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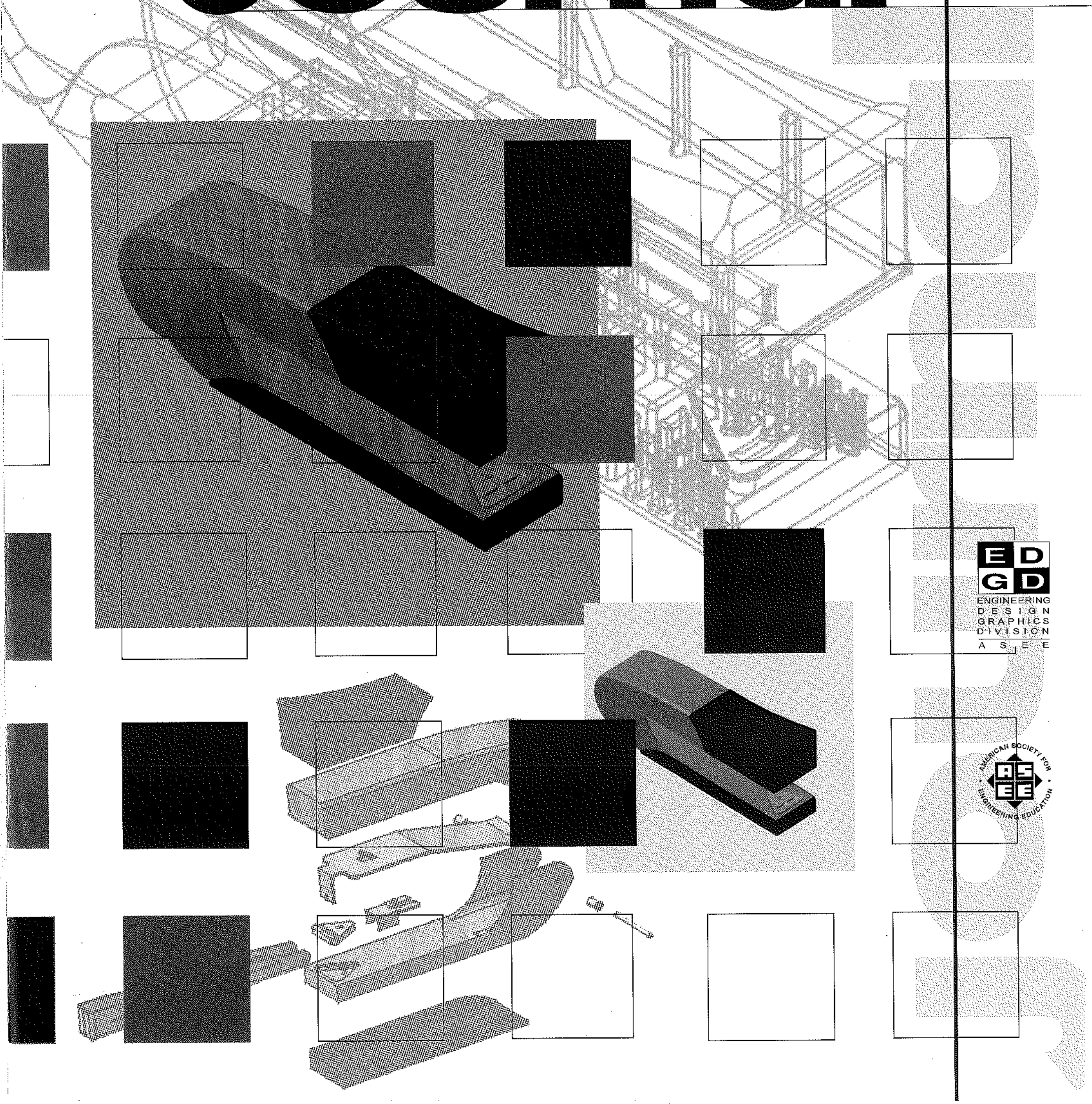

EDGD
ENGINEERING DESIGN GRAPHICS DIVISION
ASEE

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

THE ENGINEERING DESIGN GRAPHICS
Journal

WINTER 2003

volume 67 number 1

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.

Cover graphics were created by Computer Graphics Technology undergraduate students at Purdue University.

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[From the Editor]

Dear Members:

Congratulations are in order for five of the authors/co-authors of papers published in this issue of the *Journal.* Ted Branoff, Nate Hartman, and Eric Wiebe won the Chair's Award at the Annual Conference for their paper titled *"Constraint-Based, Solid Modeling: What do Employers Want Our Students to Know?"* Judy Birchman and Amy Secrest won the Oppenheimer Award for their paper presentation on *"Enhancing the Appearance of Information Graphics"* at the MidYear meeting this past fall. Steven Schroff should also be commended for once again supporting graduate students within the Division. His support allowed two graduate students to attend and present papers at the MidYear meeting in Indianapolis. The two recipients were Amy Secrest who is finishing up her master's degree at Purdue University this semester and La Verne Abe Harris who is working on her Ph.D. at Arizona State University. Congratulations!

Finally, I have continued to print the notice about the Oppenheimer Endowment Fund in the *Journal* on page 5. If you are interested in contributing to this endowment fund please contact Ron Barr. And thanks to all the members who have made contributions to this endowment so that we can continue to honor Frank Oppenheimer for all of his contributions to the EDG Division.

It is time to start enjoying Spring after a very long and cold winter that the majority of us in the Division had to deal with this year.

Hope to see everyone at the Annual Conference in Nashville this Summer.

Susan G. Miller

Susan G. Miller

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Message from the Chair

Sheryl Sorby
Michigan Technological University

Dear Colleagues,

I guess now I am the official "bottleneck" in getting the Journal out on time and I apologize for that. Where does the time go? You should have gotten a ballot in the mail for the election of EDGD officers. Please make sure you take the time to fill it out and send it in—we really do want your active participation in division business. If you are reading this after you have already sent your ballot in, you have our sincere thanks for providing us with your input.

I trust that everyone is busy with your work and personal life. Spring is in the air, even here in Houghton where the snowbanks are beginning to subside—I can now see over them when I pull up to a Stop sign. I hope you are all working on papers for the annual or mid-year conferences (or for the Journal of course!). We are anxious to hear about your curricular innovations and special projects.

Once again I have been pondering what to focus on for this Chair's message. I think the division is in great shape; things are moving forward as far as I can tell. My biggest worry lately stems from internal problems we are facing here at Michigan Tech. With the prospect of significant budget reductions, it is sometimes difficult to maintain a positive attitude towards my profession and my vocation. I know that many other institutions are also experiencing financial difficulties, so I trust I am not alone in my feelings of discouragement. The question I keep asking myself is "Why do I bother?" Many of you probably feel the same. Why bother trying to implement improvements in our courses that are neither appreciated by students nor valued by administrators? Why bother learning the latest version of the software when no one will be there to shake our hands and say "a job well done!"? Why bother writing a paper or a proposal when we may not be earning a raise in pay this year? Why bother serving on a division such as EDGD when our on-campus colleagues do not see the worth in our participation and leadership? Why not just teach our courses in the same old way, recycle old homework and exams, hold minimal office hours, and go home at 2:00 in the afternoon?

Many of us could earn more working in industry. Many of us could have far fewer headaches if we just kept our heads down and accomplished minimally. Many of us could spend more time with our families if we didn't go to the office on the weekend to put the finishing touches on our various projects. The fact that we don't, speaks volumes about our integrity, dedication, sense of professionalism, and character.

These questions have been rattling around in my head for some time now as we face these difficult financial times in higher education. Faced with significant budgetary problems, we are often confronted with increased section sizes, little opportunity for professional growth, and a general feeling of apathy and poor morale.

