Special Edition

The Journal of Engineering Graphics
SPECIAL 1967 VOLUME 31, NO. 4, SERIES 94

ENGINEERING GRAPHICS AND DESIGN

Proceedings
The Seventh Summer School
June 15, 16, 17, 1967
Michigan State University
Sponsored by the Engineering Graphics Division ASEE

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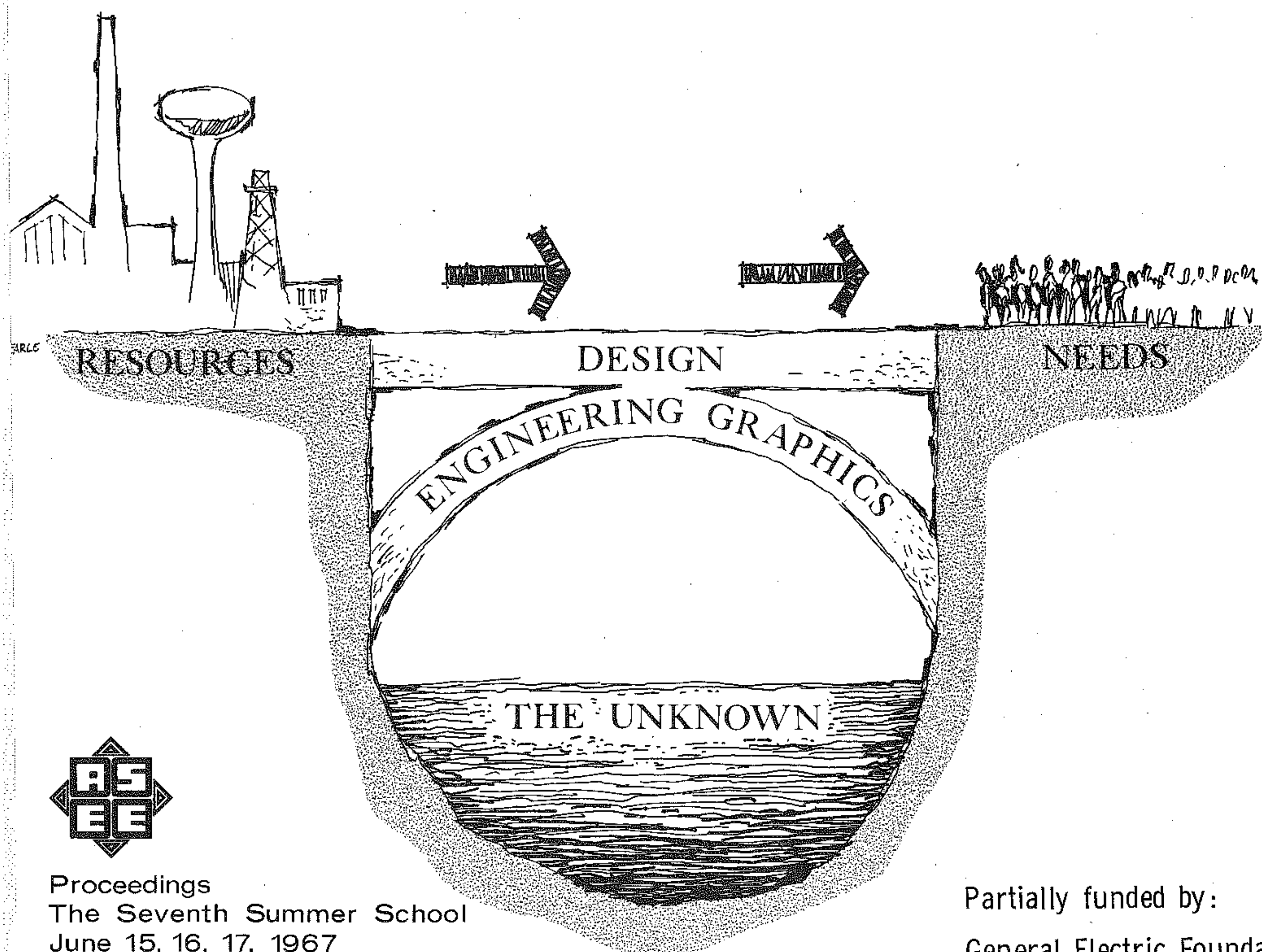

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FOREWORD

The 7th Annual Engineering Graphics Summer School devoted to instruction in Engineering Graphics and Design is now a matter of history. The proceedings of this important milestone are herewith made a matter of record.

The summer school was held at the Kellog Center on the beautiful campus of Michigan State University at East Lansing, Michigan, on June 15, 16 and 17, 1967.

The central theme was based on the conviction that engineering design is central to the practice of engineering and is therefore central to engineering education. The conference focused attention on ways graphics teachers can effectively lead their students into the development of creative ideas by removing obstacles which are acknowledged as actually inhibiting creativity. Slicing prominently through every presentation, every workshop, and lecture was the conviction that engineering graphics courses with their powerful potential can continue to exert a tremendous influence upon the engineering student.

The purpose of the summer school was:

1. To present engineering graphics as a vehicle for instruction in engineering design.
2. To broaden the outlook of engineering graphics educators in the area of design education.
3. To give educators intense coaching in curriculum planning, writing of case studies, writing of design projects, and the role of graphics in design education.
4. To bring graphics educators into contact with recognized authorities in design education.

The summer school was sponsored by the Division of Engineering Graphics of the ASEE and partially supported by the General Electric Foundation and the Keuffel and Esser Company. Grateful appreciation is herewith extended for their invaluable vote of confidence which resulted in a highly successful summer school. A total of 126 engineering educators attended which represented nearly half of America's accredited engineering schools. There was also a substantial representation from Canada. Appropriate certificates were mailed to summer school participants testifying as to their attendance.

The summer school committee was composed of:

Chairman, Percy H. Hill, Tufts University
Earl D. Black, General Motors Institute
Peter Z. Bulkeley, Stanford University
Jerry S. Dobrovolny, University of Illinois
Matthew McNeary, University of Maine
William B. Rogers, United State Military Academy
Wayne Felbarth, University of Detroit
James R. Burnett, Michigan State University
Henry Krause, Michigan State University

The proceedings of the summer school have been compiled and edited by Herbert W. Yankee of Worcester Polytechnic Institute. Inquiries regarding the availability of copies should be directed to:

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The price is $1.00

Grateful acknowledgement is made to the following members of the publication committee for their work as indicated:

COVER AND TITLE PAGE	James H. Earle Texas A & M University
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THE WORKSHOPS	Klaus E. Kroner University of Massachusetts
DESIGN PROJECTS	Webster M. Christman, Jr. University of Wisconsin
RESULTS OF THE SURVEY	Earl D. Black General Motors Institute

Appreciation is also extended to the following who served on the review board for various portions of the proceedings:

Philip Brach, Northern Virginia Community College

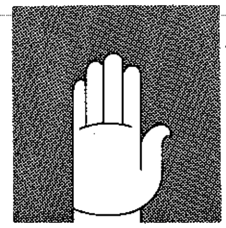
Edward W. Jacunski, University of Florida
Chairman, 1966-67 Division of Engineering Graphics

Eugene G. Pare, Washington State University
Chairman, 1967-68 Division of Engineering Graphics

Finally the editor wishes to offer grateful thanks for the helpful assistance which he received from F. L. Larue, Jr. of the University of Southwestern Louisiana and Victor B. Cole of the University of Hartford who reviewed the editor's rough draft of the follow-up survey (Part V) which was mailed to all summer school attendees in July of 1967. To the faithful 36 respondents we offer our sincere appreciation for their most welcome and valuable thoughts.

Herbert W. Yankee
Worcester Polytechnic Institute
December 1, 1967

INTRODUCTION



PERCY H. HILL

Professor and Chairman, Engineering and Design
Tufts University

"...... The designer must first of all have a general plan, a conception, or much better, a number of alternative plans, about how a particular result is to be achieved; he must work out what is required in terms of materials and manufacture to translate this selected conception into practical terms -- and not till then -- he must put the whole thing down on paper, usually in a drawing, in order to communicate it to people who will have to make the thing and put it into service. It seems to me that most University programmès turn this process upside down. They start with the technique of communication, the drawing, before the man has anything to say. They include a great deal of technical knowledge required to transform a conception into a practical reality, but they do little or nothing to promote or encourage the originality, the habits of mind, from which the new conceptions come. It is at this point, at the initiation of a new conception, that I believe our designers course should start."

From the Opening Address by Dr. D. G. Christopherson,
Vice-Chancellor of Durham University, London,England,
on the occasion of the first Conference on Design Methods
held at Imperial College, London, in September 1962.

Based on the conviction that engineering design is central to the practice of engineering and therefore central to engineering education, the Engineering Graphics Division of A.S.E.E. presented its seventh summer school devoted to this central theme. One can no longer debate whether design should be taught to engineering students, but methods of achieving this objective are not well known. Instruction in design is much more difficult than time-tried techniques used to communicate knowledge in traditional subjects and disciplines. Measurement of student performance (evaluation) is even more difficult when one deals with the open-end type design situation. But design is at the heart of engineering education, for it is what engineering is all about; it is what an engineer does. It is the one area that permits an individual to think for himself, exercise his creative ability, and express himself as an individual. It also requires skill in applying physical laws and mathematical principles to self-invented situations in order to verify results. Students enroll in our colleges and universities to learn these laws and principles, so that what they design will conform to the basic laws of nature. Until recently, however, little to no attention was paid to instruction in the techniques of design and encouragement of creative abilities. It is only proper that design be taught to engineering students as early as possible and at each level during their undergraduate years in order to show how disciplines learned are applied, to continually kindle the spark of creative and inventive ability, and to involve students in the realism of engineering.

To design is to create, to devise something new, to seek the unique solution, but above all to engineer a device, system or process that will benefit society in some way. Design is often involved with innovating the new-product required to "turn-a-profit," seeking out new methods to advance technology in space and under-sea exploration, and to solve problems created by the industrial revolution, including pollution(air, water, and waste), transportation, employment and automation, etc. The summer school intended to expose educators to an over-view of the design process with an in-depth experience in conceptual design and creativity. Every effort was made to show attendees some of the problems related to design education, how it differs from instruction in traditional courses, and how they might construct design projects and restructure courses to include design instruction at the earliest possible undergraduate level.

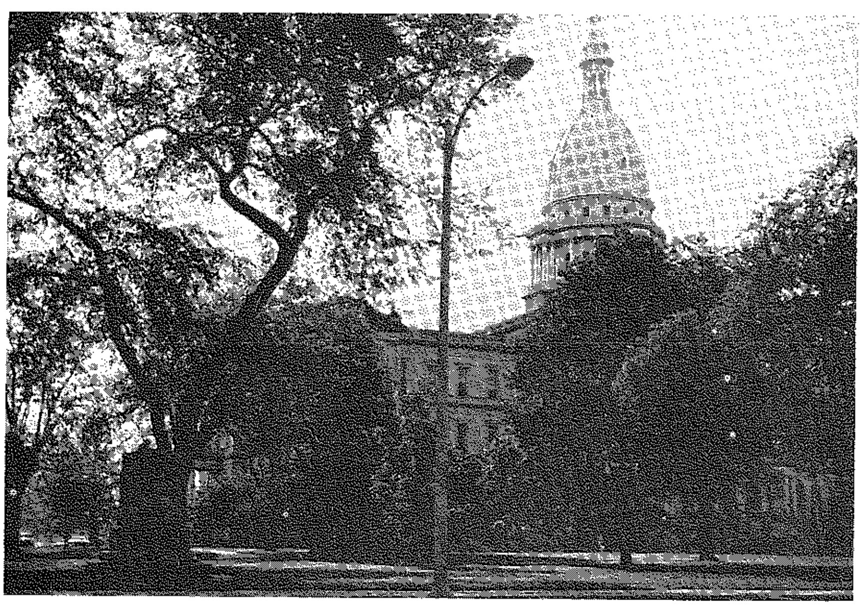
One might argue that design should be taught only at the senior or upper levels after the student has gained suitable knowledge in the engineering and basic sciences to complete a reasonably comprehensive project with some level of proficiency. If we wait this long, we will have done the student an injustice. Design should be introduced as early as possible and practiced continually for an individual to begin to learn the technique of coming up with unique ideas that are worthwhile. Maturity in science allows one to apply physical laws in verifying a concept, but ideas can originate at any level and it is better to stimulate the imagination early rather than to suppress it until later and expect it to blossom, for more often than not -- it never does. To learn design from the point of view of the student requires total involvement in the design process, freedom to come up with new ideas as possible solutions to a defined need, the ability to accept criticism for design solutions and to defend one's point of view. This can all be learned because motivation is on the student's side when it comes to open-end type design problems.

The freshman year at many engineering institutions seems to be structured so that the interest of any beginning student is soon lost. With the exception of engineering graphics, he learns more about mathematics, pure science, and the humanities -- subjects he has taken in high school. Yet our student comes to us with some excitement for engineering through tinkering with tools in repairing and putting things together, science projects in high school, or an interest in building bridges, space flight, etc., that he has read about. He does not understand why he has to postpone the learning of a creative profession until his second or third year or sometimes after graduation. Therefore, by the time he begins to experience the realism of engineering, or before the engineering faculty has any real contact with him, he may have disappeared. Many of our students never really know what engineering is all about until their third or fourth year, and a few not until employment. Since engineering graphics is a traditional discipline of analysis and a means of communicating ideas to one's self as well as to others, it seems to be the proper vehicle for an introduction to engineering design. Of all the engineering disciplines, graphics is the closest to the creative process and has the best opportunity to make the transition into an introductory design program.

To teach design requires an individual with some creative talent and flexibility of mind to accept non-conventional ideas. It is not a requirement for the instructor to have solved every design problem he assigns his students; in fact, it is better to think along with the student, offering assistance only when absolutely necessary. To succeed in design education, the instructor should assume the role of "coach" instead of the traditional one of "teacher". It is important to have design experience and keep abreast of new component developments, new products, and analysis techniques through technical literature. If we wish students to be more creative, we must put them into contact with creative people. If we wish students to learn to design, they must come into contact with practicing designers.

