Planning the EDG Curriculum for the 21st Century: A Proposed Team Effort

Ronald E. Barr
The University of Texas at Austin

ABSTRACT

A group project, titled "Planning the Engineering Design Graphics Curriculum for the 21st Century," has been proposed for the field of Engineering Design Graphics (EDG). 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 project would be inaugurated by a Summer School. At the Summer 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 following two years to finalize the curriculum plan. The results will then be published in a Monograph in time for the dawning of 21st century. 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. This paper serves as an introduction to the project, and is followed by five position papers on significant subtopics related to the overall project.

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 (Hoelscher & Rising, 1949) 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* (Special Edition, 1967), 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. Many EDG faculty believe, that the Summer School format offers the best approach for planning the EDG curriculum for the 21st century.

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 is possible that a new paradigm, along the lines of Concurrent Engineering (Barr & Juricic, 1992, 1997), would be the natural future direction for Engineering Design Graphics education.

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. 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 full group will reconvene at follow-up meetings in conjunction with ASEE/EDG conferences the following two years. 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 educational materials 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. Each attendee was given approximately 5-10 minutes to comment on the proposed project and to offer suggestions and improvements for future work on the project. Many of the ideas discussed at the pre-proposal meeting were incorporated into the current project description.

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 in *Table 4*) 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 as consultants for the project.

Structure of the Project

The structure of this proposed 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, and will serve as committee chairs for the working groups that will ensue during the two years 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

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***

***Table 1** - Survey results from pre-proposal planning session (ranked from highest to lowest, N=16).*

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 (*Table 3*). The faculty participants will interact through email and internet web sites to communicate ideas and results of their trial course efforts. It is expected that a series of position papers, co-authored by a variety of teams from the group, will be presented at the follow-up meetings. 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 1*.

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 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 the months of June, July, or August. A typical daily format for the Summer School is suggested in *Table 2*. The daily schedule includes times for lectures, demonstrations, discussions, planning, and resolutions.

Planning for the Summer School will be the responsibility of the project director. This

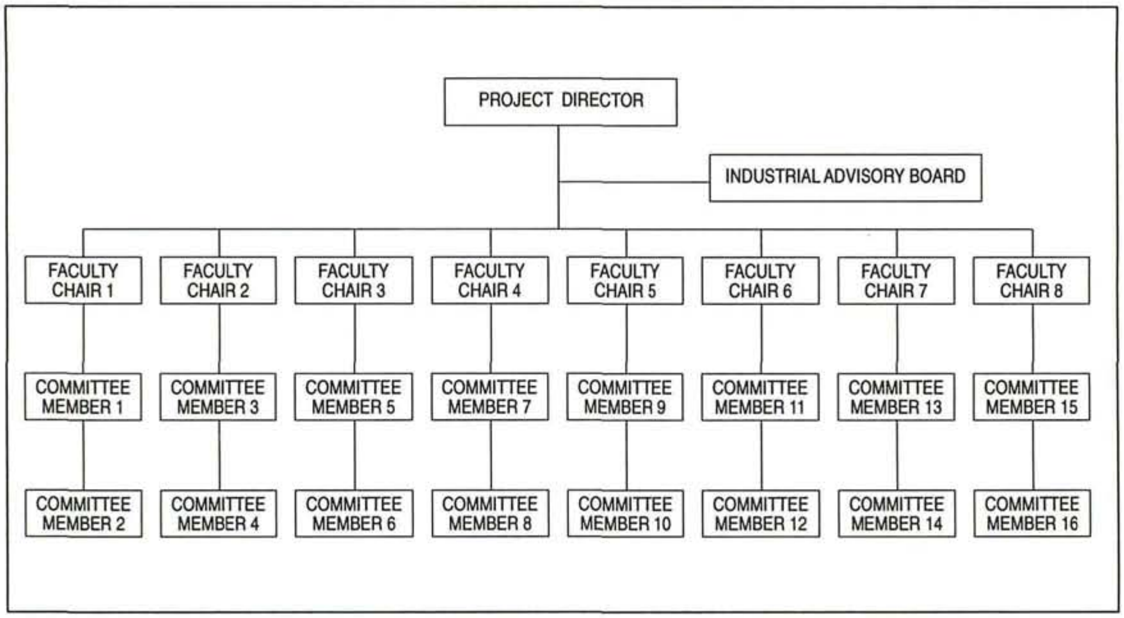

Figure 1 *- The structure of this proposed project consists of a project director who will recruit and select eight faculty subcommittee chairpersons. These eight faculty chairs will play a major leadership role at the Summer School and will serve as committee chairs for the working groups that will ensue during the two years 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 spanning companies such as Ford, General Motors, SDRC, and Sulzer Orthopedics.*

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 the following two years. Although no specific dates have been determined, potential meeting sites, in conjunction with ASEE/EDG conferences, have been identified and are listed in *Table 3*.