I guess the reason that I "bother" to continue to strive to do my best is that, ultimately, I have to be able to live with myself and to feel as if I have contributed positively to improving my little corner of the world. I had a friend who used to teach at the University of Michigan (he's retired now). We were discussing many of the things that we do for our students and our departments that are really "above and beyond" the call of duty. I asked him why he worked so hard to make sure his students got the type of education they deserved. He looked at me and said, "My reward will be in heaven." I'm not sure he was really talking about the afterlife, per se, but I think he captured the spirit of how many of us feel about our calling as university faculty members. Many of us could earn more working in industry. Many of us could have far fewer headaches if we just kept our heads down and accomplished minimally. Many of us could spend more time with our families if we didn't go to the office on the weekend to put the finishing touches on our various projects. The fact that we don't, speaks volumes about our integrity, dedication, sense of professionalism, and character.

It's difficult to keep moving forward in these troubling times, but we must. After retirement, we want to be able to look back on our careers and say to ourselves, "I done good."

Take care of yourselves, don't work too hard, and I hope to see you all in Nashville this June. AND don't forget about Scottsdale in November!

Sheryl Sorby

Oppenheimer Endowment Fund

Dear EDGD Members:

The Engineering Design Graphics Division of ASEE is establishing an endowment fund for the Oppenheimer Paper Award, which is given each year to the author/presenter of the Best Paper at the annual EDG Midyear meeting. Frank Oppenheimer created the award to improve paper presentations at the EDG Midyear meeting, and he has personally sustained it financially over the last three decades. The purpose of the endowment is to permanently honor him and his contribution to the EDG Division by having a fund to support his award in perpetuity.

Individual EDG member donations are being solicited over the next several months until a target corpus is met. Several donations and pledges in the range of $50-$250 have already been received. If you would like to donate, write your check made out to "ASEE EDG Division," write a note for "Oppenheimer Endowment," and send it to:

Ronald E. Barr
Chair, Oppenheimer Endowment Fund Committee
Mechanical Engineering Department
Mail Code C2200
University of Texas at Austin
Austin, Texas 78712

Constraint-Based, Solid Modeling: What do Employers Want Our Students to Know?

Theodore J. Branoff, Nathan W. Hartman, and Eric N. Wiebe
North Carolina State University

chair's award
ASEE 2002 Annual Conference in Montreal, Quebec, Canada

Abstract

Over the last twenty years, engineers, technologists, technicians and educators have watched the development of three-dimensional modeling go from wireframe to solid. More recently, constraint-based modelers have replaced 2D CAD and constructive solid geometry modelers as the tool of choice for many engineering applications. These modelers place the 3D model at the center of the design process database. Over the last several years, engineering graphics educators have been adjusting their curricula to better prepare students to secure employment in environments where constraint-based modelers are used. One of the big concerns in engineering graphics education is the importance of documentation in the curriculum. How much time should be spent covering multiview drawings, standards for dimensioning and tolerancing, sectional views, conventional practices, auxiliary views, or geometric dimensioning and tolerancing? Do employers want students to know these "drawing" practices? Do they want students to be proficient in constraint-based modeling? What do they expect students to know when they leave the university and what do they want them to learn on the job? This paper summarizes literature in engineering design related to constraint-based modeling.

Introduction

Engineering Design Graphics educators are at a critical point in time relative to curriculum development. Developments in computer technology over the last twenty years have drastically changed the way products are designed and manufactured. Although industry has kept up with these changes, many university programs have been slow to update curricula for a variety of reasons. These discrepancies between industry and education are evident when one examines the topics presented at EDGD (Engineering Design Graphics Division) conferences and published in the EDG Journal versus those topics published in trade journals, white papers, and other engineering publications. Within the EDGD there are still quite a few papers and presentations concerning 2D documentation. Recently, there have even been discussions of a nationally normed test for engineering graphics that is mainly focused on documentation (Croft, Demel, & Meyers, 2002).

Part of the reason for the discrepancies may be that within the EDGD there are a wide variety of educators from institutions that have different goals. The EDGD has traditionally focused on preparing engineers to understand graphics. Participants at the last several Midyear Conferences of the EDGD have been from universities who prepare engineers and technologists and also community college instructors who prepare technicians. There are distinct differences between what these three groups of people should be able to do in a work setting as defined by the Panel on Engineering Infrastructure Diagramming and Modeling (as cited by the School of Technology at Michigan Technological University, 1998). Engineers need to be conceptualizers, innovators, planners, designers, developers, decision-makers, formulators of techniques and methods, and synthesizers of information. Technologists, on the other hand, should be prepared to be operators of systems, translators of concepts, directors of technicians, implementers, appliers of established techniques and methods, maintainers of systems, and analyzers. Finally, technicians should be prepared to be performers of operational tasks, users of proven techniques and methods, builders of components, operators, testers, collectors of data, maintainers of components, and preparers of technical drawings. If engineering design graphics faculty are preparing technicians, then focusing on engineering documentation is appropriate. If faculty are mainly preparing engineers and technologists, then the focus must be on something other than creating documentation. Currently, the status seems to be centered around documentation. In a national survey of engineering and technical graphics educators, Clark and Scales reported that only 16% of engineering and technical graphics faculty evaluate solid models in introductory courses, while 40.9% evaluate 2D CAD drawings (Clark & Scales, 2001).

When examining engineering publications, 2D CAD topics are rare. The current topics in recent trade journals, white papers and online journals are data exchange, online collaboration, understanding geometry defects and how to fix them, advanced modeling techniques, behavioral modeling, knowledge-based systems and integration of information throughout the design process, and the need for hybrid employees. If our students are to be successful in the workplace, educators must examine the kinds of topics that students will face.

Data Exchange

Exchanging data between two CAD systems and between a CAD system and other engineering applications continues to be a major concern for many firms. This is especially true for the automotive and aerospace industries where hundreds of subcontractors may be contributing to the production of the final design. Companies typically select from direct translators (where files are read and written in their native data sets), international standard file formats such as STEP, IGES, etc., or from various software that runs from a common geometry kernel to produce machine-independent geometry (Theorem Solutions, 2001). As CAD systems become more complex, and the need for translating more than just geometry between systems increases, companies will need to have individuals that understand problems with geometry and how to remedy them. In addition, they will need to have individuals who understand how to get data from one application to another with as little data loss as possible. The benefits of exchanging data with third party suppliers are too great to ignore. It is more cost effective to spend money on fixing data than to try to compete without the expertise of these third party suppliers (Dean, 2002).

Collaboration

Most CAD vendors are changing their focus from developing only core capabilities in modeling to online collaboration functions (Beckert, 2001). Collaboration software allows individuals at different locations to manipulate engineering documentation and models to simultaneously design a product (Dvorak, 2001a). The online companies who are developing collaboration software are trying to change the way manufacturers operate. Instead of paying for one system to be located within a company that can handle all design and manufacturing functions, online application service providers (ASP) are developing software that can be accessed on a "pay per use" basis. Companies can even test most of these applications at no cost (Dvorak, 2001b). What does this mean for educators? Students who can come into a company and collaborate with customers, suppliers, and other employees will be more effective. They will allow their company to surpass the competition by saving time, reducing costs, and bringing products to the market faster (Sofranec, 2001).

While there may be no common answer as to how to accommodate collaboration in the new engineering graphics curriculum, there should be no reason to ignore it. Companies are devoting too many resources to this issue for it to become a passing fad. Communication is stressed throughout most university degree programs, and the techniques provided by the Internet and related technologies have only served to further enhance its coverage. In fact, some graphics programs make communication the platform upon which they operate. At the annual EDGD midyear meeting in San Antonio, Acheson suggested that partnerships between engineering graphics programs and ASPs might be a way to address issues that currently plague our field today. These issues include software costs, integration and installation support, currency of instructor training, and exposure of students to new technologies (Acheson, 2001).