Presentors and workshop leaders at the summer school, although following a planned program and schedule, represent design programs from different schools with varying points of view. It is now the responsibility of each attendee to filter any differences and plan a program at his school to fit his particular student body, faculty make-up, and curriculum.

Finally, it must be said, that it will require a bit of experimentation and dedication on the part of the attendees to set up successful design programs at their institutions. But any effort in the direction of involving students in open-end design situations with the instructor in the role of "coach" will produce a surprising motivating force in classroom interest in the subject. The student will quickly appreciate being allowed to do a bit of original thinking for himself under faculty guidance which, after all, is what education is all about.



State Capitol Building East Lansing, Michigan

WELCOME TO THE 1967 ENGINEERING GRAPHICS SUMMER SCHOOL

EDWARD W. JACUNSKI
Chairman, 1966-1967, Engineering Graphics Division, ASEE
Assistant Dean, College of Engineering
University of Florida

I want to welcome each and everyone of you to the 1967 Summer School. This is probably the most significant summer school that the Graphics Division has ever had in its existence. It is significant that the results of this conference may very well determine not only the future value and impact of graphics upon engineering education but also the future effectiveness of the Graphics Division within the ASEE.

I will briefly dwell on the purpose of this summer school and try to explain why a new look in engineering graphics education is of paramount and of utmost importance.

By virtue of a by-law in its constitution, the drawing division established a very important plank in its platform. Article VI reads as follows: "The Executive Committee shall arrange for special summer schools to be sponsored by the society, or by the society and other cooperating organizations. These special summer schools shall be held as need arises but they shall not be more frequent than once every five years." The wise thinking that established this by-law had a most serious objective in mind: Each five years the division would meet, review the progress of the past five years and chart a course for the next five. The annual and midyear meeting in between were held to maintain continuity.

When the drawing division was first organized within the SPEE (now the ASEE) in 1928, it became the only common meeting ground for teachers in the drawing field, and under the guiding hands of such illustrious leaders as Thomas E. French, F. G. Higbee, George J. Hood, O. W. Potter, P. P. Hoelcher, and many others, it grew into a lusty child. It became one of the largest groups among all engineering sections. At one time consideration was even given to establishing an "American Society of Descriptive Geometry" and to bring it up to par with such societies as the ASME, ASCE and IEEE. Its importance and influence as a division in engineering education was undisputed.

Through the years, from the days of its conception, the drawing division exerted a tremendous influence in standardizing the course contents and the teaching of drawing in practically all engineering schools. Each meeting became an occasion for the renewal of old friendships, a re-telling of old stories, and a discussion of mutual problems. We entertained distinguished speakers from engineering schools here and abroad. We invited industrial representatives to share in our programs and appointed committees to explore and further refine the graphics curricula. The drawing division maintained a unity of purpose throughout the years and became one of the most vigorous divisions within the ASEE. Its JOURNAL was the outstanding divisional publication.

In the late forties, underlying this atmosphere of complacency and apathy that had settled about us, an uneasy feeling of insecurity and unrest began to intrude. Nationally our expanding technology and advances in science in the world was demanding revisions and updating of the entire engineering educational structure.

In keeping with this unrest the division began to hear new voices expounding new objectives for graphics. From our traditional entrenchments these voices were heretical in sound and, often as not, branded as radical -- a distrubing element! It was shocking to think that the graphical language of engineering communications should in any way alter its basic format! That time for its instruction should be reduced! course contents altered, or objectives changed! Today we realize that these early voices, although they lacked a goal, were voices of prophecy. The 1952 Grinter Report, therefore, was not a sudden overnight release -- it was the culmination of a long study made under the auspices of the ASEE. All factors relative to our technological and scientific growth were reviewed and related to our academic structure. To update, to keep pace and to project into the future, called for criteria and guidelines -- and these were stated in broad and general terms. They had to be, in order to allow for flexibility within the objectives of our nation's many engineering schools.

The preliminary Grinter Report of 1952 suggested two types of curricula: <u>The Professional-General</u> and <u>The Professional-Scientific</u> and, moreover, there should be a separate curricula for the two objectives. However, the schools of the nation, sharply aware of the exceedingly revolutionary changes in our science and technology -- and spurred on by the tremendous success of Sputnik -- elected to pursue the professional-scientific route. This decision, more than any other, withdrew drawing - and other tried and time-tested traditional courses - as having little professional usefulness in the new scientific concept. No degree granting department went to bat for us, nor supported our very fine statement of objectives which W. E. Street and his committee submitted to the Grinter study group.

All of you are aware of the entervening years. We've worked vigorously at overhauling our courses. We've changed and upgraded their contents. We've worked hard to make ourselves respectable and acceptable. As a division we continued to meet to discourse. We discussed our mutual problems, compared notes, swapped information and continued our efforts to do our best within the circumstances our schools allowed us. Each one of us had to adjust differently.

Even though we've been hurt time-wise, during this passage, we have learned a lot about graphics. We have learned of its versatility and its many sophisticated uses. We know that it is not and should not be taught as a terminal course outside of the engineering context. We have learned, also, that it is not a single course but rather a sequence of courses which can be put to practical use on all levels of engineering. Our job is to convince those who, until now, have not wanted to be convinced, that graphics is essential to engineering literacy.

I know that practically all of you are asking in your minds, why did the division wait until 1967 to do something about it - some fourteen years after the so-called Grinter Report labelled it a "Non-Departmental Engineering Course" and gave it a downhill shove?

The truth of the matter is that the division has not been inactive and has not lost sight of its original mission to promote graphics. The division, through many of its dedicated members, working within the time impositions and often with diverse academic goals and engineering objectives of their own particular schools, continued to experiment and to reevaluate their courses in order to retain them as effective and essential to engineering.

In several schools the efforts of these individuals have been successful and they have received recognition and have been placed on an equal footing with other engineering courses. It is from these schools that your summer school committee is borrowing some of the strength for this summer school.

The division was unable to make a salvage effort until now because it was boxed in. To borrow a popular phrase - the political climate was never just right. We never knew which way to turn, what guidelines to follow, or what our goals should be, we had no unity and could offer no clear objectives. We were in a period of incubation and simply had to wait for the right moment -- and that moment, we feel, is at last at hand.

Just as a rising ground swell of opinion culminated in the Grinter Report of 1954 and provoked massive changes in engineering education, an equall rising protest, in the interim years, has induced th ASEE to undertake a nation-wide study and indicate, in broad and general terms, the direction which engineering education must take if it is to meet the demands of the future. Accordingly, four years ago, ASEE established a committee on "Goals of Engineerir Education." This time the Graphics Division was ask to present its views and objectives. The Graphics Committee, charged with this responsibility, decided to be positive and realistic in its report and state the position and objectives of the division clearly and simply.

The preliminary report of the goals study was published in 1965 and several helpful references to graphics were made. This recognition although condi tional in nature -- was the very encouragement the division needed. It was inspirational! At last there are general guidelines to be interpreted and developed.

In the 1967 interim report, under a section entitled "Communications" the following significant statements are made:

> "All engineering languages should be utilized - verbal, pictorial and symbolic."

> "Engineering graphics as a method of communication is a critical but controversial element of engineering education. Some schools have eliminated the subject from the college curriculum. Instead they <u>require</u> it as a prerequisite for entrance <u>or</u> include it as a part of <u>other courses</u> such as <u>design</u>."

> "The engineer should be able to visualize spatial relations and so supply graphical techniques for the analysis and synthesis of complex relationships."

And in commenting on new developments in certain advanced areas in graphics, such as the compute it states:

> "--Hopefully these developments will stimulate and attract the vigorous and creative teachers in this important field."

Another feature of the interim report is the knowledge that the professional-scientific curricula advocated by the old Grinter Report, has swung through a full circle and the professional-general is now recommended with a definite stress on creativ ty and design in engineering.

In planning this summer school it was decided that this advocation of creativity and design should be our theme and that by concentrating our efforts i this direction we will be riding in a vehicle that wa no longer traveling on a down-hill road.

1967 is the year of opportunity for graphics. Everything seems to dovetail as though by plan -- but whether by plan or coincidence the advantage is here.

-The years of self-analysis and reappraisal have given us a new graphics perspective which is meaningful, up-to-date, and of true engineering value. We have learned that graphics cannot be separated from the mainstream of thought and development in engineering education -- that it can be used as an effective engineering tool by the freshman in his daily assignments and by the graduate in his original research. We have learned all this and welcome the opportunity to implement this learning.

-The goals study has come at a time when we can meet its challenge with a more forceful graphical image in engineering education.

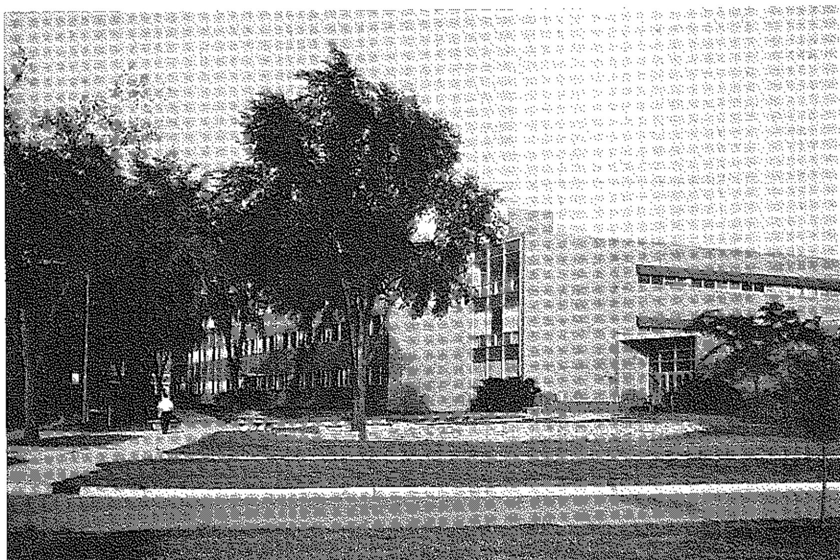
-The goals study is recommending a professional-oriented curricula with emphasis on creativity and design at all levels of engineering study -- and graphics, in the design function in engineering, has a strong position.

-The wonderful coincidence, therefore, that our five-year summer school should come at this time, has given us a purpose and we can chart our course, for at least the next five years, with a greater feeling of confidence and well-being than we have heretofore enjoyed in the last fourteen years.

This summer school was not designed to be panacea and cure-all for the many graphics ills that you may have at your respective schools -- in one form or another we have all experienced setbacks. Its purpose is to give you something tangible and definite to take back with you and use as a basis upon which to build and survive and perhaps even re-build. If you have a one-semester course you will have to abridge and improvise. If you have more time you will have more justification for doing a better job.

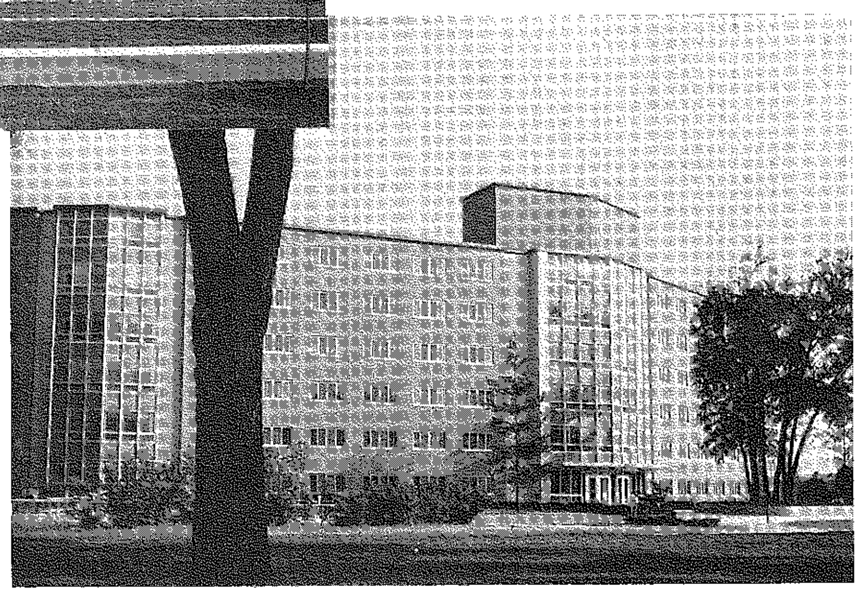
The division through its membership, its committees and its leadership will work with renewed vigor to maintain and support you in your efforts.

I personally wish you success.



Engineering Building

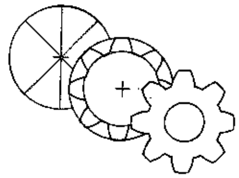
Michigan State University



Student Residence Hall

Michigan State University

THE ENGINEERING DESIGN PROCESS



PERCY H. HILL

Professor and Chairman, Engineering and Design
Tufts University

"Imagination is more important than knowledge, for knowledge is limited, whereas imagination embraces the entire world ..... stimulating progress, giving birth to evolution".....

Albert Einstein

One is often asked the question - can design really be taught? Since design is central to engineering - it is what an engineer is mostly concerned with - the creation of new and better things for society; my question in reply is, can one teach engineering? If engineering can be taught, design must be taught. Design by definition is a means towards this end. Engineering design is an iterative decision-making process for developing engineering systems or devices whereby resources are optimally converted into desired ends. To design is to create - to put together something new or arrange existing things in a new way. Design is a process where the result achieves a social need.

Engineering Design begins with the awareness of a social or economic need. The need must first be translated into an idea and eventually into a reality that stands up against the laws of nature to be proven a truly workable idea. This requires of the designer a knowledge of physical laws and the ability to communicate ideas. The engineer must have a working knowledge of the basic and engineering sciences as well as economics, manufacturing methods, sales, and advertising. He must have his finger on the pulse of the market in which his device is to be placed for design as well as engineering terminates in a product that must benefit society in some way.

