Design Graphics.

Project Goals and Objectives

The specific objective of this project is to establish a team of highly-motivated Engineering Design Graphics faculty who will work together and devise a plan that will serve as a modern curriculum guide for all engineering graphics instructors at both two-year and four-year schools across the country. The inaugural event will consist of a three-day Summer School to be held in 1999 in Austin, Texas. At this school, approximately 24 faculty will convene to discuss major issues, seek advise from industrial representatives, form sub-committee teams with specific assignments, and return to their home institutions to work on their specific parts of the curriculum plan. The teams will interact through email and internet home pages. Ideas will be shared, discussed, tested in local classes, and refined in this manner. The whole group will reconvene at follow-up meetings during the 1999-2001 era at ASEE/EDG meetings that have already been pre-identified. During these activities, the curriculum plan and attendant educational materials will be developed and finalized. The full results of the project will then be published in a Monograph that will be distributed to all engineering, technology, and two-year college faculty who are identified as teaching Engineering Design Graphics. It will also be distributed to all engineering and technology deans. It is expected that the information and details contained in the final Monograph will be seminal and will spawn the next generation of EDG textbooks and other class material for the 21st Century.

Preliminary Planning

Enthusiasm and support for this project was demonstrated by the convening of a pre-proposal planning meeting. The planning session was held on July 30, 1998 in Austin, Texas in conjunction with the opening of the *8th International Conference on Engineering Computer Graphics and Descriptive Geometry*. Sixteen EDG faculty members attended this pre-proposal meeting (see Figure 1). Each attendee was given approximately 5-10 minutes to comment on the proposed project (based on earlier perusal of a 1997 proposal plan), and offered suggestions and improvements for this 1998 proposal re-submission. A number of the ideas discussed at the pre-proposal meeting were incorporated into the proposal re-submission. An important major activity at the meeting was the conducting of a preliminary opinion survey of EDG topics and areas that need research as they pertain to the future of EDG. Results of this preliminary survey are depicted in Table 1. Faculty at the meeting also discussed potential sub-topical areas (as suggested later in Table 6) that should be covered at the Summer School and subsequently researched. In addition, faculty recommended names to contact for the Industrial Advisory Board that is planned for the project (see later Table 3).

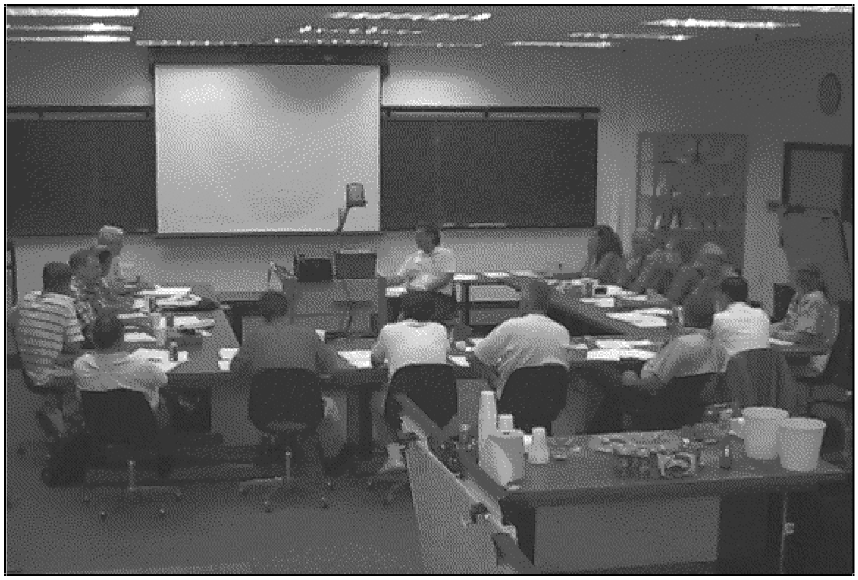

Figure 2 – A pre-proposal planning meeting was held in Austin, Texas on July 30, 1998.