Understanding 3D Geometry

Current 3D CAD systems incorporate many functions that employees must understand if they are to be successful in the engineering design environment. Feature-based CAD programs now automate many processes that were once tedious to produce, such as fillets and rounds or patterns of holes. Although this makes modeling much faster and easier, when problems arise in the geometry, sometimes the solution is not evident. It is important to understand that these problems may arise from structural defects or violations of the rules of solid modeling, low accuracy or problems with tolerancing, and unrealistic geometry or features that are typically created by inexperienced CAD operators. These issues with model quality can create larger problems within a company if the models are used for other downstream applications (Izurieta, 1998).

Surface Modeling Techniques

Solid modeling systems have increased rapidly in their capabilities over the last 12 years. Systems have come from having the user apply Boolean operations to create solid models to sophisticated constraint-based modelers that incorporate design intent into large assemblies. For many engineering companies, solid modeling systems continue to meet their needs. There are, however, some industries and applications where surface modeling systems are more beneficial. These include packaging, footwear, ceramics, toys, and automotive and aerospace components (Christman & Naysmith, 2001). In the CAD/CAM industry, close to 60% of North American mold makers receive design data electronically in the form of surface models (PTC, 2000). It is evident when reviewing periodicals related to engineering design that students will need to understand complex modeling techniques and strategies for both solid and surface models in order to be competitive in the workplace.

Behavioral Modeling, Knowledge-Based Systems, and Integration of Information

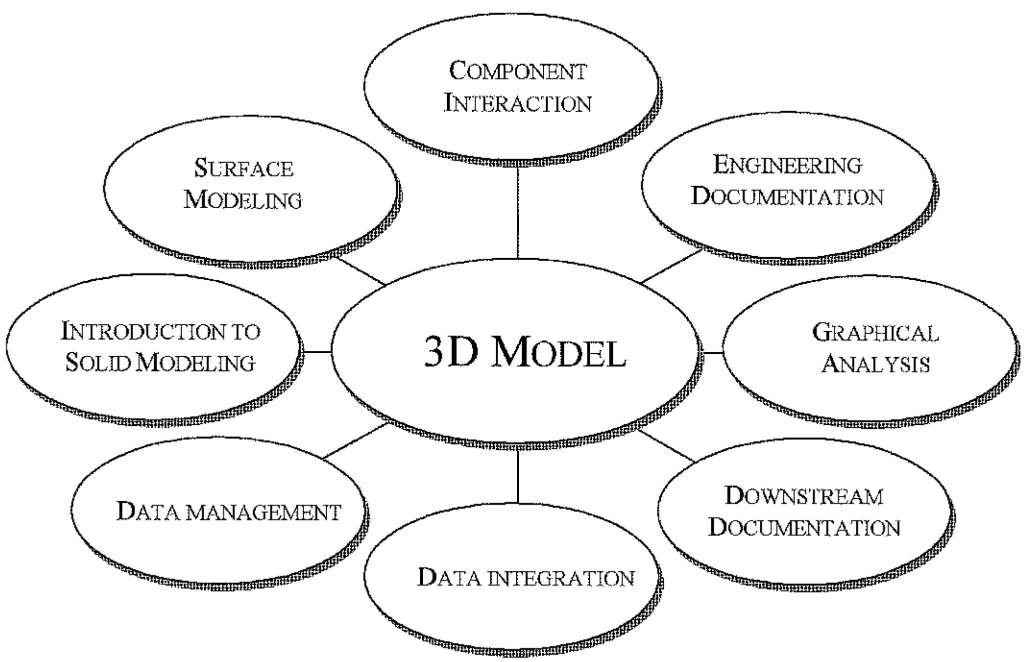
Mechanical design automation technology has evolved from 2D CAD to 3D CAD to solid and surface modeling to feature-based parametric modeling to behavioral modeling. Smart or intelligent models contain information about geometry, processes, applications, and desired model behaviors (Luby, 2001). CAD modeling has traditionally been used to capture complex geometry and assemblies with hundreds or even thousands of parts. Because companies do not function only on geometry alone, systems have been developed to cut down the time from design to manufacture by including intelligent information along with the model. This information includes specifications, design details, costs, materials, tooling, assemblies, and testing data (Greco, 2001). These knowledge-based systems are intelligent software that can manage and take advantage of design engineering tasks. They capture design intent, part relationships, standards, and rules that govern product configuration, engineering, and geometry. Knowledge-based systems also allow the product expert, rather than a programmer, to define and write the rules using spreadsheets or the proprietary language within the software. When using knowledge-based systems, new employees must be prepared to work in a culture of knowledge management where they understand the rationale for design decisions and are capable of working with systems that proactively support expertise and documentation of best practices (Versprille, 2001). Students need to be ready to use these knowledge-based systems to successfully move engineering information through the design process. Many articles have been written in past ASEE publications regarding incorporation of design principles into classroom activities. These types of modeling systems allow engineering graphics educators to give students meaningful, design-based assignments, and it gives them the ability to assess their students based on realistic solution requirements to problems, rather than tedious minutia.

Hybrid Employees

Since more and more engineering and technology applications are happening online, many employers are looking for individuals who not only have knowledge in their content area, but who also can do some level of programming in web-based environments. Traditionally employers have kept designers and programmers separate. Stereotyping employees and keeping individuals separate undermines collaboration efforts. Some of the blame can be placed on educational institutions, but many companies continue to keep design and technology departments separate (Holzschlag, 2001).

To take advantage of this collaborative environment, Branoff and Hartman (2002) have suggested the adoption of a curriculum model separated in tiers of responsibility and level of detail. The tiers are the same ones mentioned in the Introduction of this paper: engineer, technologist, and technician. While it is possible that there could be some overlap between these different disciplines, the courses used in the preparation of these individuals would all be conducted within the spirit of the following curriculum model for engineering design graphics. All of these courses contain the majority of the requisite knowledge suggested by industry trends as being important.

There has been an issue raised during past presentations of this model regarding pedagogical approaches to teaching with this model. The engineering student will be given an overview of each of these topics with an exemplary activity to match. The goal is to give them an appreciation of how each of these topics impacts the design process. Unfortunately, most engineers spend little of their time on the job actually doing what most of them would consider "design work". All too often, engineers are tasked with responsibilities, in addition to those mentioned in the Introduction of this paper, relating to field issues and problems, negotiations with suppliers, testing, project management, and other tasks which leave them little time to do any productive design work. Because of these



extra responsibilities, it is critical that the technologist and technician be well versed in these topics. Technologists will be immersed in the integration and relationships of these topics. They will spend time creating geometry, managing databases, integrating systems, and exploring down-stream uses for the model. They will be immersed in laboratory exercises to emphasize these topics throughout their formal education. Technicians may not cover the breadth of material that engineers and technologists deal with, but they will explore, with a great deal of depth, several of the topics of the aforementioned curriculum model, such as geometry creation techniques and the use of data management systems. These levels of the engineering graphics curriculum closely correspond to the stages of the engineering design process that already exist, namely concept, development, and implementation.

Industry Surveys

During December 2001, several companies in the Raleigh, North Carolina area were surveyed to determine the types of skills that applicants would need to secure a position doing constraint-based modeling. Thirty-five individuals were asked to rank 37 topics and educational experiences for their importance in a hiring decision. Eleven individuals responded to the survey. The highest ranked topics were assembly modeling, constraint-based modeling, modeling strategies, 3D geometric primitives, and orthographic projection. Most companies required people to have associate degrees in engineering technology, one required a 4 year degree in engineering, one required a 4 year degree in a technology area, and one reported only a high school diploma was necessary for employment. All survey respondents worked for companies that did primarily engineering design or manufacturing and worked in either an engineering or design manufacturing department.