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 4*. 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 for later publication.

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

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

***Table 2** - Typical daily schedule for the summer school.*

Event	Place	Date
Project Meeting	Biloxi, Mississippi	November 1999
Project Meeting	St. Louis, Missouri	June 2000
Project Meeting	San Antonio, Texas	January 2001
Paper Presentations	Albuquerque, New Mexico	June 2001
Paper Presentations	Berkeley, California	January 2002
Paper Presentations	Montreal, Canada	June 2002

***Table 3** - Potential sites for project meetings and presentations.*

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

2. Sketching
- Lettering
- Sketching Lines and Circles
- Sketching Pictorials
- Sketching Manual Constructions
- Use of Instruments
- Computer Sketching
- Basic Elements of 2-D CAD

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

4. 3-D Computer-Aided Design/Modeling
- Wireframe Modeling
- Surface Modeling
- Solid Modeling
- Parametric Modeling
- Feature-Based Modeling
- Constraint-Based Modeling

5. Graphics Applications
- Graphics Applications to Design Analysis
- Mass Properties Analysis
- Finite Element Analysis
- Kinematics Analysis
- Graphics Applications to Manufacturing
- Rapid Prototyping

6. Teamwork and Design Projects
- The Design Process
- Reverse Engineering
- Dissection Labs
- Team Projects
- Project Reports
- Teaching Paradigms in Graphics

7. Graphics Documentation
- Generation of Engineering Drawings
- Sectioning Methods
- Dimensioning Techniques
- Assembly Drawings
- Standards
- Shading and Visual Realism

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

***Table 4** - Potential subcommittee topics.*

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.								

Table 5*- Matrix approach to classifying the EDG curriculum for various constituencies.*

series of chapters that reflect the sub-committees' findings in their respective reports. In particular, a matrix approach *(Table 5)* will be employed to identify the multi-level curriculum content for the various EDG constituencies. The Project Director will gather all the material following the follow-up meetings 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 then. 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 (*Figures 2 through 8*). These questions and many more will no doubt arise during this project. The team structure of this proposed project nicely lends itself to discussion, consensus building using Delphi studies, testing of educa-

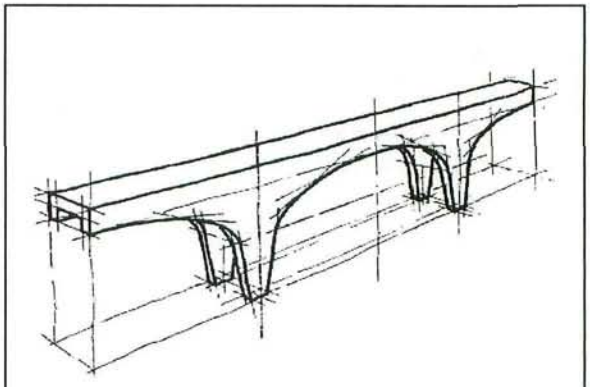

Figure 2 *- What role does sketching play in the EDG curriculum? Is it still a necessary function with all the availability of CADD software? If such, what type of sketching and how much is appropriate? What about the need for 2-D constructions and the use of manual instruments?*

tional materials, and resolution of conflicting issues. The 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 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.

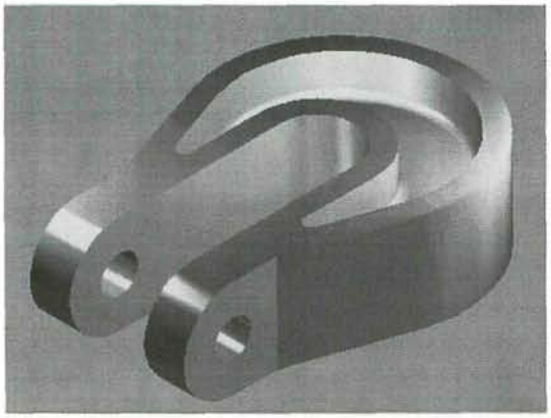

Figure 3 *- How much of the EDG curriculum should be based on solid modeling? Does solid modeling, with its rendering capabilities, aid in the EDG student's visualization abilities? Is it really the answer, or should students still make 2-D drawings?*