Table 1: Survey Results from Pre-Proposal Planning Session
(ranked from highest to lowest, N=16)

Score*		Score*	
5.00	Developing 3-D Visualization Skills	3.13	New Computer Lab Development
4.44	Parametric Modeling	3.06	Drawing Standards and 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 and Software Skills
3.63	Dimensioning	2.69	Finite Element Analysis
3.50	Sections	2.63	Color Rendering and Visual Realism
3.50	Pictorials	2.63	Charts and 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

*Based on scale of:

5	4	3	2	1
Very Important		***Somewhat Important***		***Not Important at All***

Structure of the Project

The structure of this proposed CCLI project consists of a project director (proposal PI) who will recruit and select eight faculty subcommittee chairpersons. The faculty chairs will play a major leadership role at the Summer School in 1999, and will serve as committee chairs for the working groups that will ensue during the year following the Summer School. In addition, another 16 faculty will participate in the Summer School and will become members of the working sub-committees. This entire group will function over a two-year period to conduct educational research

activities in EDG and to document this work in a final Monograph for national dissemination. Activities after the Summer School include testing of materials at home institutions and follow-up meetings at ASEE/EDG conferences that have been pre-identified (see later Table 5). Working with this faculty group will be representatives from our Industrial Advisory Board who will offer suggestions from their perspective. The overall structure of the project is shown in Figure 2. Lists of potential faculty participants and industrial advisory members are shown in Tables 2 and 3.