In a survey of 28 companies, Cumberland identified areas of expertise necessary for the next generation of engineering graphics technicians. He concluded that engineering graphics programs should include the following topics: macro programming, data translation, file and data management, CAD standards, constraint-based solid modeling, web technologies, simulation and animation, internships, collaboration, and a study of current trends and issues (Cumberland, 2001).

Conclusion

As the EDG educators look ahead to prepare for the future, it is critical that trends in industry be examined so that students will be properly prepared to enter the workforce and make a difference. Currently, industry seems to be looking for individuals who can move data throughout the design process, collaborate online with customers, suppliers and coworkers, identify and fix problems with 3D geometry, use powerful knowledge-based systems to design complex assemblies, and be flexible enough to do design and development work. Is there evidence that companies are having problems because they cannot find employees who can handle these tasks? The United States Navy recently delayed delivery dates on the LPD 17 San Antonio-class landing platform dock ships for many of the reasons stated above. Although the main reason for the delay was the overall design complexity of the ship, other factors included problems with design integration, miscalculating the complexity of the CAD environment, a shortage of qualified designers, and converting 3D design information into fabrication instructions (Burgess, 2001).

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Enhancing the Appearance of Information Graphics

Judy Birchman and Amy Secrest
Purdue University

Abstract

Informational tables are often an important part of technical papers. It is important that the data presented is quickly and easily understood. The primary purpose of tables is to give the reader a quick overview of the information presented in the research paper. Although the data is often painstakingly collected, most authors spend little time formatting the information for presentation. Many authors rely on the automated features provided by software to format the information and do little to embellish the final version of the table. This paper will focus on improving the readability and legibility of informational tables. Topics will include design and formatting considerations such as font specifications, contrast, spacing and alignment. Examples will demonstrate how applying standard design concepts to information graphics can enhance the overall effectiveness of the data.

Introduction

The term information graphics covers a variety of graphic formats —charts, graphs, diagrams, pictographs and tables. One only has to think of the works of Leonardo da Vinci, René Descartes and Sir Isaac Newton to realize that these visual formats have been around for a long time (Meyer, 1997). An industrial draftsman, William Playfair, is credited with developing the graphic methods for charting facts and figures including the line graph, bar chart and pie chart that we use today (Holmes, 1991). He is also credited with developing the journalistic form of "information graphics" (Meyer, 1997). Artists who specialized in presenting visual information began appearing in the 18th century and the term "graphic designer" was finally coined in 1922 (Meyer, 1997). At the start of the information age in the early 1980s, the need to mix text and visuals was in demand. Graphics were employed to help readers see the "big picture". With the advent of desktop publishing, in the 80s and 90s, graphics became more economical and the use of information graphics escalated (Meyer, 1997).

The purpose of technical papers, written by specialists for their peers, is to convey information (Markel, 1988). Research articles and conference papers are forums for presenting data, research results and industry trends. Information graphics can be considered the "pictures" of technical writing which clarify and support the text (Markel, 1988). Typically, technical papers use two types of graphic aids — tables and figures. The scope of this paper will cover guidelines for using tables in technical papers.

Tables

Information graphics are a shorthand means of presenting information (Kosslyn, 1994). If done well, the reader can quickly see and understand a trend, pattern or relationship among elements. Unlike charts, tables focus the reader's attention on the data itself rather than on the representation of the data (Parker, 1990).

Definition

By definition, a table is a matrix of information. Traditionally, tables are used to present a large amount of information in an orderly fashion. Tables allow the reader to quickly focus on a specific item by scanning the matrix or to compare multiple items by scanning the rows or columns. For example, a table that compares the features of six CAD packages can be used in multiple ways. As shown in Figure 1, one reader can pick out the software package they are interested in and focus on the row, which highlights the included features.

CAD Software Comparison Table				
	CompuCAD V2.0	Martin Show Designer 4	Stardraw 2D V3	WYSICAD V3
Full CAD		X	X	X
Layers	X	X	X	X

Figure 1

Another reader might select a particular feature they are interested in and scan the column, which shows which packages include that feature. Other readers might scan the entire table to compare the different packages.

Appropriate Uses

Rabb states —"When graphs aren't specific enough and verbal descriptions are too cumbersome, tables offer elegant solutions for showing exact numeric values (Rabb, 1993)." The primary reason to use tables is to present information in a simple and visual format. Tables are used to substitute for a written description in order to break up the text and better organize information for the reader. There are a number of situations, which are appropriate for tables.

Whereas charts generally focus on a trend or comparison, tables are a way to organize data for the reader to peruse. They work for many situations because they can convey large amounts of quantitative data and can show several variables for a number of items (Markel, 1988).

Horton (1991) describes several situations, which are best handled by a table; 1) if there is a large amount of data to be displayed; 2) if the reader needs to see the exact values of the statistics; 3) to show side-by-side comparisons; and 4) to simplify access to the information the user is targeting .

Types of Tables

Horton describes three common types of tables— Look-up-a-value, Decision and Selection and Matrix (Horton, 1991). A look-up table is designed to have the reader find a particular value at the intersection of a row and column. An example of a look-up table would be one that shows the data transfer rate for various web connections on the Internet. The user could easily find the particular rate of the target connection type.

A decision table provides the user with a variety of options. It assists the user in making a decision by showing the alternatives. The user can compare the various options and make a decision. For example, if the reader is trying to select the best file format to use for a web image, the table could guide them to make the proper choice. It's like an if-then statement— if this is true, then do this.

A matrix table is used to show relationships between two items. The intersection of each row and column shows the relationship between the two categories. A mileage table would be a good example of a matrix table.

Legibility and Readability

Tufte states — "Excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency (Tufte, 1983)." A successful table makes it easy for the reader to 1) recognize the way the data is organized; 2) find the information; and 3) interpret the data (Schriver, 1997). Visual cues are the tools that graphic designer's use to improve the readability of a document. Something as subtle as bold text for the title, telling the reader to "start here", or a line separating a heading from the data are devices to assist the reader in scanning the table. Both the legibility and readability of a table are controlled by the decisions of the designer.

Legibility is determined by the speed at which the actual words can be recognized or comprehended by the reader (Brady, 1988). Factors that affect legibility include the type of font, size, style and case of the text.

When selecting fonts to use in a table, select standard fonts, which are easy to read. Avoid fonts that are extremely narrow or wide. Use different font sizes or styles to emphasize key text elements. Also allow enough space around the text so that it stands out and be sure that if a screen is used, it is light enough not to interfere with legibility.

Readability refers to the relative ease with which the reader can read the material. Factors that affect the readability of tables include contrast, alignment and spacing. Visual cues have more to do with readability than legibility. The elements added to enhance the table make it better or worse.

Enhancing Tables

Clarity is probably the most important consideration when laying out a table. A good layout makes it easy for the reader to scan the table and pick out the relevant data or grasp the relationship between items. In order to increase the clarity of the message and the readability of the table, consider the arrangement of elements and how they are structured. Gestalt psychology tells us that "...the way things look depends not just on the properties of their elementary parts, but also, and more importantly, on their organization (Schriver, 1997)."

Adding Contrast

Contrast is simply making elements stand out from one another by making them different. Consider contrast when creating headings, borders, dividers and backgrounds. Figure 2 shows a table that has no contrast between elements. Headings and data are displayed with the same font size and style. Borders and dividers are all the same line weight and isolate the data. Tufte refers to this type of design as "information prison" (Tufte, 1983). It is difficult to scan and compare the data. To improve the readability of the table as shown in Figure 3, the following steps were taken.

First, the headings were changed to make them stand out. The title was changed to a larger font and bolded. The column and row labels were also bolded. In addition, instead of using all upper case for all the headings, some were changed to upper and lower case. The reader can quickly see the way the table is organized.