The ability to design is both a science and an art. As a science it can be learned through repetitive drill, experience, and problem-solving techniques. As an art it must be practiced with total involvement for one to become proficient. The designer is an idea man, continually seeking novel needs to benefit society or turn a profit. He often deals directly with the customer in defining a novel product and works backwards to the design. The ability to continue coming up with ideas is an art based on the creative process.(1) Once the idea is recorded, the engineer must cause the design to unfold through study of the abundance of literature related to a possible solution often involving heat transfer, fluid flow, material science, vibrations, economics, optimization, reliability, human factors, and much more. Here is where design becomes a science and the engineer analyzes. Science and art, analysis and synthesis, cannot be separated in the process of design for they rarely occur independently. More often than not they are simultaneous activity.

The process by which a total design comes about from the first glint of an idea to an eventual marketable product is illustrated in the following diagram: it must be remembered, however, that the process is iterative and decision making and serves as a sequential guide to design -- not as a formula.

(1) "Training 1970's Design Engineer", P.H.Hill, MECHANICAL ENGINEERING (A.S.M.E.) May 1966, Vol. 88, No. 5.

"Creativity Can be Taught", P.H.Hill, MACHINE DESIGN (Penton Press), August 1964, Vol. 36, No. 20.

ITERATION AND DECISION MAKING

IDENTIFICATION OF NEED	Imagination supplies the need through the stimulus of being irritated or disturbed by a situation confronting you and the decision to do something about it.
DEFINITION OF GOAL	An expression in general terms of one's commitment for a system or device to satisfy the need.
RESEARCH	Collection of all available information related to the goal.
TASK SPECIFICATIONS	Listing of pertinent data and parameters that will tend to control the design towards the desired goal.
IDEATION	The process of coming up with new ideas.
CONCEPTUALIZATION	Ingenious, innovative, creative, inventive activity in the form of the generation of alternative possible solutions to the required goal. Usually takes the form of freehand sketches.
ANALYSIS	Testing selective concepts against physical laws.
EXPERIMENT	Construction of prototype and laboratory testing to prove workability, reliability, durability, etc.
SOLUTION DESCRIPTION	Specific information that defines the system or device. Consists of a design report containing description of device, drawings, specifications, parts lists, cost breakdown, etc.
MANUFACTURE	Consideration of volume of production, shop requirements, automation, scheduling, quality control, inspection, etc.
DISTRIBUTION	Competitive pricing, advertising, marketing, profit, etc.
CONSUMPTION	Consumer feed-back, repairing, servicing, etc.

A DESIGN CASE HISTORY

WILLIAM S. CHALK
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University of Washington

Abstract

The following discussion parallels Professor Hill's comments on the Design Process. One (freshman engineering student) design project is presented in detail as an illustration of how the students utilized the Design Process.

Background

Mountain-climbing trainees in the University of Washington Mountaineering Club substitute two 100 pound tires to represent a typical climber, secure a climbing rope to the tires, hoist them about 25 feet above the floor, release the rope suddenly, and expect a belayer trainee to stop the tires before they reach the floor. The rope runs from the seated trainee horizontally to a wall and then through two pulleys to the tires which hang vertically under one wing of a football stadium. The other end of the rope is looped one-half turn around the trainee's waist which is protected by a leather "girdle." The trainee braces his feet against a wood frame, anchored to the floor, to simulate the position he would assume on a mountainous terrain. A successful trainee saves the "climber" if he stops the tires before they hit the floor.

The Mountaineering Club invited a freshman engineering graphics class to witness a training session and to participate in hoisting the weight. Figure 1 shows the class hoisting the tires in preparation for the simulated "accident."

Figure 2 is a schematic plan view of the training facility.

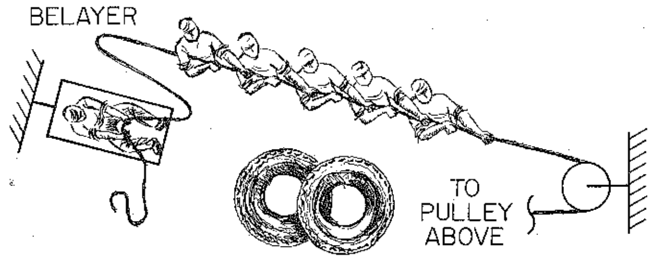

Figure 2. Schematic Plan View of Training Facility

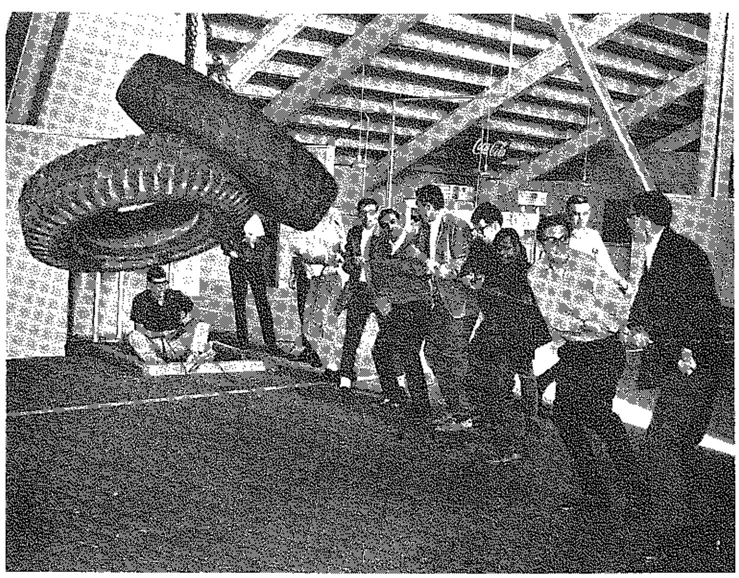

Figure 1
Freshman Graphics Class Participating in a Training Session

Identification of a Need

All club members agreed that hoisting the tire was providing them with beneficial exercise, however, they said they were dissatisfied with the procedure for two main reasons. The first is that hoisting the tires is too time consuming and secondly that releasing the rope so the trainee is "surprised" is only partially successful. Hence, the club asked the freshman engineering graphics class to solve these problems.

The class had previously been formed into four-man teams. Each team met to decide just what the problems were and what they would propose to do to solve them.

Definition of Goal

Team Number Seven concluded that they would devise a powered hoisting mechanism for raising the tire in a reasonably short time. They would also design a quick-release mechanism to aid in surprising the trainee. Furthermore, they would attempt to keep the costs as low as possible and have the system operable by one man. Also, they would utilize the existing equipment.

Information Search

They proposed their plan to the Mountaineering Club in a subsequent meeting. It was accepted. Now the team needed more information to specifically define the problem and to prepare detailed task specifications. They questioned the club representative about the desired time to lift the tires, the power available at the training site, the frequency of usage during a training session and during the year, the portability requirements, the money available, the types of devices other clubs are using and any further requirements which the club may have wanted.

Task Specifications

After conferring with the Mountaineering Club, Team Seven concluded that their design must meet the following requirements:

1. Handle a maximum of 250 lb.

2. Raise the load to a height of 30 feet in less than one minute

3. Be able to release the lifting rope suddenly as a "surprise" to the trainee

   a. While the tire is moving upward

   b. After the tire has stopped at any one of several stops, e.g., 20', 22', 24', etc.

4. Cost less than $100 not counting the existing rope, pulleys, and tires

5. Be easily maintained, but seldom requiring maintenance

6. Store easily, thus be compact and portable

(Their instructor had previously added several requirements:)

7. Deliver complete assembly and detail drawings in three weeks to the Mountaineering Club

8. Prepare a written report

9. Present an oral report to representatives of the Mountaineering Club and invited faculty members at the termination of the design project

Further Research

While the task specifications were being formulated the team chairman was preparing a tentative schedule of the team's activities. One member was to investigate hoisting devices. Another was to consider sources of power and quick-release mechanisms. A third member was to visit the training site again and check the available power as well as to take measurements of the surroundings. (See the Bibliography (5) for a guide to sources of design information.) The team was beginning to appreciate the utility of sketching for recording the ideas they found in library references and for taking field data. (3)

Further Task Specification

The Task Specification which required the most attention and which put the most constraint on the team's activities was the requirement that the project be completed in three weeks. An average college student in a three-hour credit course is expected to spend about nine hours per week on that course; therefore, Team Seven had only 110 to 120 man-hours available for the project. The team chairman had the responsibility to make the most effective use of these hours to accomplish the specified tasks. Using the Design Process as a guide and conscientiously planning their time brings most student design teams through a project successfully and with a high degree of satisfaction. (See Bibliography, 1 through 9 for further discussions on the Design Process.)

Ideation, Conceptualization

After collecting and discussing information related to the various assignments, the team met several times to "brainstorm" their problem. Sometimes they attacked the whole problem and at times they concentrated on specific portions such as power devices, lift mechanisms or quick-release mechanisms. During these sessions one man acted as a recorder at a chalk-board. Everyone was to offer ideas and no one was to evaluate or criticize each others suggestions during this ideation and conceptualization phase.

A systematic approach is helpful during an ideation session; for example, mechanical systems could be considered first, then electrical, etc. Also a number of texts have check lists as guides for asking questions and considering many facets of design problems. (1, 5, 10)

Preliminary Analysis

Team Seven's next step was to evaluate and analyze their ideas. The obviously impractical ideas such as using "levitation" or hiring "cheap labor" were eliminated immediately. The available electricity under the stadium preempted the other types of power (gasoline, hydraulic or pneumatic).

Technical Analysis

Their next effort was to determine if the remaining ideas were workable. They utilized a "first-order" analysis approach; for example, they estimated that to move the 250 pounds vertically 30 feet in one-half minute required about one-half horsepower. On a friction drum with a coefficient of 0.3 and a manually applied tension on the low side of 50 pounds, required about one wrap around the drum. The radius of the drum affected the torque required and the RPM. T.T. Woodson (5) calls this approach an "order-of-magnitude" analysis. The group asked for help in estimating sizes of members to withstand forces, moments, and torques. (Thus the need for their engineering courses such as strength of materials and dynamics was effectively demonstrated.)

Cost Analysis

Their preliminary cost analysis was based on information they could uncover in manufacturer's catalogs and from calling sales offices.

Decision Making

The team now had the problem of selecting the most promising system to fulfill the task specifications. The students were asked to employ a decision table (2) to gain experience with a systematic decision-making tool. They were also told that more complex techniques were available (5, 6, 7).

Decision Table

A decision table can be explained by an expression as follows:

$$S = \sum_{i=1}^{n} (\text{weighting factor})_i \times (\text{value factor})_i$$

where S = relative ability of a system to meet all the requirements of the task specifications.

n = number of task specifications.

Weighting Factor - relative importance of each task specification on a basis of 1 to 10, 10 being high.

Value Factor - relative ability of the system being considered to meet a particular task specification on a basis of 1 to 10.

An annotated copy of Team Seven's decision table is shown in Figure 3 as an illustration of its use.

Task Specs.	Wt.	System A	System B.
Cost	9	10(90)	5(45)
Ease of Operation	8	3(24)	5(40)
Realism	3	7(21)	7(21)
Total		(135)	(106)

Figure 3

Illustration of a Decision Table

Schematic drawings of System A and System B are shown in Figure 4.

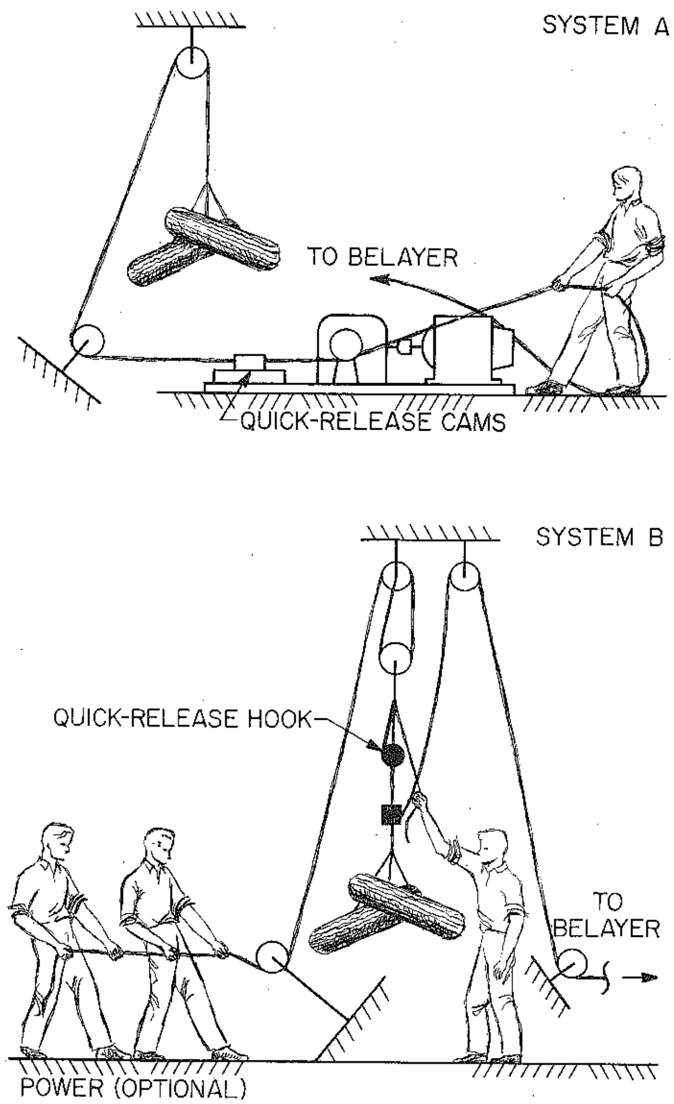

Figure 4. Schematics of System A and System B

Decision

Ultimately System A was selected as the most promising to fulfill the original task specifications. Team Seven's decision was based on the information they had at that time. They wanted to investigate other ideas but the constraint of time forced them to move on to the next steps.