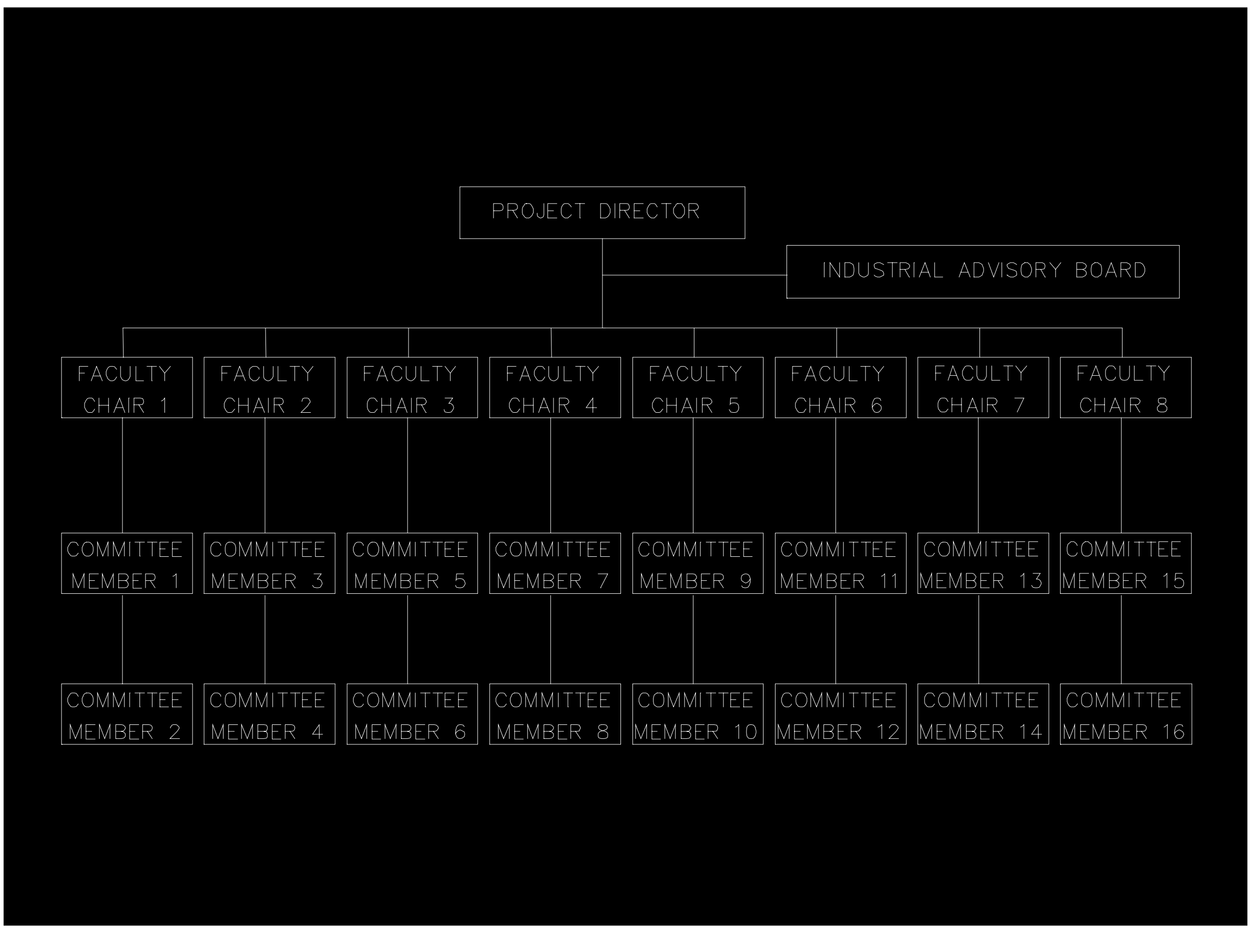

Figure 2 - The structure of this proposed project consists of a project director who will recruit and select eight faculty subcommittee chairpersons. These eight faculty will play a major leadership role at the Summer School in 1999, and will serve as committee chairs for the working groups that will ensue during the year following the Summer School. In addition, another 16 faculty will participate in the Summer School and will become members of the working subcommittees. Working with the faculty group is an Industrial Advisory Board, consisting of approximately ten representatives from the industrial sector.

Table 2: Potential Candidates for Summer School Faculty Participants

Vera Anand Clemson University	Larry Goss University of Southern Indiana	John Nee Central Michigan University
Holly Ault Worcester Polytechnic Institute	Thomas Krueger University of Texas at Austin	Mary Sadowski Purdue University
Gary Bertoline Purdue University	Dennis Lieu University of California - Berkeley	Timothy Sexton Ohio University
John Cherng University of Michigan-Dearborn	Robert Mabrey Tennessee Tech University	Sheryl Sorby Michigan Tech University
William Cole Northeastern University	Kim Manner University of Wisconsin - Madison	Dennis Stevenson University of Wisconsin - Parkside
Janak Dave University of Cincinnati	Michael McGrath Colorado School of Mines	Michael Stewart University of Arkansas-Little Rock
Jon Duff Arizona State University- East	Craig Miller Purdue University	Steven Wendel Sinclair Community College
Renata Engel Penn State University	Jeffrey Mountain University of Texas at Tyler	Eric Wiebe North Carolina State University

Table 3: Potential Candidates for Industrial Advisory Board

Thomas Agner Powertrain Engineering Division Ford Motor Company Dearborn, Michigan	John Milbery Regional Technical Manager Solidworks Corp. Dallas, Texas
Charles Casgrain CAE & CAD/CAM Department Ford Motor Company Livonia, Michigan	Michael Murphy Senior Contact Engineer General Motors Corp. Oswosos, Michigan
Nathan Hartman Technical Training Engineer Rand Technologies Schaumburg, Illinois	Stephen Schroff CEO Schroff Development Corp. Mission, Kansas
Mark Lawry Engineering Training Division Structural Dynamics Research Corp. Milford, Ohio	Sam Wood CAD/CAM Facilities Manager Sulzer Orthopedics, Inc. Austin, Texas
Peter Loney Senior Implementation Engineer Parametric Technology Corp. Southfield, Michigan	One more member To be identified

The Summer School

The Summer School will serve as the inaugural, invigorating event for this project. Approximately 24 faculty will meet for three full days in Austin, Texas to make presentations, discuss global issues, formulate plans, organize working subcommittees, and convene with specific assignments for the upcoming academic year. While specific dates for the Summer School are not fixed at this stage, likely available dates would include August 9-11, 1999 or August 16-18, 1999. A typical daily format for the Summer School is suggested in Table 4.

Planning for the Summer School will be conducted by the project director. This planning will include recruiting the eight faculty chairs and other working group participants, establishing a daily schedule of events, inviting industrial speakers, and arranging the logistics for the school. The project director will also oversee the follow-up activities after the Summer School, including the scheduling of the follow-up meetings in 1999-2001 (see Table 5 for a list of planned meetings for this project).