Figure 4 *- 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?*

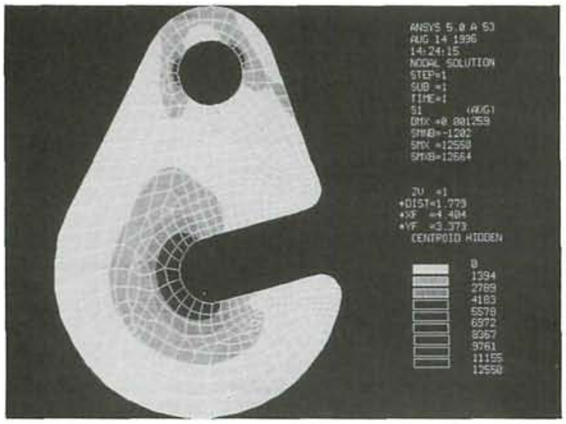

Figure 5 *- Is it plausible to introduce a design analysis component? Can exposure to the finite element analysis approach help or hurt the student's understanding of the modern approach to engineering design? What other design analyses can EDG students experience?*

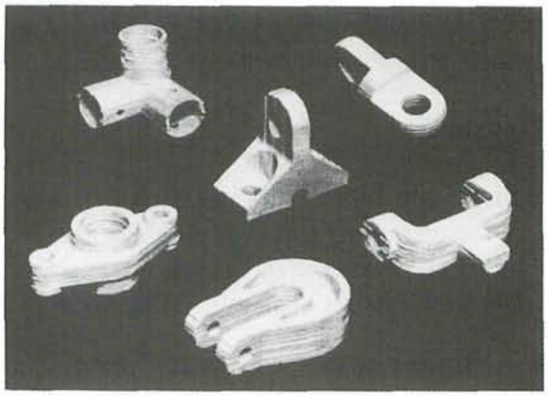

Figure 6 *- Are physical prototypes a natural, modern extension of creating graphics for the design process? Does the ability to see and hold a product of their design activities offer added meaning and enthusiasm for their freshman EDG experience?*

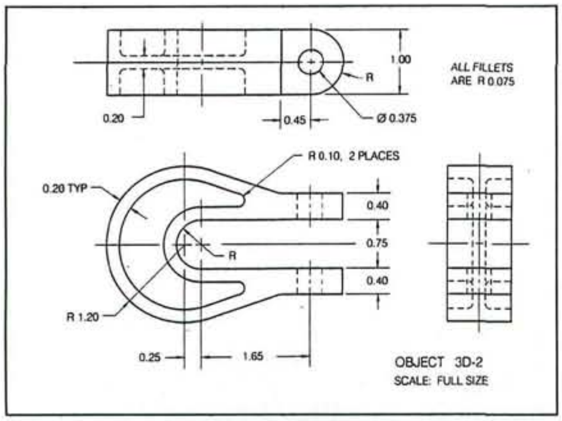

Figure 7 *- Should an engineering drawing be generated directly from the solid model database? Will engineering drawings still be needed in the modern design paradigm? If for no other reason, will they be needed for legal matters?*

Figure 8 *- 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?*

Author's Note: *A proposal to support this project was submitted to the National Science Foundation (NSF) in November 1998. Unfortunately, it was not funded during that cycle. However, our group is committed to planning the EDG Curriculum for the 21st Century, even without funding. If you are interested in this project, please send an email to the author at: rbarr@mail.utexas.edu.*

References

Barr, R. and Juricic, D. (1992). A new look at the engineering design graphics process based on geometric modeling, *Engineering Design Graphics Journal*, 56 (3), 18-26.

Barr, R. and Juricic, D. (1997). Classroom experiences in an engineering design graphics course with a CAD/CAM extension. *Engineering Design Graphics Journal*, 62 (1), 9-21.

Hoelscher, R. and Rising, J. (editors) (1949). *Proceedings of the summer school for drawing teachers*. New York: McGraw-Hill Book Company.

Special Edition (1967). Engineering graphics and design. *The Journal of Engineering Graphics, 31*, (4).