Manufacture, Distribution and Consumption

The remaining activities were, to develop the details of the design of System A, to prepare an assembly drawing, to prepare detail drawings, to write a report and to organize an oral presentation. (In an industrial situation they would most likely pursue the design through manufacturing. Furthermore they would probably become involved with distribution and consumption of the design, and handle customer feedback problems.)

Iteration

The team reviewed the original task specifications and met with the Mountain Climbing Club again before developing System A in detail. They found that a mountain climber's philosophy had crept into the requirements of the design. Reliability, operability and safety were given more importance than cost or the element of "surprise" built into the training device.

The group proceeded to develop the design of System A and eventually selected a 1-1/2 HP motor, a 20 to 1 gear reducer, a coupling, ball bearings, a drum shaft and 4 inch dia. drum. Their major hurdle was the design of the quick-release mechanism.

Their first idea was to have two opposing offset cams which would allow the rope to pass easily one way but would bind on the rope in the opposite direction. Then, to release the rope, the operator would jerk the rope upward and out of the cams. This was deemed to be too awkward. Ultimately, they decided to incorporate a quick-release on one of the cams. A toggle mechanism was employed as shown in Figure 5.

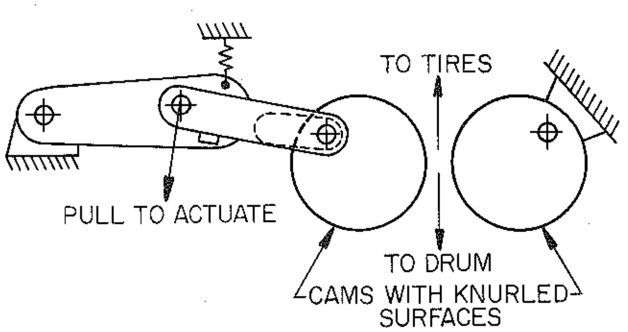

Figure 5. Quick-Release Mechanism

Experimentation

Next, they built a simple model of the whole system as preparation for the oral report and to see if their design of the quick-release mechanism would work. (Often, a prototype of only a portion of a design is sufficient to determine whether or not a system will work.)

Solution Description

Finally, detail drawings were prepared, an assembly drawing was made and the two reports, oral and written, were completed. The report also included a cost breakdown.

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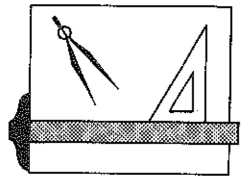
NOTES ON GRAPHICS AND INTRODUCTORY DESIGN IN ENGINEERING CURRICULA



DR. HENRY O. FUCHS
Professor of Mechanical Engineering
Stanford University

OBJECTIVES

We have a course called "E-9" which is normally taken by all engineering students in their first or second year. We consider it an opportunity to balance the curriculum by exposing the students to some experiences which they may not encounter in their undergraduate courses, but which we consider to be characteristic of engineering.

Open-ended problems

One of these experiences is the encounter with ill defined open-ended problems. These are problems which are either loosely stated or merely implied in a situation so that it is the task of the student himself to formulate a definition of the problem. They also are problems which, after they are defined, admit several solutions, none of which is clearly superior to the others. In short, they are design problems. The first struggle with such a problem is frustrating to most high school graduates. We want to provide a sympathetic environment in which frustration resistance can be developed on reasonably simple design problems, preferably with pleasure in the process.

Visual thought

Another important experience is the use of visual thought and visual communication. Most courses develop verbal and mathematical skills. We want to balance this by visual understanding and visual expression.

Independent learning

The ability to learn without detailed programmed direction is a third important objective. We practice this art on selected topics of descriptive geometry. These topics mesh nicely with the development of visual skills.

The art of engineering

Finally we attempt in this course to balance the heavy doses of engineering sciences and of humanities by an appreciation of engineering as an art. It involves working with people; bosses, customers, clients, vendors, foremen, draftsmen, accountants and many other people can make or break the success of engineering work. Due regard for these people is one aspect of the art of engineering. Skillful approximation is another aspect. This includes the estimation of magnitudes (strengths, costs, loads, markets, etc.) whose more exact values cannot be obtained under the given circumstances. It also includes consideration of the tolerances inherent in all works of man or machine. Finally and most importantly it involves the achievement of a desired objective with the available limited resources. By "limited resources" we mean not only financial or physical resources. We mean mainly the very limited knowledge available for the solution of most real engineering problems. Advanced engineering frequently goes beyond the application of known science or known experience. It manages by iterations or experiments to produce the experience necessary to do the jobs. We would like our students to feel some of the thrill which comes with the practice of this art.

LIMITATIONS

E-9 is a four unit ten week course. We have 20 hours of "lecture", meaning attendance in a classroom; 60 hours of "laboratory", meaning attendance in a room equipped with drawing boards and lockers; and on the average 40 hours of homework to arrive at the 120 working hours which correspond to a four unit course. We must avoid using this limited time for purposes which do not contribute to the objectives which we want to achieve.

We cannot use E-9 to equip the students with specific prerequisites for succeeding courses, such as a knowledge of the drawing conventions and nomenclature peculiar to one of the branches of engineering. We do however point out the practical importance of such conventions and use a few of them in the design project, as examples of the many which must be learned later. We need not use E-9 to introduce computer programming, nor to practice written communication, as we have other required courses for these purposes. We cannot ask the students to handle design projects, learn the elements of descriptive geometry, learn about the art of engineering, and to learn freehand perspective thoroughly enough to be proficient in it. We only teach the rudiments of sketching, and rely on another course, required of students who elect the Mechanical Engineering Design option, to improve their sketching skill.

In other words, we do not try to equip our students with a set of mental tools sufficient for any given purpose; we only try to have them use some tools skillfully, merely as examples, and to start them on the way to search out or make whatever tools will be required in the tasks they will meet in the future. We avoid a superficial survey by asking the students to perform active creative work.

PROCEDURES

We may consider E-9 to be made up of three components in parallel with several cross-connections between the parallels. The three components are graphics exercises, engineering discussions, and Design projects. An outline of the course, as it was given a year ago, is shown in exhibit I.

Graphics Exercises

The first column lists the laboratory exercises. We started by handing each student a plow-bolt and asked him to sketch it. Next we asked him to explain by graphic presentation the working of a sexless connector for co-axial microwave conductors. The invention and development of this connector had meanwhile been studied in case history ECL-1, and the case had been discussed in class. (The connector is a coupling which incorporates in one piece a male thread, the female thread which matches it, and slots through which the males can pass before being twisted into engagement with the females.)

This early effort at graphic explanation was iterated at the end of the course in a technique suitable for slide presentation; the slides were projected in class and grades assigned publicly while the slides were on the screen.

After these freewheeling exercises we went into more formal work on projections and descriptive geometry. The numbers (H 2, etc.) refer to sheets in P. H. Hill's portfolio on Engineering Graphics and Design. The various books to which this portfolio is keyed were available in the drawing room together with several other books on graphics and on descriptive geometry. The students were expected to learn from these books as needed. The only lecture on orthographics was used to demonstrate a large box of plastic, with hinged sides at different angles, in which a piece of steel pipe was mounted, parallel or perpendicular to some sides and at odd angles to another orthogonal set of sides. We explained the importance of choosing a suitable direction of viewing and the method by which one arrives from any two orthogonal views to any other desired view with no more than at most one intermediate auxiliary view. The rest was left to the interaction of students and books, with help by laboratory instructors if it was specifically requested.

We are aware that our students would have learned more descriptive geometry if we had helped them more, but they would then have learned less of the art of independent learning. We consider the latter more important than the former.

The formal exercises eventually led to the solution of a real life problem which had been discussed in a case history. A mirror block was part of the view finding optics in a camera. The camera designer had wasted several days in trying to define and draw the block by shortcut methods before he decided to review his descriptive geometry and do it correctly. We are indebted to him for his candour in relating the case history to our case writer.

In reviewing these exercises we have seen some of the cross-connections between the case histories discussed in the "lectures" and the graphics laboratory. The connections between the laboratory and the graphics work required by the project are obvious.

Lectures and Case Histories

The lectures included class discussion of four case histories. Exhibit II gives the abstracts of these case histories as they appear in our bibliography of engineering cases. Two of these cases furnished problems suitable for the laboratory exercises besides showing engineers at work in real life situations. The other two showed the methods of design as used by a current young engineer and by the Wright brothers sixty years ago. They furnished impressive reinforcement for the lessons learned in doing the design project. The necessity and universal occurrence of iterations is not appreciated by students unless they see that all engineers iterate. We consider this lesson most important, and very difficult to learn for young people who are in daily contact with the triumphs of pure reason, as told by admirers of the heroes after the last iteration has been made. For this reason we try to include shop drawings with change notes in our case histories.

The other lectures attempt to put the work of this graphics course in perspective or to help the student by showing methods which he can use in doing his design project.

Design Project

The project assignment for last year's autumn quarter is shown in exhibit III. We received a large variety of solutions, from very complex to very simple, and from sloppy to thorough. These different solutions all were based on a common Technical Problem Statement. The individual problem statements which the students had turned in on October 19 were reviewed promptly and a common statement was then developed in a class discussion. This included limitations on size, cost, operating effort, and values of force or impulse required to open the nuts.* These forces had been determined by the students in experiments devised by them. The statement also included criteria which were to be used in reviewing and revising design ideas.

We made special efforts to be prompt in reviewing and returning the papers which were demanded of the students in the schedule given with the design project. This was accomplished by talking comments into a dictating machine and getting them transcribed the next day for distribution to the students. To permit a prompt feedback we had to insist on punctual delivery of the papers to us. The evaluation of the project will be discussed in a talk on the Evaluation of Student Design Projects later on in this conference; it will therefore not be explained here.

In autumn 1966/67 we used only one single design project. Other instructors prefer to use several, to give the student more than one chance at design. A short simple project as a starter and a longer main project with iteration might be a suitable compromise.

* We had given each student three black walnuts.

Grading

We want our students to loosen up their thinking and their sketching muscles. Therefore we try to keep the atmosphere playful and to relieve grade worries. Many of the exercises are simply checked in. A reasonable facsimile of work will achieve a passing grade. Some students get absorbed in their designs and spend long hours on it; others do very well with much less apparent effort; a few just cannot become free enough to produce any original design. These few have a rescue open by bearing down on learning the descriptive geometry. We point this out to relieve fear of poor grades, and we consider it an important secondary function of the geometry content of this course.

CONCLUSION

Pressures on the curriculum require that time be spent on only the most urgent needs. The teachers in our design division all believe that E-9 is very valuable, but are aware that other teachers might consider parts of it as expendable. In a recent review of the course by the executive committee of the School of Engineering we declared that we could manage with only three units if we omitted more of the geometry content. After the review the committee decided to leave the course with four units, with the following catalog description:

"Exercises in engineering design stressing problem definition, conception of alternative solutions criteria for evaluation. Presentation of solution in forms suitable for understanding and execution by others. Emphasis on spatial thinking and graphic communication. Orthographic projection and elements of descriptive geometry. Illustration of the engineering design process through practical examples."

The concurrence of the other Departments in our School confirmed our convictions and encouraged us to try harder to achieve the objectives of this course.

EXHIBIT I

School of Engineering
Stanford University

E-9

Autumn 66/67

Week	Lab. Exercises	Lectures	Project
1	Sketch plowbolts	Introduction	Warm-up
2	Explain connector ECL-1	Co-ax connector case ECL-1 Creative Thinking	Ideas and criteria
3	Orthographics H2 Visualization H3	Orthographics Design Method	Technical Problem Definition
4	Pictorials H 10 Pictorials H 11	Sketching methods Mirror case ECL-54	
5	Analysis of Points, Lines, Planes H 12 Prim. Auxiliary H 14	Value System Types of Drawings	First general design
6	Secondary Auxiliary H 16 Skew lines H 17 Start Mirror Block ECL-54	Oil Well case ECL 1-13 Dimensioning	
7	Dihedrals H 18 Angle between line and plane H 19	Tolerances	Some significant detail drawings
8	Plane Intersections H 21 Curved Intersections H 22	Curved Surfaces History of Engrg. Drawing	Second general design
9	Finish Mirror Block ECL-54	New Drawing Techn. Wright Airplane case ECL 1-14	
10	Slide show diagram of connector ECL-1	Patents, Ethics	Complete design report

Note: ECL numbers refer to cases from our Engineering Case Library

EXHIBIT II

(Outlines of 4 cases)

ECL-1 Hewlett-Packard Company 1, (A) Mechanical design of Coaxial Microwave Connectors, (B) History of Coaxial Microwave Connector Design, K. H. Vesper, 1964, (C) Commercial Development of the Sexless Connector by Amphenol Corporation, Sue Hays, 1967

Anthony Badger, a mechanical engineer, has been asked by his management for the mechanical design of a better coaxial connector for microwave frequencies. Electrical engineers in the company have been able to state some physical requirements for him, and from his own observations of connectors being used, other requirements can be deduced. Part (B) of the case shows how Mr. Badger approached the problem, his idea sketches and his detail work. Part (C) shows the redesign done by Amphenol who purchased the patent and market the connector

Total 65 pages (Parts A,B,C) with 16 text, 49 exhibits.

ECL-54 Beckman and Whitley, Inc. II, Design of a Mirror Mount, H. O. Fuchs, D. A. Horine, 1966
Les Brown, who was in charge of the job said, "We wasted a considerable amount of time due to the fact that we had all forgotten our descriptive geometry." The case concerns the determination and communication of the specifications for a block which fits into the camera and holds a mirror which reflects the light at 90 degrees to the side and 30 degrees upwards. The erroneous original sketches and the finished shop drawing with tolerances are shown beside the data necessary as background for this part.

Total 12 pages (Parts A,B) with 5 text, 7 exhibits.

ECL 1-13 Development of an Oil Well Tubing Stripper Rubber, P.E. Bickel, H.O. Fuchs, UCLA, 1964

Part one is a formal report submitted as evidence of accomplishment in applying for registration as Mechanical Engineer. Part two is an informal tale of adventures recalled on the project.

Total 30 pages with 14 text, 16 exhibits.