Lectures and discussion sessions will be primarily led by the faculty chairs, with the project director and other attending persons participating as their expertise warrants. In advance of the Summer School, the faculty chairs, in consort with the project director, will select the topical issues they will address during their lecture. Some preliminary subtopics have already been identified and are listed in Table 6. Each lecture session will last 90 minutes and will have: 1. a formal presentation, 2. a hands-on demonstration, and 3. a discussion session. Each day will also include a daily compilation of resolutions, which will contribute to the final subcommittee assignments and tasks. Guest speakers from the Industrial Advisory Board will also be solicited as their time and availability permits. Evening activities would include continuation of the daily demonstrations, planned computer exercises, or small "rap-sessions" over dinner. By the end of the School's third day, a rough draft of committee topics and assignments will be established for finalization before adjournment. Monograph writing assignments will also be established.

Table 4: Typical Daily Schedule for the Summer School

Day 1:	Introductions and Objectives
	Lecture and Demonstration 1
	Discussion Session 1
	Lecture and Demonstration 2
	Discussion Session 2
	Lunch
	Guest Speaker from Industry 1
	Lecture and Demonstration 3
	Discussion Session 3
	Wrap-up and Resolutions 1
	Evening Group Activity 1
Day 2:	Lecture and Demonstration 4
	Discussion Session 4
	Mentor Lecture 5
	Demonstration 5
	Discussion Session 5
	Lunch
	Guest Speaker from Industry 2
	Lecture and Demonstration 6
	Discussion Session 6
	Wrap-up and Resolutions 2
	Evening Group Activity 2
Day 3:	Lecture and Demonstration 7
	Discussion Session 7
	Lecture and Demonstration 8
	Discussion Session 8
	Lunch
	Wrap-up and Resolutions 3
	Compilation of Resolutions
	Subcommittee Assignments
	Finalization of Plans
	Finalization of Time Schedule
	Adjournment
	Return Home

Table 5: Pre-Identified Sites for the Summer School and Follow-Up Meetings

Event	Place	Date
Summer School	Austin, Texas	August, 1999
Follow-Up Meeting #1	Biloxi, Mississippi	November 1999
Follow-Up Meeting #2	St. Louis, Missouri	June 2000
Follow-Up Meeting #3	San Antonio, Texas	January 2001
Monograph Publication	Kansas City, Missouri	May 2001
Paper Presentations	Albuquerque, New Mexico	June 2001
Paper Presentations	Berkeley, California	January 2002

Table 6: Potential Subcommittees Topics

1. Introduction to Graphics and Design
    - Engineering as a profession
    - History of Graphics in Design
    - Design Process
    - Taxonomy of Graphics and Geometry
    - Role of Graphics in Engineering Design

2. Manual Sketching
    - Lettering
    - Sketching Lines and Circles
    - Sketching Pictorials
    - Sketching Manual Constructions
    - Use of Instruments

3. Visualization Techniques
    - Projection Theory
    - Orthographic Drawings
    - Pictorial Projections
    - Techniques to Enhance Visualization
    - Spatial Ability Tests

4. 2-D Computer-Aided Design
    - Basic Elements of CAD
    - Basic Construction Techniques
    - Descriptive Geometry Techniques in CAD

5. 3-D Computer-Aided Design/Modeling
    - Wireframe Modeling
    - Surface Modeling
    - Solid Modeling
    - Parametric Modeling
    - Feature-Based Modeling
    - Constraint-Based Modeling

6. Graphics Applications
    - Graphics Applications to Design Analysis
    - Mass Properties Analysis
    - Finite Element Analysis
    - Kinematics Analysis
    - Graphics Applications to Manufacturing
    - Rapid Prototyping
    - Reverse Engineering
    - Team Projects

7. Graphics Documentation
    - Generation of Engineering Drawing
    - Sectioning Methods
    - Dimensioning Techniques
    - Assembly Drawings
    - Standards
    - Rendering