Second, the borders and dividers were simplified to call out related groups of information. After removing the grid structure, rules were added to emphasize particular divisions of information. Since the table focuses on comparing the data for a series of years, the verti-

North Carolina vs. National SAT Scores				
NC	1998	1999	2000	2001
MATH	492	493	496	499
VERBAL	409	493	492	493
USA				
MATH	512	511	514	514
VERBAL	505	505	505	506

Figure 2

North Carolina vs. National SAT Scores				
	1998	**1999**	**2000**	**2001**
NC				
Math	492	493	496	499
Verbal	409	493	492	493
USA				
Math	512	511	514	514
Verbal	505	505	505	506

Figure 3

cal dividers were dropped to facilitate a comparison of data across the rows. A rule was used to emphasize the two major categories being compared. Third, a dark screen was added behind the title to set it off and allow the text to be reversed to white. This adds a contrasting background to set off the table from the rest of the page.

Aligning in a Meaningful Manner

A meaningful alignment of elements will lead to a good "continuation" of the data (Schriver, 1997)." Consider the alignment of headings and data values from both the readability and the organizational standpoint.

Bad continuation can result from something as simple as the justification of the text. For example, in Figure 4, the numbers in the columns do not align and the headings are center justified which makes it difficult to read. Another factor related to alignment, is how items are grouped or ordered. It is helpful to the reader if the table elements are arranged in some meaningful manner to improve the effectiveness of the information (Schriver, 1997). The redone table shown in Figure 5 regroups items to add more structure to the table to assist the reader. Two subcategories have been added, repetitive data has been repositioned and the numbers have been organized from high to low.

If column headings contain more than one line of text, align them along the bottom to avoid gaps between the headings and the data (Brady, 1988). Also, be aware that some fonts contain characters which are not uniform (the same width) and can lead to subtle misalignments of the data. If things don't look quite right, try a different font.

Web Connection Types and Rates

Connection	Data Rate	Bandwidth
28.8 modem	3.6 KB	28.8 KB
T1	32-193 KB	256-1,544KB
14.4 modem	1.8 KB	14.4 KB
T3	5.5 MB	44 MB
56K modem	7 KB	56 KB
33.6 modem	4.2 KB	33.6 KB
Frame relay	7-64 KB	56-512 KB

Figure 4

Web Connection Types and Rates

Connection	Data Rate	Bandwidth
Home		
56.0 modem	7.0 KB	56.0 KB
33.6 modem	4.2 KB	33.6 KB
28.8 modem	3.6 KB	28.8 KB
14.4 modem	1.8 KB	14.4 KB
Corporate		
T3	5.5 MB	44 MB
T1	32-193 KB	256-1,544 KB
Frame relay	7-64 KB	56-512 KB

Figure 5

Improper alignment, of design elements can also lead to difficulty reading down a column. Figure 5 showed that the two data groups were separated by a space but since the reader would be comparing data in a vertical direction, the columns were screened in that direction to improve continuation. However, if the headings were centered and the background screened as in as in Figure 6, the layout would interfere when the reader scans down the column.

Web Connection Types and Rates

Connection	Data Rate	Bandwidth
Home		
56.0 modem	7.0 KB	56.0 KB
33.6 modem	4.2 KB	33.6 KB
28.8 modem	3.6 KB	28.8 KB
14.4 modem	1.8 KB	14.4 KB
Corporate		
T3	5.5 MB	44 MB
T1	32-193 KB	256-1,544 KB
Frame relay	7-64 KB	56-512 KB

Figure 6

Creating Space

White space, or the blank areas around table items, also serves as a visual cue to the reader. More space between items tells the reader they are separate and less space say they are grouped or related in some way. Consider both horizontal and vertical spacing when laying out a table. Vertical spacing would include areas above and below headings, line spacing or the distance between rows and the space between data and rules. Horizontal spacing would primarily be the space between columns of text and between text and grid lines.

Also, consider the proportion of white space to positive space. The data should not be so spaced out that it is difficult to follow or so cramped that it is trapped. Keep columns close together; don't spread them out more than is necessary. If it is necessary to spread out the columns in order to fit a particular area such as a page column, use a graphic devise such as a rule or screen to guide the reader's eye across the row (Figure 7).

Flash Raster File Formats

File	PC	Mac
GIF Image	Yes	Yes
Photoshop	Yes	Yes
Windows Bitmap	Yes	No
Truevision Targa	Yes	Yes

Figure 7

Using Graphic Devices as Organizers

Tufte refers to graphic over-embellishment as "chartjunk" (Tufte, 1983). For tables used in technical documents, the use of graphic devices should be limited to enhancing the data. Each element should serve a purpose such as organizing, clarifying or highlighting the information. Schriver asks the question — "Do the visual cues support the rhetorical goals for understanding and making use of the content? (Schriver, 1997)"

Graphic devices include rules, borders, and screens. In general, use a limited number of graphic devices to organize the data. More specifically, keep line weights thin and screens light enough not to obscure the data. If spacing is tight, use thin rules between columns and rows. When using screens shade the rows or columns based on the way the data should be scanned.

Conclusions

As the examples have illustrated, the proper use of visual cues and graphic devices can enhance the legibility and readability of table statistics. When creating a table, consider how the reader will scan the table and add visual cues to assist the user in finding and understanding the data.

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Table Data Sources

Table 1.
http://www.stagetec.co.uk/CADCOMP.htm

Table 2. and 3.
http://www.wcpss.net/evaluationresearch/index_reports/2001/2000_2001_scholastic_assessment_test_results.pdf

Table 4., 5. and 6.
Mohler, James L. (2002). *Flash MX – graphics, animation & interactivity,* 5. United States: Thomson-Delmar Learning.

Table 7.
Mohler, James L. (2002). *Flash MX – graphics, animation & interactivity,* 177. United States: Thomson-Delmar Learning.

The Changing Philosophies for Graphics Educators

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Abstract

Over the past 20 years, engineering and technical graphic educators have seen major changes in what we teach, how we teach, and, for the most part, whom we teach. The computer has revolutionized the pedagogical practices we use in most fundamental engineering graphics courses and has allowed us to develop new ways to use models to improve the design, analysis, and production processes. Computer modeling changes the content we teach our students in the classroom and laboratory. Given these changes, have we as a profession changed the underlying principle we believe is fundamental to the profession?

This paper examines these changes through a historical perspective related to educators' view of fundamental philosophical beliefs and how the philosophical change in what and how we teach can affect our future as a profession. Discussion about the need for establishing an educational philosophy and how this will help the future of our field will be included. Philosophical approaches for bringing about change will be discussed as well and the effects it will have on engineering/technical graphics classrooms of the 21st century.

Background

"As things are... mankind (is) by no means agreed about the things to be taught, whether we look to virtue or the best life. Neither is it clear whether education is more concerned with intellectual or moral virtue. The existing practice is perplexing: no one knowing on what principle we should proceed—should the useful in life, or should virtue, or should the higher knowledge be the aim of our training; all three opinions have been entertained. Again, about the means there is no agreement; for different persons, starting with different ideas about the nature of virtue, naturally disagree about the practice of it (Apps, 1973)."

Over the years, educators in higher education have seen changes in the way we teach, the content we teach, research we conduct, and the expectations in our jobs. Graphics educators are no exception to the ever-evolving environment in modern education. Given these changes and the trends in education and graphics education, have professionals in graphics really thought about the role their individual philosophies of education play in the success and continued growth of their disciplines and careers as well as the influence it has upon others in higher education? This paper will discuss how a professional graphics educator needs to develop an educational philosophy and how their personal educational philosophy influences the type of content they teach, the reasons for teaching their subject matter, and their overall job satisfaction. Everyone has a philosophy towards education, they just have to recognize it and use it to make decisions based upon their belief system.