ECL 1-14 The Wright Brothers' Airplane, H. O. Fuchs, UCLA, 1964

A history drawn from published sources including quotations of Orville Wright taken from a deposition he gave as a witness in a 1920 lawsuit. Intended for introducing freshmen to engineering design.

Total 29 pages with 14 text, 15 exhibits.

EXHIBIT III

Project for E-9

Autumn 1966/67

Stanford University — School of Engineering

Black walnuts have stronger flavor and grow on sturdier trees than English walnuts. But they are tough nuts to crack and therefore do not sell nearly as well as English walnuts.

Design a device or method for removing the meat from the shells of black walnuts. The device or method must be suitable for home use.

You will receive a "Design Notebook." Keep all your notes, calculations, sketches for this project in it, and bring it with you to all E-9 lectures and labs. Some drawings may be made on larger translucent sheets (11 x 17 or 17 x 22).

Schedule:

Ideas and Tentative Criteria - to be turned in	Oct 10
Technical Problem Statement	Oct 19
First General Design	Oct 31
Significant Details	Nov 9
Second General Design or Model	Nov 21
Complete well organized Design Report	Dec 5

CURRICULUM PLANNING FOR A LARGE CO-OP UNIVERSITY

WILFRED P. RULE
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Northeastern University

Let me state at the outset that I claim no great insight to effective teaching, especially the effective teaching of Graphics. I further admit to a disturbing degree of confusion each time I set about revising my department's Graphics curriculum.

This confusion, however, is not with respect to what subject matter to cover, for I AM NOT INTERESTED IN COVERING SUBJECT MATTER per se. This is a remarkably strange statement to include in a paper entitled "Curriculum Planning for a Large Co-op University", but I believe it is important to set the tone of this tirade immediately. The inclusion or exclusion of minor topics such as conics, monographs, dihedral angles, graphical calculus, developments, etc., is of minor importance. As I see it, THE DEVELOPMENT OF LOGICAL, ANALYTIC, AND CREATIVE THOUGHT PROCESSES is by far more important and more difficult to achieve.

Many brilliant engineers have not had the benefit of a good course in descriptive geometry, and yet they survive. On the other hand, those who have what is described as a good course in descriptive geometry are sometimes unable to display reasonable competence in the subject six months after the course is over.

This does not suggest we should get rid of descriptive geometry (it happens to be a favorite subject of mine), or get rid of graphical calculus, or any other subject within the Graphics domain. What it does mean is that the teaching of these subjects for their <u>content alone</u> is not justified.

Each of these subjects has a logic; a sequentially evolved theory; a group of underlying laws. Each of these subjects can, therefore, be used to display logical thought, the analytic approach, and creative problem solving. On this basis, these subjects have a place in the engineering curriculum.

The justification for down-grading subject matter and up-grading thought processes lies in the fact that man's knowledge doesn't age with time - it becomes obsolete. Attempting to acquire technical knowledge in four college years that will have application five, ten, fifteen years after graduation is ridiculous. This means you can't focus on subject matter only. You must focus on the development of a logical, agile, flexible mind. This, in turn, means requiring extreme participation on the part of the student. He must constantly be asked to make decisions, draw conclusions, or provide the necessary logic.

If, in teaching any subject, you lecture on and on, asking only that the student absorb your words of wisdom, YOU ARE DOING A DISSERVICE TO THE STUDENT. If you use rote methods; constructional procedures; stereotyped applications, YOU ARE ALSO DOING A DISSERVICE. Actions such as these are resorted to by well intentioned individuals who place undue emphasis on learning the subject matter. Unfortunately, every professor in captivity believes he teaches a logical, thought provoking course. It just isn't so. As the time for Graphics has diminished, we have crowded more and more subject matter into fewer and fewer contact hours.

I would ask each of you the following questions:

Do your lectures frequently (and I mean frequently) require the student to provide the next step, rather than showing it to him?

Do you often provide several possible conclusions to a point being developed and ask the class to determine which of these is justified? <u>Graphics is a tremendous place for doing this</u>.

How often do you assign a homework problem that isn't a carbon copy of the lecture, and let the student work it out for himself?

Have you ever asked a student to learn an entire topic on his own?

To be sure, a whole course or a whole exam can't be new, provocative, challenging material, but some of it can - the more the better. In the past, knowledge was rather stable, permitting one kind of teaching. Things are more dynamic now, requiring a change in teaching methods.

My point can be simply stated. It's not what you teach. It's how you teach it. A concrete example may help. Every engineer must be capable of reading machine drawings. There are, however, many ways to convey this ability. I intend to examine two extremes.

One approach starts by showing a pictorial and three views of a block. The block is modified by some cut (described again by a pictorial and three views). At this point, I have no quarrel with such an approach, but if it continues showing every example under the sun to gain mastery of the subject, I feel the subject is being taught improperly. This is teaching by example, which has its place, but not to extremes. Teaching this way is a long and tedious process that does little to develop good thinking habits.

Many educators are hostile to this approach. They feel it is sub-professional and has no business as a college level activity. Couple this with an over-crowded freshman year, and troubles are sure to develop.

An alternate approach is to attack the problem on a more theoretical basis. That is, via descriptive geometry. This subject emphasizes logical and analytic thinking. It starts by classifying points, lines, and planes and proceeds to projection theory. If these principles are properly understood, machine drawing can be shown to be little more than a practical application of a limited number of basic principles.

I am not prepared to say that the student exposed to the descriptive geometry approach is any better able to read machine drawings than the student taught by example. That is not the point. The point is that one student has been exposed to a logical line of reasoning. He has been challenged to think and not just to remember, while the other student has not. Those who rely on memory are attached to the past. Those who think have a share in the future.

Which of the two students just described will be better able to adjust to the impact computers will have on engineering in the next ten years? Which student is better equipped to supply our nation's needs in new and expanding fields such as aero-space or medical engineering?

This brings me to the topic of design. I am in favor of it. It requires a man to think. Coming from a large CO-OP school, I have experienced demands to produce good draftsmen for industry. I am told they can become designers later on. This, of course, affects my curriculum planning, but to yield to these demands is not in the best interest of the students. They didn't come to Northeastern to be draftsmen. They came to become engineers, and the function of an engineer is to design. Fight it all you want, but you're probably revealing your own inadequacies. Look at the INTERIM GOALS REPORT. See what they think the engineer of the future will be doing and then answer the question, "Am I helping?"

Design is a sound vehicle for preparing future engineers. Design is not tied to any specific body of knowledge. Because it is not subject oriented, it is less apt to become obsolete. The only subject it draws on to any degree is graphics. Graphics is the prime means of communication in design.

Design transcends subject matter and strikes at a more fundamental process. That process is a thought process I can best describe as the opposite of analysis. One dictionary definition of design is "To plan mentally; To conceive or execute a scheme or plan." A definition of synthesis is "To compose or combine elements or parts so as to form a whole". Now it seems to me these functions or processes are synonymous with engineering. With this in mind, how much attention do we give to design at the University? The answer is, not enough. We have been preoccupied with analysis. Design has suffered because of it. Analysis is important, but so is design. We can't lessen our concentration on analysis, but I am sure we must increase our design effort.

I am leading up to the proposition that the inclusion of a design emphasis in your graphics courses is highly advisable and in the long run will be the best preparation for your students.

You will be surprised to find that the graphics would benefit from such a move. The inclusion of design shows the student the role an engineer plays in society and further convinces him of the need and importance of graphics to convey design ideas. To do this we will have to drop some conventional topics such as those involving drafting techniques. I believe you can teach drafting techniques such as lettering, use of triangles and T-square, etc., and still get poor performance BECAUSE THE STUDENT IS NOT MOTIVATED. I also believe the converse is true. Motivate these students (through design) and they will generate reasonably high quality work with minimal direction. A second benefit to the design approach is <u>awareness</u>. Design makes the student interested in how things work and this awakening is a serious contribution to his professional development. As an example, we asked our students to consider the problem of separating two large bodies such as the nose cone and booster of a missile. They were to conceive of at least six ways to accomplish this, the ideas to be presented in the form of sketches. The best idea was then to be selected and developed in the form of detail drawings.

Students used exploding bolts; electro-magnetic couplings; pneumatic and vacuum seals; mechanical interlocks; solenoid operated releases; chemical separation methods; pyrotechnic seams; etc. The quality and quantity of the graphical material used by the students to display their ideas was an order of magnitude better than I can get out of students using conventional assignments. This is because the students can immediately see the results of poor graphics. His ideas are rejected or even ridiculed.

Following, you will find a three-quarter outline of our graphics course at Northeastern. Much of the subject matter is highly conventional, but a good deal isn't. Descriptive geometry precedes machine drawing. The number of machine drawing lectures is minimal. There are a lot of design topics. For example: the design process, barriers to creativity, design components, design case studies. On top of all this, we teach computer programming. During the course we may ask the student to design a device to eliminate the cash register check-out girl at the supermarket, or develop a computer program to drill a bolt hole pattern by numeric control.

Some may ask, "What has this to do with graphics?". My answer is, everything. It typifies how the modern engineer will use his graphics. This approach challenges the student and makes him think. We know that he is more apt to do a highly professional drafting job because if he doesn't, it detracts from the design ideas he is expressing, and these ideas are very important to him - they are his.

Following also is one of several case studies we use that asks the student to analyze graphical data as it relates to the performance characteristics of an aircraft. This is an attempt to place conventional material in a more sophisticated, thought provoking setting. To many, I am sure this will appear to be an impossible problem. I find my students approach it with great enthusiasm.

We are fortunate to have three quarters (one year) of graphics with slightly more than four hours per week of lecture and lab. We have to justify this time. Often we have doubts. Always we have problems, but our problems are not with respect to a stagnant course.

I feel that an approach such as described above is far from best. Much improvement and polish is needed. I feel, however, that it is an approach that is needed if we are to carry on our role as teachers in the rapidly changing technical world of tomorrow.

QUARTER I

COURSE SCHEDULE - 9.101

Class	Topic	Assignment
1	AN INTRODUCTION TO ENGINEERING Design Components Group 1 - A look at the objectives of this course with respect to DESIGN:STUDENT Student Projects	Read Chapt. 1 Introduction to Engineering, by KRICK
2	THE DESIGN PROCESS Design Components Group 2 - Major aspects in the DESIGN PROCESS - Problem Formulation - CREATIVITY - SEARCH FOR INFORMATION.	Read Chapt. 6 & 7 Assignment of Design Project #1
3	CASE STUDIES Design Components Group 3 - Design of an automatic pilot - Concept of measurements & feed-back.	Read Chapt. 8 & 9
4	GRAPHICS AND DESIGN - PRESENTATION Multiview Drawings - Isometric Sketch - Micky Mouse Sheet - Design Components Group 4	Read Chapt. 4 Sheets 6 & 7
5	DESIGN / MANUFACTURE / GRAPHICS Design Components Group 5 - Manufacturing methods and the role of the engineer and graphics.	Read Chapt. 2 & 3 Submit Design
6	TYPICAL POSITION OF POINTS, LINES AND PLANES ORTHOGRAPHIC PRINCIPLES	Sheets 4 & 5
7	AUXILIARY VIEWS - PRIMARY Points, lines, planes	Printed Sheets
8	AUXILIARY VIEWS - SECONDARY Lines, planes - Application T. L. line	Printed Sheets
9	VISIBILITY - TETRAHEDRON, ROD, ETC.	Printed Sheets
10	TRUE LENGTH LINE Auxiliary and Revolution	Sheet 12
11	POINTS AND LINES IN PLANES Angle between plane and principal plane	Sheet 18, 19(2)
12	MID - TERM EXAMINATION	
13	AREA OF A PLANE	Sheet 20, 21
14	PARALLEL AND PERPENDICULARITY	Sheets 14,15,16,17
15	DIHEDRAL ANGLES	Sheet 22

Class	Topic	Assignment
16	SHORTEST DISTANCE BETWEEN SKEW LINES	Sheet 24
17	DESIGN PROBLEMS INVOLVING DESCRIPTIVE GEOMETRY (1) Cable Layout - Missile Problem (2) Determination of Angle - Wind Screen (3) Clearance - Incoming Aircraft	
18	HOLIDAY	
19	HOLIDAY REVIEW	
20	CONTINGENT	

NOTES:

1. TEXT BOOK: INTRODUCTION TO ENGINEERING AND ENGINEERING DESIGN
   E. V. KRICK
2. WORK SHEETS: PROBLEMS IN GRAPHIC SCIENCE AND DESIGN
3. GRAPHIC REFERENCE TEXTS AVAILABLE IN LIBRARY RESERVE ROOM
   (A) ROWE & McFARLAND - "ENGINEERING DESCRIPTIVE GEOMETRY"
   (B) WELLMAN - "DESCRIPTIVE GEOMETRY"
   (C) PARE-LOVING-HILL - "DESCRIPTIVE GEOMETRY"
   (D) HOOD & PALMERLEE - "GEOMETRY OF ENGINEERING DRAWING"

OBJECTIVES - FIRST FIVE SESSIONS

One of the major objectives of the first five sessions of this course is to show these students the role of the engineer - especially his design function - and to convince him of the need and importance of graphics to convey his design ideas. We are dropping more and more of the "technical aspects" of drafting, and many may ask "How can you expect good drafting techniques if you don't teach them?"

I believe you can teach drafting techniques such as lettering, use of triangles and T-squares, etc., and still get poor performance BECAUSE THE STUDENT IS NOT MOTIVATED. I also believe the converse is true. Motivate these students and they will generate reasonably high quality work by themselves or with minimal direction.

A second major objective is the initiation of "Design Awareness". If we can make these students interested in how things work, a serious contribution to their professional development will have been started. At their level of understanding, the use of design components seems the best vehicle for this undertaking. Therefore, I want these students to develop a repertoire of basic components as well as an appreciation of the basic laws of science that govern their behavior.

Next, they should be shown the steps in the design process. Most importantly, I want them to see the role that graphics plays as their prime medium for engineering and design communication.