8. Instructional Technology Issues in Graphics
    - Use of Multimedia
    - CD ROM Tools
    - Animation/Simulation
    - Use of WWW website
    - Virtual reality
    - Hardware/Software Issues
    - Modern Teaching Materials in Graphics

Monograph Preparation

The highlight of this project will be the production and dissemination of a Monograph that will serve as the basis for EDG curriculum planning for the 21st century. The Monograph will be an edited and illustrated series of chapters that reflect the sub-committees' findings in their respective reports. In particular, a matrix approach (see Table 7) will be employed to identify the proper curriculum content for the various EDG constituencies. The Project Director will gather all the material following the 2001 follow-up meeting and will insure that all topics are addressed. He will also be editor-in-chief of the Monograph; but all committee members who participated in the formulation of the chapters will be identified as contributing editors of the Monograph. Preparation and printing of the Monograph is expected to take about 4-6 months, and it should be ready for dissemination by June 2001. It is expected that the Monograph will be seminal, and that it will spark the next generation of EDG textbooks by authors who participated in this project, and by other faculty who have been influenced and motivated by the project.

Discussion and Conclusions

Many pedagogical questions arise to meet this challenge of modernizing the EDG curriculum and promoting it on a national basis. Some of these issues are posed here for thought through examples of EDG curriculum content and illustrations of the types of problems graphics students could be expected to solve (see Figures 3 through 9). These questions and many more will no doubt arise during this proposed CCLI-EMD project. The structure of this proposed project nicely lends itself to discussion, consensus building, testing, and resolving of these issues. The 1999 Summer School will actively expose, mete out, and organize the issues for further study. The working groups will systematically follow through with investigations, classroom testing, evaluation, and preliminary reports. The follow-up meetings in 1999-2001 will review and discuss the reports, and arrive at some conclusions about each of these issues. The curriculum guide Monograph will organize the results into a professional format for widespread public dissemination and consumption by the dawning of the 21st century.

Table 7: Matrix Approach to Classifying the EDG Curriculum for Various Constituencies

Constituency	Sub-Topic 1	Sub-Topic 2	Sub-Topic 3	Sub-Topic 4	Sub-Topic 5	Sub-Topic 6	Sub-Topic 7	Sub-Topic 8
Core	Common Core Topics							
4-Year Engineering	*							
4-Year Technology								
2-Year College								
Pre-College								
Upper Division								
Non-Engineering								

*Each cell will be completed with curriculum items appropriate for that constituency under each sub-topic.

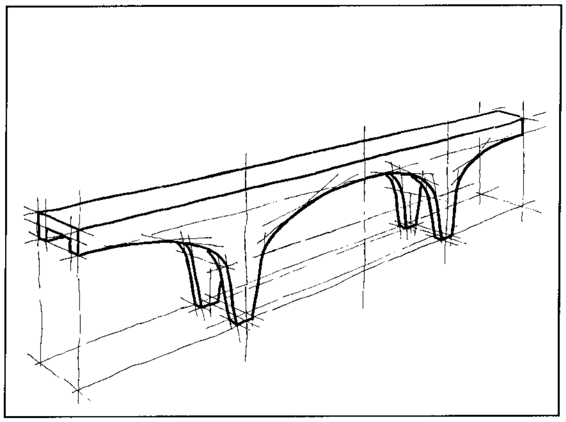

Figure 3 - What role does sketching play in the EDG curriculum? Is it still a necessary function with all the availability of CADD software? If such, what types of sketching modes and how much are appropriate? What about 2-D constructions and the use of instruments? .

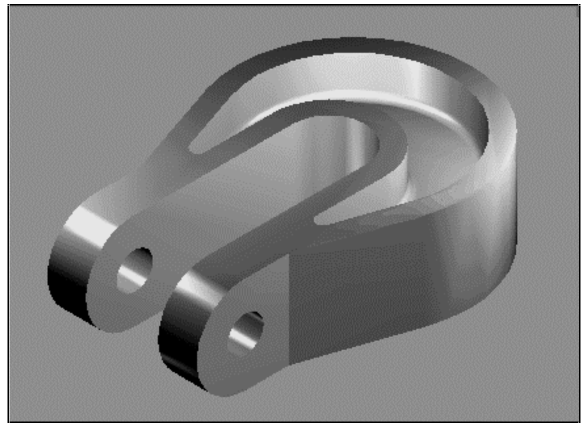

Figure 4 - How much of the EDG curriculum should be based on solid modeling? Does solid modeling, with its rendering capabilities aid in the EDG student's visualization abilities? Is it really the answer or should students still make 2-D drawings?