Many of us have been asked over the years to define our philosophy for education. With this request comes the anxiety of summarizing the feelings and opinions we have concerning what content should be in our field and how we should deliver this information to students. Although many new faculty feel the need to conform to the existing methodologies and beliefs of senior faculty, each of us need to reflect upon our beliefs and decide what it is that we stand for in graphics education, what is it we believe in, where the future of our profession needs to head, and the contributions we as individuals are going to make. Given this, and the importance of such a statement of beliefs, do we know the foundational and traditional philosophies associated with education and how to develop an educational philosophy for ourselves?

Over the years, the author of this paper has spoken to many graphics educators about their educational philosophy only to find many do not know how to develop a statement about themselves or the history behind it. It is the hope of the author that this paper will help both new and tenured members of the graphics profession to see the need for taking a look at what goes into a personal philosophy of education. As we see growth, change, and trends in education come and go, the one thing that will help professionals in graphics education keep their focus is the understanding of what they believe and stand for in education.

The Basics

Philosophy has its beginnings in the days of Socrates and is derived from two Greek words that mean "the love of wisdom." It has been said that a philosopher is someone that seeks the truth, is a lover of wisdom, and is in constant pursuit of knowledge. Philosophy was first used by people who were seeking knowledge and purpose concerning their existence on earth. Egyptians wondered about life after death, and Thales, a noted Greek philosopher, was concerned about the substance of life. As people found this study to be of importance, individuals begin looking at the natural world around them and asking questions about life and why things happen in their world that they cannot explain. This led to the study of natural philosophy commonly known today as science (Moore, 1988).

Since it's beginning, philosophy has always asked questions some people feel should not be asked. But over the years, it has grown into a definition that includes the general beliefs and attitudes of a person as well as a body of knowledge that is now classified as its own discipline. It is the feelings of the author that philosophy plays a major role in defining a discipline. Graphic educators need to consider their philosophy and the role it plays in establishing graphics education as a discipline. A philosophy provides clarification for both what is and what has been done. It provides the educator with a framework for what they stand for and where they are headed in education as well as provide a useful structure for solving instructional problems throughout their career.

Areas of Study

Philosophy, like any subject matter, has components at its core. In this case, we can identify three major areas of study related to philosophy, just as graphics education has a core content (i.e. two-dimensional, three-dimensional graphics, projection theory, etc.), philosophy is no exception.

The first area of study related to philosophy deals with *metaphysics*. In this core area, the person is concerned with problems relates to the nature of reality, and how people play a role in it. This area of philosophy is the most controversial because it asks questions concerning why the universe is the way it is and looks at the essential nature of the mind and soul. You might say that a person studying this aspect of philosophy would ask questions about things and the causes of things being what they are (Weber, 1960). Metaphysics is the area that people most often associate with the study of philosophy (Moore, 1988).

Axiology is an area within the study of philosophy that deals with values. This area has two fields of inquiry: ethics, the study of problems associates with right and wrong and/or good and evil; and aesthetics, the study of beauty and ugliness and how we determine which is which. Axiology can also be associated with looking at values found in religious, social, and economic structures (Weber, 1960).

The third area of study within philosophy is *epistemology*. In this area, people are concerned with theories or problems related to the nature of knowledge and determination of what is important. Philosophers in this area question the importance of knowledge and its relationship to our senses. One would also question the truth of knowledge and the role intuitions play in defining our knowledge. Educators would use this philosophical realm to question how people learn and what is the most important knowledge to be taught. A graphics educator defining their personal philosophy would see this area as one that raises issues related to our profession, such as the need for descriptive geometry, dimensioning, and a continued focus on documentation drawings.

All these areas are part of a personal philosophy of education. However, epistemology is the area most educators focus on because they see it as the most relevant to their chosen field of study. But, before one can begin the process of understanding and developing a philosophy for his or her subject area, an understanding of the "traditional" education-based philosophies needs to be studied and reviewed.

Traditional Schools of Thought

Before one can develop a personal philosophy of education, it is best to review some of the traditional schools of thought or theories related to education and the belief systems professionals in education use in the discipline they teach. Once you ponder these philosophical schools of thought, you will be better prepared to analyze your beliefs in the philosophy you have towards graphics education. It is very rare that an individual actually subscribes to just one education-based philosophy. Most will pick and choose components of many different philosophies to develop their own personal philosophy. This process of incorporating elements from several philosophies is generally called an eclectic philosophy. Below are descriptions of more common schools of thought found within education and eclectic philosophies.

Realism is one of the oldest educational schools of philosophy. In this philosophical realm, people believe that only experience can bring meaning and knowledge to an individual. Realists favor areas and disciplines in science and; therefore, subscribe to the scientific method as a form of inquiry. Graphic educators that have realism as a part of their personal philosophy typically believe that students need to learn through real-world situations in and out of the classroom (i.e. co-ops), and all knowledge gains in the classroom must meet the present needs of industry. The graphics educator that has components of realism in their philosophy would also see education in graphics as training, not knowledge to be used in future situations and growth.

Idealism is another historical school of thought in education philosophy. Professionals who ascribe to this educational philosophy would value thinking and place a greater emphasis on the cognitive domain. Development of the mind is the goal for this school of though and little effort is placed on skill development. The idealist would see education of the classics and basics as more important than the study of a specific area that is not considered "academic." A graphics educator with this type of philosophy would see the need to teach visualization, but would question the need to teach skills (i.e. technical, engineering). A graphic idealist would place a greater emphasis on understanding visual theory and would question the use of hands-on activities. The linkage between classroom and real world experiences, like those of a realist, would not be considered (Weber, 1960).

Pragmatism emerged in education in the late 1800's and is closely associated with its famous follower, John Dewey. An educator that considers himself or herself a pragmatist is someone that places great value on applying ideas and facts to real world problems. Great value is placed on problem solving and learning the knowledge and skills needed for living in the world, as it exists. Most vocational educators adhere to this school of thought, as do many educators in engineering and technical education. Pragmatism and graphic education seem to work well together, and many graphic classes taught today are based on its philosophical concepts. Graphics educators who feel we should teach the most commonly used software and the latest techniques related to our field would include pragmatism in their personal educational philosophy (Moore, 1988).

Existentialism was popular in the 1960's. This school of thought places emphasis on the individual, and the concept that a person can best determine what he or she needs to know and do. The attitude of a teacher who ascribes to this philosophy allows students to explore different areas within a discipline and decide what interests them and what they wish to pursue. A graphics educator with this type of philosophy would place great value on self-paced instruction and tutorials. Modern existentialism can be seen in many areas of distance learning and on-line instruction (Ozmon & Craver, 1986).

Reconstructionism is a philosophy encompassing change and has its origins going back to the early 1900's. Reconstructionist's constantly look back to see if changes are needed in both the structure and content presented in the classroom. They are always looking towards the future and feel the need to mold the future as they think it should be. Graphic educators who are reconstructionist always try the latest software and trends in our field. They are constantly forecasting the future needs of industry and are determined to shape the profession's content and teaching strategies (Howick, 1980). Some would say they are on "the bleeding edge of technology."

The philosophies discussed above are considered by many education-based philosophers as the historical and traditional schools of thought that one could relate to his or her personal philosophy of education. The following schools of thought are not mentioned often in personal educational philosophies, but should be considered when developing one.

Perennialism has it roots in the philosophy area of realism. This school of thought states that the sole purpose of education is to cultivate the mind through the study of permanent truths that are traditionally found in classical studies. Therefore, the truths that one seeks out with this philosophy are those that have a history and have remained constant over time. Only the past has remained unchanged; therefore, you would teach the basics of a subject, not the current trends. A graphics educator having perennialism in their educational philosophy would see the need to continue teaching board drawing, descriptive geometry, and multiview projection using pencil and paper. Computer aided design (CAD) would not be taught because it is a tool and not part of a content or curricula area (Wingo, 1974).