With respect to testing, I would propose giving them a list of six components on an exam and asking for the identification of any four.

QUARTER II

COURSE SCHEDULE - 09.102

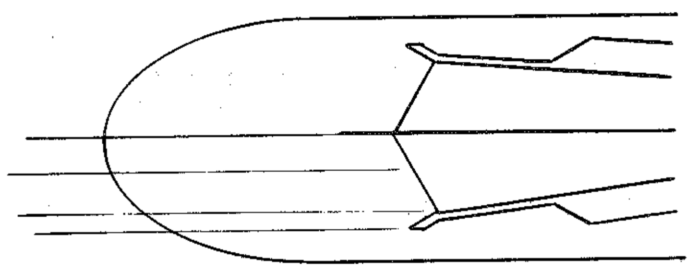
Class	Topic	Assignment
1	PREPARING ORTHOGRAPHIC DRAWINGS Line convention - Alphabet of lines - Scales - Letters - Placement and Choice of Views.	Pg. 24-30,39 Pg. 60-67 Prob. 3-10:3-4
2	ISOMETRIC PICTORIAL Axis - Distortion, offset construction - 4 center method - Curves.	Pg. 76-85 Sheet 81 or Book
3	OBLIQUE PICTORIALS Definition - Types - Cavalier - Cabinet - Distortion - 4 center method.	Pg. 86-88 Book
4	VISUALIZATION Combine descript-pictorial and orthographics to visualize objects - View Graphs/Frency Missing Lines Intensive Work Session.	Missing view sheets
5	SECTIONAL VIEWS Cutting plane-Offset - Half, aligned, full..sections Ribs & Webs.	Pg. 108-118 Sheet 79, Quizzes 09-23 to 09-24
6	DIMENSIONING Crowding - Size - Location - Conventional Procedures	Pg. 124-135 Sheet 76
7	WORK SESSION Part to be Mfg. - Try to pull all of above together, especially dimensioning, to show purpose. Relate to Numeric Control Design Project.	
8	LIMIT DIMENSIONING Types - computations - Tolerance & Allowance	Pg. 136-143 Sheet 77
9	REPRESENTATION OF STANDARD PARTS Threads - Terms - Symbols - Rivets - Bolts - Screws	Pg. 167-193
	PRODUCTION PROCESSES	
1.*	CHAPTER 11 - Metal Casting	
2.*	CHAPTER 12 - Metal Cutting	
3.*	CHAPTER 13 - Production Machines	

*These lectures to be inserted as necessary.

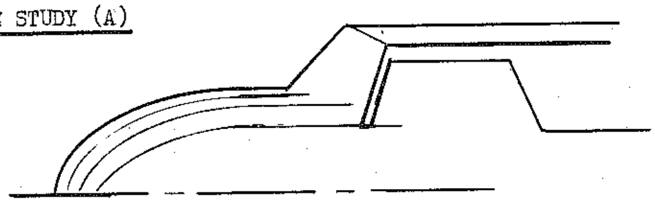
QUARTER III

GRAPHICS - OUTLINE

Class	Topic	Assignment
1 2	INTERSECTIONS Intersections of a line and a plane; a line and a solid; plane and a plane; plane and a solid.	29; 30(1) 32; 33
3 4	DEVELOPMENTS Development of lateral surfaces (plane and curved) and connecting transition pieces.	41,43 44,45
5	DESIGN PROJECT "A": Design windshield; molding strip and canopy, as requested in CASE STUDY (A).	See case study A



CASE STUDY (A)



Class	Topic	Assignment
6	DESCRIPTION OF TERM DESIGN PROJECT - (Individual) (4 total sessions) 1 Statement 2 Progress Evaluation 3 & 4 Presentation	
7	EMPIRICAL EQUATIONS Linear-Linear; Linear-Log, and Log-Log equational forms	56,57,58
8	FUNCTIONAL SCALES Design and calibration of isolated functional scales.	59,60
9 10	NOMOGRAPHS Design of two and three variable nomographs.	SPECIAL 61,62

QUARTER III

GRAPHICS - OUTLINE (continued)

Class	Topic	Assignment
11 12	GRAPHICAL CALCULUS - differentiation GRAPHICAL CALCULUS - integration	65
13	DESIGN PROJECT "B" Instrument an aircraft so that a velocity Vs time plot can be obtained during runway tests as described in CASE STUDY "B". From this plot determine: (a) Maximum brake rate (b) Maximum thrust	SEE CASE STUDY B
14	TERM DESIGN PROJECT - MID PROGRESS REPORT -	
15	MID TERM EXAMINATION	
16	GRAPHICAL TREATMENT OF VECTORS Vector addition - $A_1 = bi + 5j + 3k$ Vector subtraction - Relative Velocity Problem Vector components (orthogonal) - Velocity of a mechanism	SPECIAL
17 18	GRAPHICAL ANALYSIS OF MOTION CASE STUDY "C" CAM DESIGN	SEE CASE STUDY C
19 20	DESIGN PRESENTATION	
21	1966 - 1967 DESIGN SHOW SLIDES	

CASE STUDY B

Our company has been chosen to test and evaluate certain performance characteristics of a newly designed aircraft. Specifically, we have been asked to instrument the aircraft for the purpose of obtaining velocity vs. time information during the runway testing of this aircraft.

We have been advised that the test plan calls for two runs - one at maximum and one at normal thrust. During each run, the aircraft will start from a stationary position with brakes locked and with power (thrust) set just below the static capacity of the brakes. The brakes will then be released and the aircraft will accelerate to lift velocity (140 m.p.h.). On reaching this velocity, he will not take off, but rather he will apply emergency braking procedure. That is, he will deploy a braking parachute and at the same time apply the aircraft's brakes.

Our responsibilities in this matter are as follows:

(1) Design the instrumentation needs to obtain the desired velocity vs. time plot.

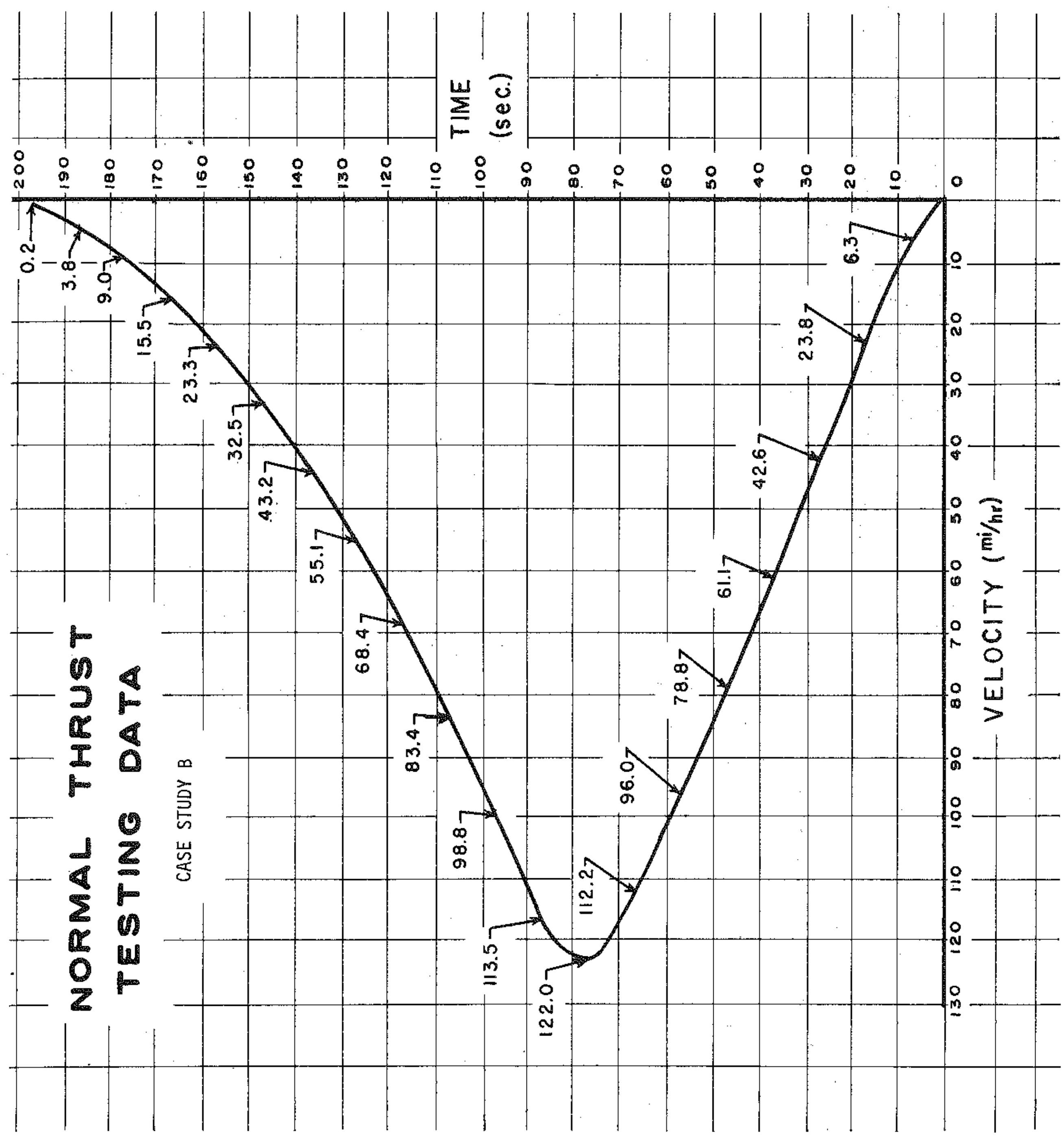
(2) After obtaining the test results (see enclosure) the information is to be analyzed and a report submitted.

(3) Items in this report must include:

- (a) Minimum runway for take off
- (b) Static capacity of the brakes (pounds force)
- (c) Acceleration vs. time curves
- (d) Displacement vs. time curves
- (e) Verbal description of the thrust characteristics of the engines
- (f) Explanation of any abnormal results
- (g) Evaluate the effectiveness of the braking parachute
- (h) Time for engines to develop maximum thrust

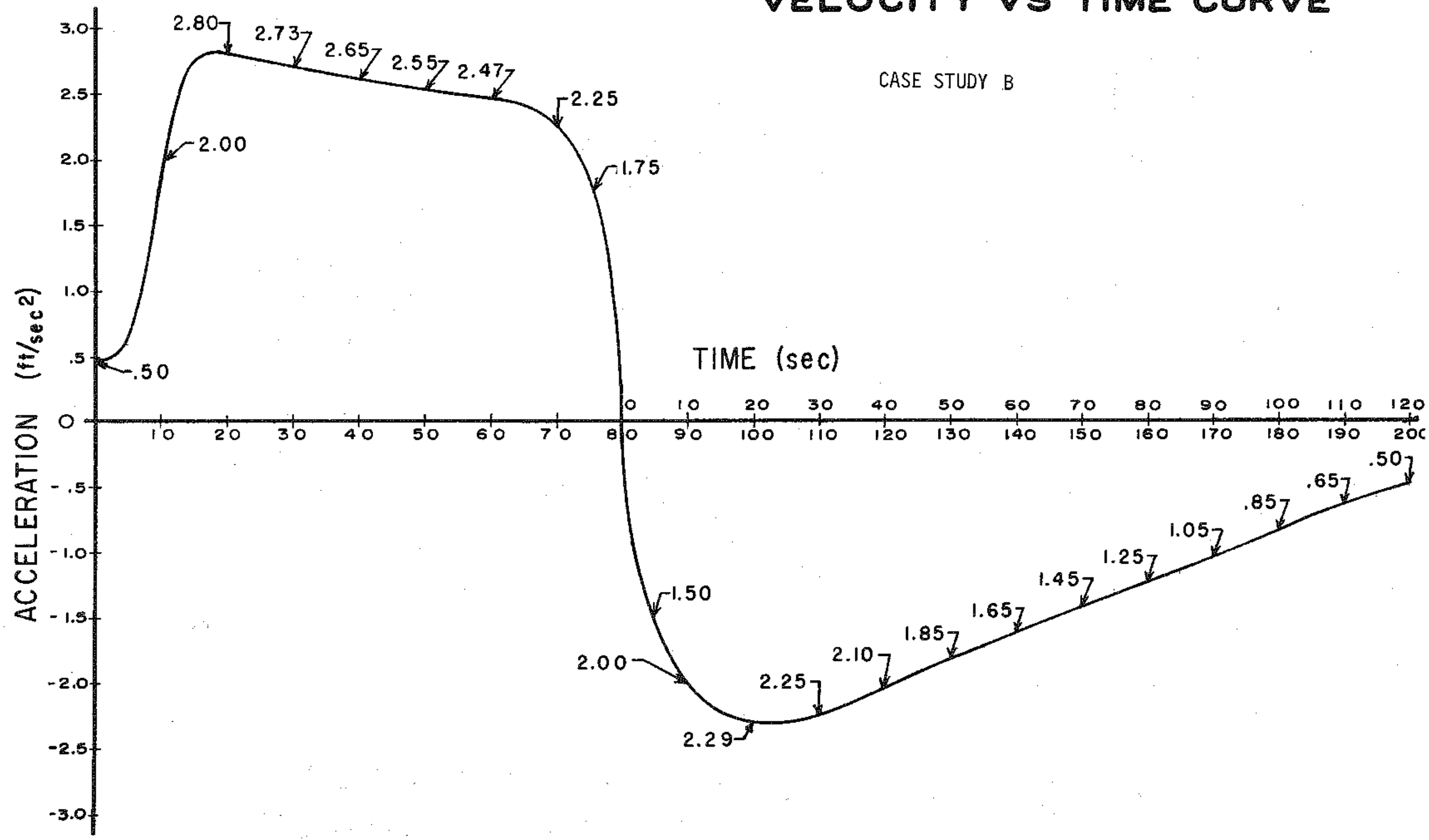
List these items and your best estimate of their value in your report.

Aircraft weight 10,000 lbs.