Figure 5 - How can students work in teams in Engineering Design Graphics? Is reverse engineering an appropriate activity? What about dissection lab experiences? What about team design projects? Should they generate team-based project reports with their graphics work?

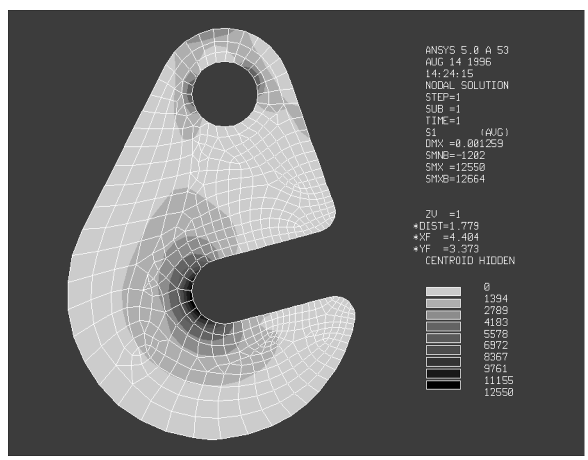

Figure 6 - Is it plausible to introduce a design analysis component? Can exposure to the finite element analysis approach help or hurt the student's understanding of the modern approach to engineering design? What other design analyses can EDG students experience?

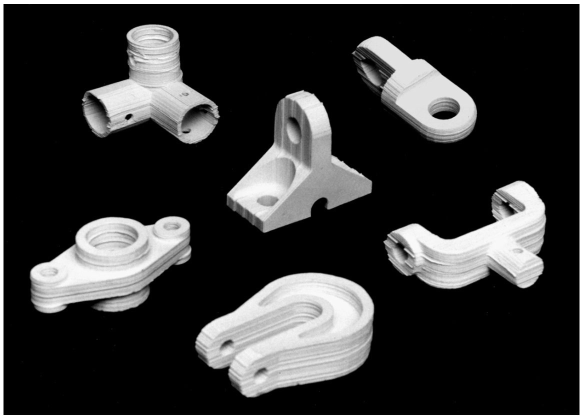

Figure 7 - Are physical prototypes a natural, modern extension of creating graphics for the design process? Does the ability to see and hold a product of their design activities offer added meaning and enthusiasm for their freshman EDG experience?

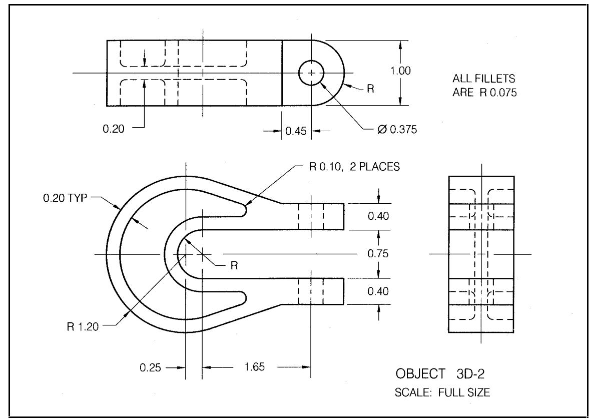

Figure 8 - Should an engineering drawing be generated directly from the solid model data base? Will engineering drawings still be needed in the modern design paradigm? If for no other reason, will they be needed for legal matters.

Figure 9 – What new technologies lie ahead for Engineering Design Graphics? Will Virtual Reality have any near-future impact on the way engineers visualize and create new designs? What about graphics communication links through the WWW? How can multimedia be used in Engineering Graphics?

References

[1] Hoelscher, R. and Rising, J. (editors): *Proceedings of the Summer School for Drawing Teachers*, McGraw-Hill Book Company, New York, 1949.

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