Logical Empiricism is a school of thought or theory that is dedicated to the use of scientific procedures. According to this philosophy, knowledge is acquired though the theological, metaphysical, and scientific phases most commonly known as the scientific method. Someone in graphics education that uses logical empiricism would only consider curricula and content that has a strong research-based background, is considered a proven method of instruction in the classroom, and has an extensive history of being used by others (Biggs, 1982).

Traditionalism is the school of thought that the American school system was first based upon. In this theory of education, one would seek truth and related values. The teacher is the authority figure and provides the structure and knowledge to the class. Traditionalists are always concerned with the preservation of their discipline area. Although some philosophers see a direct tie to realism or pragmatism, it is considered a separate theory or school of thought. Someone following this school of thought would be teaching what others feel they should be teaching, staying within the norms of what is taught in the classroom. A graphics educator utilizing this theory would only teach the content that other professionals around the country are teaching in their classrooms, so all students receive the same type of education, no matter where they live (Howick, 1980).

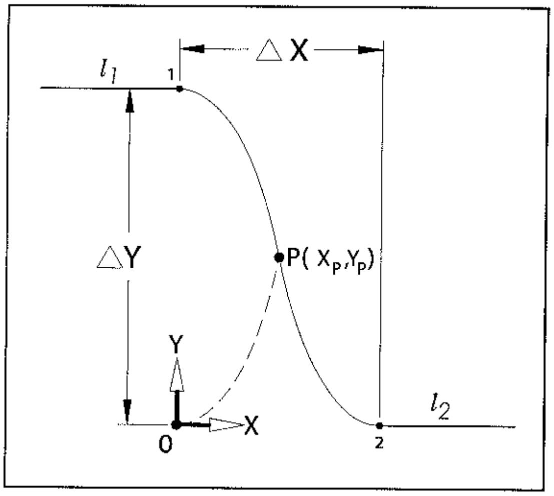


Figure 3 *Elliptic arc OP, mirrored and rotated*

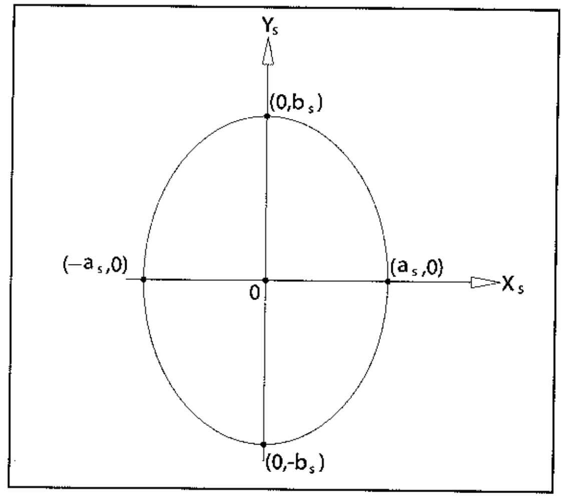


Figure 4 *The standard ellipse*

multiplication performed, and because of the variable nature of the point (i.e. vector) input. **XP**, **YP**, and **b** are all previously calculated dependent variables, where **XP** ≡ Xp, **YP** ≡ Yp, and **b** ≡ b, b being the length of the Y-direction semiaxis of the full ellipse from which arc 0P has been cut. The exclamation mark (!) in front of variable **a** in Prompt 4 tells AutoCAD® that a is a previously calculated scalar variable. **a** ≡ a, where a is the other (X-direction) semiaxis of the full ellipse from which arc 0P was cut.

Although the six prompts shown above are unique to AutoCAD®, elliptic arc construction proceeds along very similar lines in almost all CAD software offerings. As is immediately obvious in all cases, values for the two semiaxes a and b are required before any elliptic arc construction can be completed. In order to discuss how these two parameters are obtained from the limited input information (ΔX and ΔY) that is known, it proves helpful to first review some fundamental properties of the so-called "standard" ellipse.

The Standard Ellipse

In Cartesian coordinates X_S and Y_S, the equation for the ellipse shown in Figure 4 is:

$$\left(\frac{X_S}{a_S}\right)^2+\left(\frac{Y_S}{b_S}\right)^2=1 \qquad (3)$$

Equation (3) is the "standard form" of the equation of an ellipse (James & James, 1959). The resulting ellipse (Figure 4) is referred to as the "standard" ellipse, with semiaxes a_S and b_S.

Solving Equation (3) for Y_S yields:

$$Y_S=\pm b_S\sqrt{1-\left(\frac{X_S}{a_S}\right)^2} \qquad (4)$$

which produces the first derivative:

$$Y_S'=\pm\frac{\left(\frac{b_S}{a_S}\right)\left(\frac{X_S}{a_S}\right)}{\sqrt{1-\left(\frac{X_S}{a_S}\right)^2}}\ ; \qquad (5)$$

or, the alternative form:

$$Y_S'=-\left(\frac{b_S}{a_S}\right)^2\left(\frac{X_S}{Y_S}\right). \qquad (6)$$

Note that this second form of the first derivative, with the single minus sign attached, applies at all points around the closed elliptic path in Figure 4.

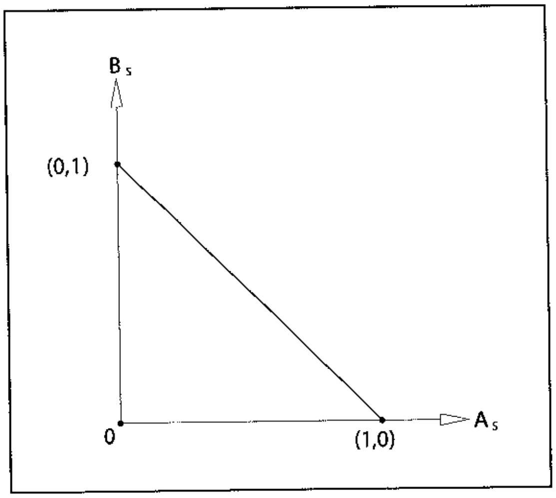


Figure 5 *The transformed standard ellipses*

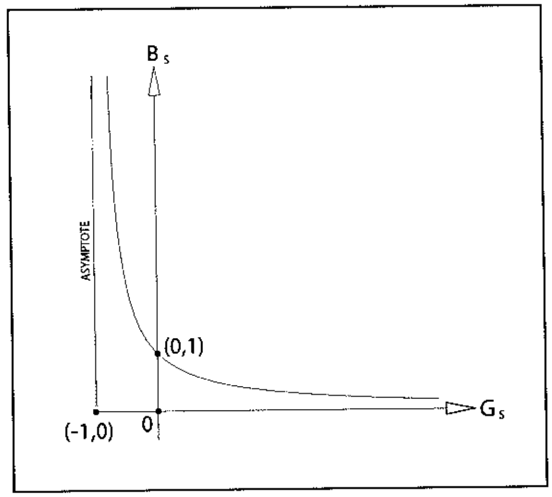


Figure 6 *Hyperbolic relationship of B_S to G_S*

To simplify the second-order Equation (3), a common transformation that is used is:

$$A_S \equiv \left(\frac{X_S}{a_S}\right)^2 , \qquad (7)$$

and

$$B_S \equiv \left(\frac{Y_S}{b_S}\right)^2 , \qquad (8)$$

which reduce the standard ellipse to the straight line

$$A_S + B_S = 1 , \qquad (9)$$

shown in Figure 5.

All standard ellipses now lie along the 45-degree line shown in Figure 5.