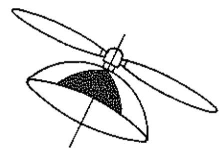

NORMAL THRUST
TESTING DATA
CASE STUDY B
TIME (sec.)
VELOCITY (mi/hr)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100 110 120 130
0.2
3.8
9.0
15.5
23.3
32.5
43.2
55.1
68.4
83.4
98.8
113.5
122.0
112.2
96.0
78.8
61.1
42.6
23.8
6.3

OBTAINED BY GRAPHICAL DIFFERENTIATION OF THE VELOCITY VS TIME CURVE

CASE STUDY B



THE IMPLEMENTATION OF A CREATIVE DESIGN PROJECT IN THE FRESHMAN ENGINEERING CURRICULUM



DR. GEORGE C. BEAKLEY
Professor of Engineering
Arizona State University

For a number of years I have been concerned that we, as engineering educators, have had very little contact with our freshmen engineering students and that we have, in general, turned their academic destiny over to our Liberal Arts colleagues. In their first two years of university work, many well qualified engineering students lose their motivation to become engineers. To me this attitude of indifference for our beginning students is largely responsible for our inability to graduate enough of our freshmen classes to satisfy the needs of industry and business. According to recently released data from the Engineering Manpower Commission, the present insufficient supply of engineering graduates will become even more critical in the years just ahead. I believe quite strongly that we in the universities are not accomplishing as much with our raw material as we should and could. Our efficiency is too low. Let me explain some factors which have led me to draw this conclusion.

In Fig. 1, which has been produced from ASEE data, we can see that nationally our annual graduating class of engineers is only approximately 50% as large as the freshman class had been four years previous. These data do not take into account all of the junior college transfers (and the numbers are substantial) who have entered the engineering educational system during this period of time. I don't know how effective your own institutions are in producing engineering graduates from a given freshman class. However, I do believe that at Arizona State University we are graduating too few of our freshmen engineering classes. Only 30% of our last two graduation classes, for example, have previously been enrolled as ASU freshmen. Although our freshmen engineering classes of 1961 and 1962 were in excess of 400 students each, the 1965 and 1966 graduating classes were in the order of 150 students each.

I know that ASU's experience is not an uncommon one across our nation. All too frequently engineering educators dismiss these data with a shrug of their shoulders or some comment such as, "Engineering is a tough program. The unqualified must be weeded out, and if this can be accomplished in the freshman year --- so much the better. We must have a good system because we certainly are turning out excellent graduates." We seem to accept the premise that every student who changes his mind about engineering as a career is in some way an unqualified student. I do not accept this premise. I believe that a majority of these students change their decision concerning engineering as a career and therefore lose their motivation to spend the required number of hours studying mathematics, chemistry, and other foundation courses.

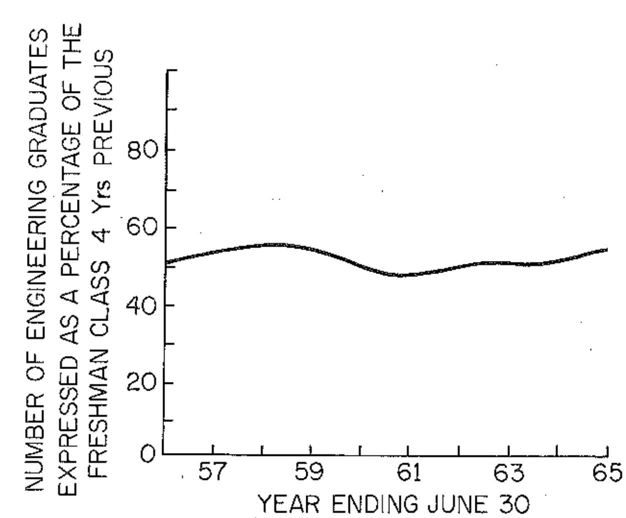


Figure 1. Graduating Class Expressed as a Percentage of the Freshman Class Four Years Previous (For the United States)

Our freshman engineering class at ASU is composed primarily of young high school graduates, over 90% of whom graduated in the upper one-half of their graduating class. Most of them come from the Phoenix metropolitan area high schools, which are excellent in quality. In fact, it is my opinion that these high schools are some of the best in the nation. These students are academically capable of obtaining an engineering degree at any engineering school in the country. For some reason, however, not many of them graduate as engineers. In my opinion the main difficulty is loss of motivation, and a substantial number change to some other academic major by the beginning of the sophomore year. If this exodus from engineering in the freshman year could be diminished substantially, ASU and other engineering schools across the nation could double the graduating classes with no appreciable increases in entering enrollments. It is to this end that our freshman program at ASU has been revised to include a creative design project and a series of lectures that bring vivid descriptions of current engineering designs of industry into the classroom. This course is Introduction to Engineering. This course was organized to give the ASU freshman engineering student an overview of engineering with the objectives of (1) helping him to decide whether engineering is the best career for him or not, and (2) increasing his motivation and commitment towards engineering. No attempt is to be made to "sell" or "promote" engineering but rather a sincere effort is to be made to expose the students to some of the thrills and frustrations that come to the engineer by allowing the freshman student to become personally involved in an authentic design project.

It is interesting to many to learn that our experience has shown that, although helpful, a successful design competition can be carried out without using engineering graphics as a prerequisite. Rather, the students learn the necessary fundamentals of technical sketching as an integral part of the course and specific procedures and techniques of engineering drawing are learned on a "need to know" basis.

For reasons of staffing and room utilization only, we schedule one half of the freshman class to take Introduction to Engineering each fall and spring semester. Each group varies from 200 to 300 students.

For one hour of lecture per week all the students meet jointly in a large lecture hall. The other two hours of recitation-laboratory are spent in 20 to 30-man recitation classes. The joint lecture series includes a few lectures on such topics as creative thinking, principles of engineering design, the engineering method of problem solving, economics in design, and engineering patents. However, a majority of these 50-minute periods are devoted to hearing various engineers from industry describe engineering designs that are in progress in their companies. We have used a number of speakers from industries outside of Arizona such as Boeing, Dow, Ford, Humble, Chrysler, and Dresser. Local industries such as AiResearch, General Electric, Sperry, and Motorola have also made a substantial contribution to the effectiveness of this lecture series. The primary purpose of the lectures is to stimulate the students and to impress upon them the dynamic nature of engineering. We made no attempt to describe the specific work per se of an electrical, mechanical, or civil engineer. Rather, engineering as a creative profession is emphasized. We attempt to recruit dynamic engineers as lecturers who speak with authority and personal knowledge about their designs. An attempt is made each semester to provide a varied assortment or cross-section review of the various industries who employ engineers. In this way the freshmen students can get a glimpse of several different phases of engineering. During the 10-minute break between classes we play stereophonic music, varying from the Beatles to Burl Ives to Sousa to Beethoven. During the playing of the music we project color slides onto a large screen at a frequency of one per 20 seconds. These slides vary from scenic trips in foreign lands to quotations, such as some of the following:

"There is no one right answer to the creative problem." John E. Arnold

"Necessity may be the mother of invention but imagination is its father."

"No one is a creative thinker unless continuously he has a thorn in his flesh." F. S. C. Northrop

"Imagination is more important than knowledge." Albert Einstein

"It is doubtful whether a human being can create without wishing to share his creation." Carl R. Rogers

"Every really new idea looks crazy at first." A. H. Maslow

"Observation, not old age, brings wisdom."

"We do not have to teach people to be creative; we just have to quit interfering with their being creative." Ross L. Mooney

"Originality is just a fresh pair of eyes." W. Wilson

"The well-being of our civilization may well depend upon how successfully we can mobilize our creative manpower."

The purpose of these activities is to sharpen the students' alertness and to put them in a mental attitude of anticipation for the lecture of the day. There are no tests given in the joint lecture and the students learn early in the semester that it is the sincere desire of both faculty and guest speakers that they get a realistic glimpse of engineering as a profession of action. Although a record is made of student absences, such absences are rare, and the vast majority of the students have indicated that this is the most interesting class hour of the week. Frequently non-registered students from other academic disciplines slip into the lectures. This semester, for example, we have several liberal arts students who have regularly enrolled for the course. Advertisement among the students has been by word of mouth only. Extensive use is made of colored slides, charts, graphs, models and other supplementary teaching aids. The students respond with enthusiasm.

Some of the joint lectures are aimed at challenging the students to use the full capacity of their intellectual resources in the solving of problems which they encounter, and especially they are encouraged to apply imagination and innovative thinking in arriving at their solutions. I believe that in too many instances we college professors repress even the slightest indication of creative thought of our students. Unfortunately this tendency begins in the elementary grades and gets progressively worse as the student advances in school. Take, for example, Henry and his high school physics teacher. The teacher hands Henry a laboratory barometer and asks him to determine the height of their multi-storied science building.

The teacher is chagrined when Henry, after thinking a moment, ties a piece of string to the barometer, lowers it to the ground from the roof of the building, quickly measures its length, and then reports his finding as to the height of the building. The teacher tells Henry that he should have known how to use the barometer with certain mathematical calculations to make his determination, and sends him back. Henry thinks a few minutes and then takes the barometer outside in the sunlight. By using a protractor and standing the barometer vertically and noting the length of its shadow and then comparing it with the length of the building shadow, he once again calculates the height of the building and verifies his first solution. At this point the teacher is even more irritated with Henry's efforts and tersely instructs him to use "a scientific method" to obtain the solution and to "do it quickly". Henry spends somewhat more time in deep concentrated thought. Finally he asks for a stop watch and once again he climbs to the roof. He drops the barometer from the roof into a fountain on the ground below. By carefully timing the free-fall of the instrument and substituting into the equation $S = V_1 t + \frac{at^2}{2}$, he once again obtains an answer which verifies his other two solutions. This time the teacher becomes very angry with Henry and tells him that unless he gets the <u>precise</u> answer by <u>the</u> correct method, he will <u>fail his laboratory work</u>. By this time Henry is completely confused and frustrated, and not knowing how else to find the precise answer, he takes the barometer to the basement and trades it to the building superintendent for a set of the architectural and engineering drawings of the building. Within a few moments he is able to give his teacher the <u>precise</u> answer that he had requested. Is it any <u>wonder</u> that the teacher collapses of apoplexy at this point? And I ask you, "Are university professors any less guilty than the high school physics teacher? In too many instances do we not give our students the distinct impression that there is only a single discrete answer to an engineering problem and that <u>only</u> this answer is acceptable for a passing grade?"

Now that you have heard something about the joint lecture portion of the course, perhaps it would be well to explain how and why the remainder of the course has been organized.

I tell the students that engineering design is actually a bridge over the unknown between the resources that are available and the needs of mankind (Fig. 2). The engineer, then, is a creator -- one who uses the resources at his disposal to satisfy human needs. When serving in this role he receives considerable satisfaction and no little thrill when he observes the effectiveness of his designs. That this is so should surprise no one. Man has been created in God's image and as such it is only natural that he should possess within himself a longing and desire to create. You will remember that God was pleased with the results of his handiwork:

> "And God saw everything that he had made, and behold, it was very good."
>
> Genesis 1:31

It is therefore natural for man to find satisfaction and pleasure in his own creative designs. Keeping these basic philosophic considerations in mind, and recognizing that the senior year of engineering study is now considered to be the most satisfying part of the curriculum for the student, we decided that some type of design experience should be introduced at the freshman level.

The freshmen students are told that a syndicate of millionaire industrialists, IDEA, Inc. (Invention Development Engineers of Arizona) is going to invest large sums of money in (1) new products, processes, or engineering designs that will be useful to mankind, and (2) young, dynamic engineering companies that have demonstrated a capability in engineering design. The recitation instructors (As an example there might be 10 such instructors for the hypothetical case of a freshman class of 300 students: 10 x 30 = 300) are the members of IDEA, Inc. Each student is assigned the task of bringing to class an innovational idea of

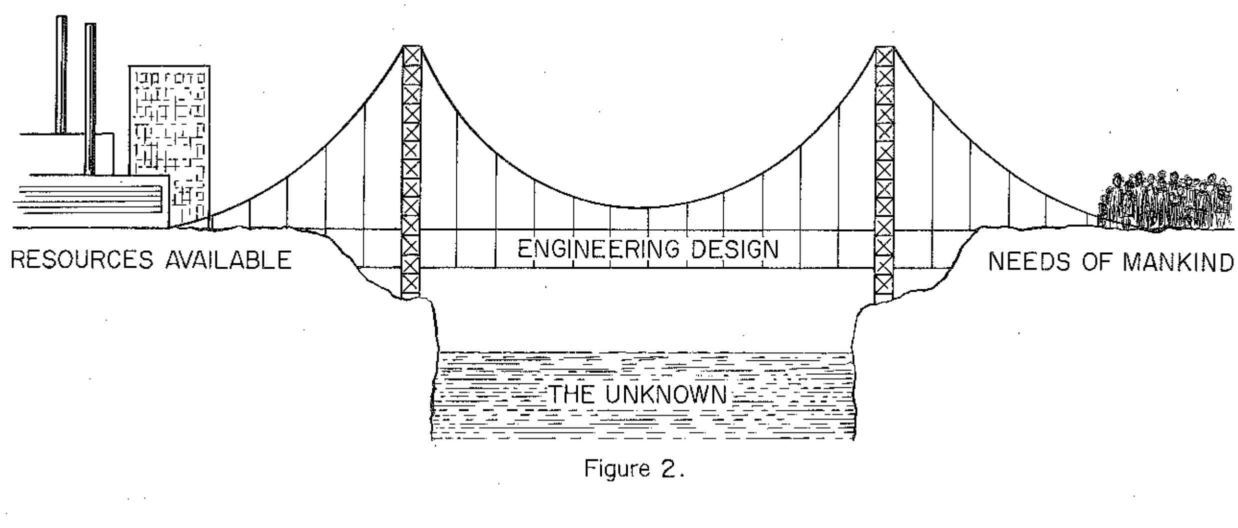


Figure 2.

a needed design which he has described on a single sheet of paper. These ideas are collected and evaluated by the members of IDEA, Inc. and a list of 20 to 30 of the most worthy is published. The students are now told that IDEA, Inc., will accept written proposals from individual engineers whose purpose it is to organize an engineering company to investigate and design (if feasible) one of the selected ideas. The proposals are handed in to the recitation instructors who select the best five in each class. The writers of these proposals are named Chief Engineers of their respective companies. The other 25 students in each recitation section are assigned to these five companies as Associate Engineers. Each company selects a name and organizes itself under the leadership of the Chief Engineer to carry out the proposed design. Approximately one-half of the recitation periods during the semester are devoted to the design and its allied activities. The Chief Engineer is in complete charge of his company during the semester and the recitation instructor (also acting as a member of IDEA, Inc.) assumes the role of a coach. About midway in the semester each company will render an oral and written preliminary design report. Just before the end of the semester each company will turn in a final design report and faculty judges will be brought in by IDEA, Inc. to evaluate the accompanying oral presentations. The ultimate purpose of this judging is to select a winner from each of the ten recitation sections. In the final competition, which is held just prior to final examination week, all students hear the finalists give their oral presentations. A printed program is prepared. For this event, executive engineers (Presidents, Vice-Presidents, Chief Engineers, etc.) from the Phoenix metropolitan area serve as judges. They select the 1st, 2nd and 3rd place winners after evaluating the engineering reports, hearing the oral presentations, and questioning the finalists. It is not necessary for a company to produce a model or prototype to accompany the presentation, but a number accomplish this also.