Another useful quantity is the variable G, defined as

$$G_S \equiv -\frac{X_S Y'_S}{Y_S} \qquad (10)$$

for the standard ellipse.

With the help of Equations (6), (7), and (8), Equation (10) yields

$$G_S = A_S/B_S . \qquad (11)$$

Using (9) to eliminate A_S from (11), we see further that

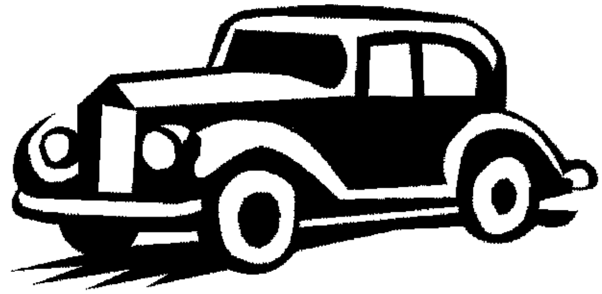
$$B_S = 1/(1 + G_S) . \qquad (12)$$

From the hyperbolic branch plotted in Figure 6 it can be seen that all positive values of G_S yield positive values of B_S within the required range:

$$0 \leq B_S \leq 1 . \qquad (13)$$

If one wishes to construct a standard ellipse through a given point (X_S,Y_S) in the plane, having given slope Y'_S at that point, from definition (10) simply calculate a value for G_S (remembering that G_S must be positive), then find b_S from (12) and (8), and finally find a_S from (12), (9), and (7). On the other hand, together with a given point (X_S,Y_S), a positive value of G_S may be selected instead of slope Y'_S. Calculations for the two semiaxes a_S and b_S then follow as before.

2003 ASEE National Design Competition
Engineering Design Graphics Division



Unlike the precisely propelled projectiles of the past, this contest is earthbound...in fact you will lose points if the project leaves the ground. The contest is to see which team of 3 to 5 members can design an **air-powered car** that traverses a 50' long x 8' wide serpentine course down and back within five minutes. The car will earn points by passing thru gates that are slightly offset from a straight line in a gently curving semicircle. Extra points will be granted if the car is able to demonstrate a controlled 360° spin at the start or along the course.

Power for the car must be self-contained and is limited to 4 AA batteries. Cost limit is $50.00 and copies of receipts are required to verify the "blue-book" value of the car. All components of the car must be constructed by students except the propeller, wheels, batteries, and motor (no kits or prefabs please). Steering must be on-board and autonomous...sorry, no remote controls permitted.

For safety, if a propeller is used, it must be guarded and the vehicle may not leave the ground at any time during its run. The car must be small enough to fit into a portable file box which measures 8.5" tall x 11" wide x 14" long. Design points (10pts) will be awarded for aesthetics and workmanship of the models. So get out the spray paint, heavy chrome, and whitewall tires to make your model a real showpiece. Major points will still come from the graphics and written report that is submitted.

The obstacle course is 50' long x 8' wide on an inside floor (tile, concrete, wood, or carpet are OK). A gentle serpentine curve defines the course with weighted Styrofoam cups (approximately 6- 8 oz. capacity) marking 5 gates which are 24" wide and are spaced every 12'-6" (see Figure A). The car will earn 10 points for each gate it passes through cleanly or 5 points for each cup that it hits. The score will be the total points accumulated from two runs (down the track and back) within five minutes. Points will not be awarded for cups blown over by wind blasts from the cars.

If your team cannot travel to the national ASEE conference to run the course an "AVI" animation burned onto a CD may be submitted to verify the operational prowess of the car. The instructor is responsible for governing the scoring and verifying a legal track layout that appears on the animation. Written reports are required in both hardcopy and electronic format. Reports from the 1st and 2nd place teams will be posted on the web for all competitors to review.

Reports must include but are not limited to:
1. Statement of the problem
2. Preliminary ideas with sketches
3. Refinement drawings with dimensions
4. Calculations for the thrust required or steering mechanism
5. Final design graphics with dimensions
6. Pictorials (or solid models) of the design
7. Conclusion and summary of the three runs

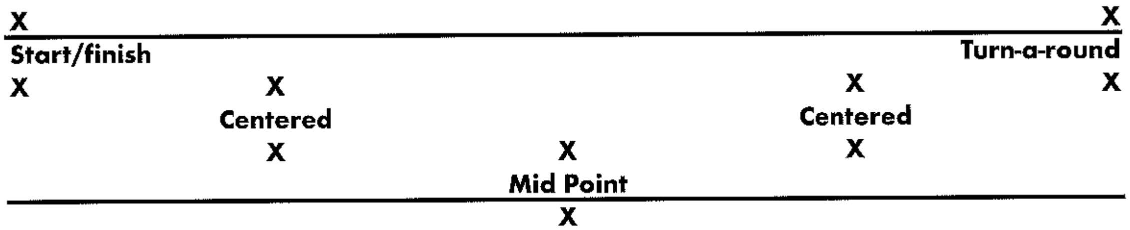


Figure. A *(not to scale): 50' x 8' track. Cars pass through equally spaced (24" wide) gates marked with X's turn around and return within FIVE (5) minutes.*

Scoring Breakdown

1. Written report: 20 points
2. Graphics: 40 points
3. Design and aesthetics: 10 points
4. Performance on the track: 30 points

An optional run to add to your local contest would be for a "DRAG STRIP"speed run for the fastest time down the track and back. This adds a lot of excitement to the contest and maximizes the efficiency of the design relative to friction, drag force, and weight.

Entry Deadline

All entries must arrive on or before Monday, June 9, 2003.
Send entries to:
Dr. Jerry Vinson, EDG Program Coordinator
Texas A&M University,
Engineering Technology Dept.
College Station, TX. 77843-3138

If you have any questions or concerns please check the contest web sight for updates at: "http://edg.tamu.edu./asee_nedge"
Dr. Jerry Vinson at 979-845-1633 or email him at "vinson@entc.tamu.edu" for additional information.

Good luck and happy racing!

Contest entries have increased exponentially over the past three years and we anticipate an even greater number of contestants for the summer of 2003 "Air Powered Car Contest". Be sure to see the contest web sight for contest description and updates at http://edg.tamu.edu./asee_nedgc or contact Dr. Jerry Vinson who is the contest Chairman (979-845-1633) email vinson@entc.tamu.edu . Have a fun and meaningful contest...see you in Memphis!

Calendar of Events

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

58th Annual EDGD
MidYear Conference
Scottsdale, Arizona
November 15-19, 2003
General Chair: Jon Duff
Program Chair: Mary Sadowski

59th Annual EDGD
MidYear Conference
Williamsburg, Virginia
November 21-23, 2004
General Chair: Patrick Devens

2003 Annual ASEE Conference
Nashville, Tennessee
June 22-25, 2003
Program Chair: Frank Croft

2004 Annual ASEE Conference
Salt Lake City, Utah
June 20-23, 2004
Program Chair: Patrick Devens

2005 Annual ASEE Conference
Portland, Oregon
June 12-15, 2005
Program Chair: Kathryn Holliday-Darr

2006 Annual ASEE Conference
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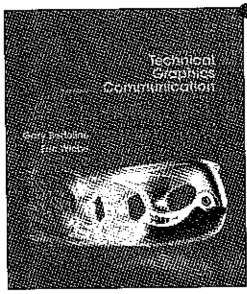

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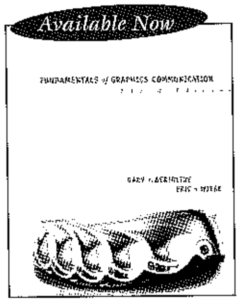

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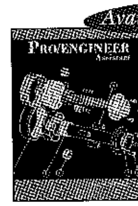

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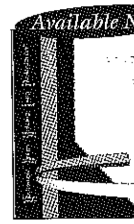

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