The basic criteria used by the judges have been:

1. Quality of the technical work
2. Evidence of good company organization
3. Economic analysis
4. Communication

To win it is not necessary that the company present a "positive" conclusion with regard to the feasibility of investing money in the design. In fact, they may recommend to IDEA, Inc. that their analysis shows that the venture would involve a loss of money rather than netting a substantial gain. Remember that IDEA, Inc. is seeking competent engineering companies --- not overly optimistic engineering companies.

Some of the designs that have been investigated these past two semesters are:

Keyless Locks
Tire Pressure Equalizer
Three-dimensional War Game
An Auto Rangefinder
A Cooling and Heating Blanket
Pre-programmed Television
Carbon Monoxide Detector
Auto Usher
Skip Incline Loader
Electric Motor Brake
An Automat Haircutting Machine
An Alarm Clock for the Deaf
Automatic Bricklaying Machine
Pulse Rate Measuring Instrument
Bicycle Automatic Transmission
Portable Magnetic Tape Typewriter
Perpendicular Parking Device
Brake Rate Indicator
Solar Pool Heater
Emergency Vehicle Detector

Teaching the freshman student is a difficult task if done properly, and it usually is more demanding than teaching the senior student. In my opinion most seniors will graduate in engineering regardless of the competence of the faculty, but this is by no means true of freshmen. In the years past, the teaching of freshmen students commanded little glamour or prestige in academic circles, largely because of the type of material that has been relegated to this level and to our general attitude that "most of the freshmen are not potentially competent to be engineers anyway." I believe to a large degree the effectiveness of our freshmen creative design program at ASU has been enhanced by our attracting as class instructors several faculty of professorial rank who normally teach only senior and graduate-level work. Their enthusiasm has been genuine and this reaction has been respected by the remainder of the faculty. Even so, a number of our faculty believe as strongly as ever that "It wasn't necessary to motivate me to study engineering and these students shouldn't be treated any differently today. What we need is more course-work at the senior level--not the freshman level." A number of this group have changed their opinions, however, as a result of their contact with the program. This has been particularly true for some of those faculty who have served as semi-finalist judges.

Our experimental work in the motivation of freshmen engineering students is by no means easy to evaluate in its effectiveness because we can never know what the results would have been had we not implemented the program. Certain indications however are interesting to contemplate. According to an anonymous questionnaire which the students completed at the end of each semester over 70% of the students have indicated that the course has had a positive motivational effect upon their selection of engineering as a career,13% indicated a negative motivational effect, with 17% indicating no opinion. Where formerly only 40% of the freshmen students continued in engineering for at least the sophomore year, this year the percentage was up to 60%. Where formerly engineering suffered a large transfer loss to physics, chemistry, mathematics, business administration, and other on-campus curricula, this year's loss to all other disciplines was only 12%. (The other 28% have withdrawn from ASU.) One fact, however, is hardly debatable. If perchance there has been no academic value whatsoever to our experiment, it has still been very worthwhile from the standpoint of improved public relations --- with the students, and with both industry and the general public.

Some general conclusions can be drawn concerning the use of the creative design project:

(1) The competition between the engineering companies is wholesome, and it promotes the enthusiastic participation of the students.

(2) The selection of design projects that the students themselves have previously originated seems to add considerable interest to the entire semester's work.

(3) The design project has stimulated a majority of the freshmen students to explore more phases of engineering on their own initiative.

(4) Freshmen engineering students are now anxious to consult with members of the engineering faculty concerning their design projects. Formerly these beginning students have been reluctant to enter a professor's office for any purpose.

(5) The students have indicated that they were both amazed and delighted to learn that engineers spend a considerable portion of their time working with people.

(6) The recitation teacher must remember his role as a coach and refrain from directing the activities, assignments, and designs of the student companies.

(7) Balancing of the personnel of the student companies (age, interest, sex, etc.) is a very important factor.

(8) It is unlikely that the student companies will be successful in developing their designs much further than the conceptual stage, but the students should never be told this.

(9) The students experience to some degree both the typical frustrations which beset engineers and the more pleasurable sensations which are associated with the design process.

(10) The initiative of the company Chief Engineers is a very important ingredient in the overall success of the program.

(11) Weekly student company Progress and Utilization of Manpower reports should be required.

(12) Extra awards (such as money, medals, certificates, etc.) to the winning companies do not contribute any noticeable incentive to the students.

(13) The lack of student proficiency in the techniques of engineering drawing is no appreciable handicap to the overall effectiveness of the program.

(14) Although interest is high, the students do not spend an inordinate amount of time on their designs to the detriment of their other courses.

(15) The joint lectures and the use of guest speakers from industry form a very important part of the course.

(16) The use of music, slides, and other extra curricular activities during the class break stimulates student interest.

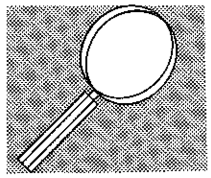
(17) The use of engineer judges for the semi-final and final competitions adds realism to the design experience.

(18) The present organizational structure of the course, Introduction to Engineering, including the creative design project, can be used with equal effectiveness for a small number of students (20 to 50) or for a large number of students (500 to 2000).

(19) The importance of an engineer's ability to communicate is vividly demonstrated to all in the semi-final and final design presentations.

(20) The inability of the student companies to complete their engineering designs emphasizes all the more to the students the importance of a broad and fundamental base of science and engineering science for all students. The students have indicated that this experience has provided them with an appreciation and understanding of the importance of such subjects as mathematics, chemistry, engineering mechanics, engineering materials, electrical networks, and fluid mechanics as required parts of their engineering curricula.

THE OBJECTIVE EVALUATION OF A DESIGN PROBLEM



WILLIAM B. ROGERS
Lieutenant Colonel, Corps of Engineers
Associate Professor, Department of Earth, Space and Graphic Science
United States Military Academy

It is a fairly simple procedure to determine the degree of absorption and extent of retention of compartmented subject matter which has been dispensed in carefully measured portions. Tests of considerable validity and objectivity can be prepared which will accurately measure a given student's ability to regurgitate his knowledge of projection theory, dimensioning techniques, sections and conventions, manufacturing operations, etc., considered separately, at a given moment in time. The design problem requires the student to dip into the whole of his knowledge and experience and intelligently combine and apply pertinent aspects of this knowledge and experience to an interdisciplinary situation. Where knowledge and experience are lacking, independent study and research become necessary. The instructor evaluation of the student design problem solution is an attempt to judge the total quality of the student's ability to stretch his imagination, utilize his education and training, and apply his skill in communicating an idea.

Where only one instructor and a small group of students are involved, the grading problem is not too difficult and may be largely subjective. Where many students are taught in several sections by different instructors, some procedure must be followed which is consistent, objective and administratively workable.

It is doubtful that the individual personality factors of the several instructors can ever be completely eliminated. There will always be the "good guy" who thinks every day is Christmas, the "hard nose" who never gave an A and never intends to, the "anti-draftsman" who will accept a clever idea outlined in blackberry jam on a dirty napkin, the old line "draughtsman" who would have rejected the invention of the wheel if not rendered in ink on neatly bordered vellum, and the "half time researcher" who solves his grading problem by tossing the reports down a flight of stairs and awards the highest grades to those falling on the lowest tread. Unless these individual idiosyncrasies of evaluation are reduced to the minimum, the students are going to be cheated in their only immediate tangible reward, the grade.

Objectivity in grading is dependent upon three conditions:

1. Use of a common evaluation procedure.
2. Frequent communication and comparison among evaluators.
3. Coordination and control by a qualified and recognized authority.

"Santa Claus," "Simon Legree," the "anti-draftsman," the "old eccentric," and the "busy researcher" must all be tuned to the same frequency. They should talk to each other once in a while about their mutual grading problems and compare results. And, they must be subject to a single authority who can convince, coerce, or command compliance and cooperation.

In establishing a common evaluation procedure several questions must be considered. First, the grading problem must be defined; what is the purpose of the evaluation? There are numerous reasons for grading student work and several generally accepted methods of "keeping score" and reporting for permanent record the results of grading. It will be assumed that comparative grades will be assigned to this problem. The purpose of the evaluation, then, is to make an objective comparison of the work of all students and to establish an accurate order of merit from which an equitable numerical or letter grade can be determined. Second, what are the elements to be considered in judging the solution? Several general questions must be considered in evaluating the solution to any design problem, viz: Will it work, and does it meet the specifications stated in the problem? What will the finished design look like; will it have a pleasing appearance and harmonize with its surroundings? Can it be made? Can it be economically manufactured in the quantity required? Is the drawing (or sketch) adequate to portray the idea? Simply stated, the three principal elements of the solution to be considered by the evaluator are function and appearance, manufacturing requirements, and graphical presentation. If a fourth element, oral presentation, is required, and it is certainly recommended, how well does the student designer "sell" his idea. If an oral presentation is not feasible, the instructor's subjective evaluation may be substituted. What is the evaluator's overall impression of the design? Finally, how should these factors be "weighted" relative to the total numerical raw score value of the problem? The answer to the last question must be based on a judgment of the students' progress and estimated capabilities, the points of major emphasis during instruction preceding the problem, and a consensus of the relative importance of the elements of the solution.

The next step in the objective evaluation procedure is to prepare a grading guide to be followed by the several instructors in evaluating the elements of each solution. The type of problem will certainly affect how simple or detailed a grading guide must be and how the different elements of the solution are weighted. The problem may require the student to design a simple one or two piece item well within the scope of his past experience. The problem may require the design of several simple mechanical parts, such as shafts, bearings, gears, cams, links, etc., and the relating of these parts to perform a certain function. This is a more complicated situation, but the design of each of the separate parts and the function of the combination are within the scope of the student's past experience and understanding. A third type of problem may require the student to design a device to perform some function completely outside the realm of his past experience utilizing both familiar and totally new ideas. While a grading guide must be organized and applied somewhat differently for each type of design problem, the principles are the same. The grading guide must make allowance for and equitably compare: a good idea, poorly presented; a drawing of high quality representing an unworkable solution; and a solution expressing an imaginative idea with an acceptable presentation, but of a design so difficult and/or expensive to manufacture as to render it impractical; and any other less than perfect solution. The grading guide must yield uniform results, within reasonable limits, when applied by each of the evaluators to a given solution. The guide must be equally applicable to both the few superior solutions, and the few very poor solutions as well as the wide range of "average," above average, and below average solutions between. The guide must not be so rigid and inflexible that exceptions cannot be made where the student solution is so obviously outstanding or so totally unacceptable in some respect that strict application of the grading rules would unfairly penalize or reward extreme cases. It must permit the evaluation of a given solution to be recreated and justified to the student, on demand, by any of the evaluators.

Here follows an example of a simple one or two piece open end design problem,and a possible grading guide prepared for this problem:

> A row of fifty flagpoles is to be erected along the inside walls, twenty feet above floor level, of of a large ballroom in such a manner that the axis of each flagpole makes an angle of 60° with the vertical masonry wall. Each flag is to be mounted in separate, but identical, socket-brackets spaced ten feet apart. The flagpoles are made of wood, 1 1/2" in diameter and 9'long. The poles will be supplied without ferrules on the lower end. Each pole is to fly a cotton drill flag approximately 5' by 7'. The socket-brackets will be attached to the wall by lag bolts set in masonry anchors. Poles must be securely fastened in the sockets but easily removable. Design a suitable socket-bracket to meet these specifications.

Figure 1, next page.

It might be argued that the "subjective evaluation"element included in the foregoing is self-defeating; that this brings objectivity right back to throwing the papers down the stairs! A good grading guide, conscientiously applied, will certainly increase objectivity in grading a design problem, but even the "best" guide must be tempered with human judgment. The evaluation of a design problem might be compared with wine tasting. A small quantity of the wine to be judged is poured into a clean glass, its color admired, its bouquet savored, and finally the sparkling juice is exposed to the taste buds. Judgment is passed, and the wine is categorized. An objective test? Perhaps not! But, when the wine taster is a connoisseur, might not his experienced judgment prove a better evaluation of the total quality of the wine than a classification based only on a scientifically objective analysis of the ingredients of the winemaker's recipe for fine wine? The instructor's experience and his intimate knowledge of his students must never be devaluated by blind adherence to inflexible rules.

The last two conditions, communication-comparison and control-coordination, deal with the human relationships of the grading problem. The different instructors assigning and grading the design effort must communicate among themselves, before, during, and after evaluation, and must be willing to submit the results of their evaluation for review, comparison and possible modification by a senior arbiter. This idea may mangle the myth of "academic freedom" cherished by a few campus aesthetes, but should not disturb the disciplined professionals of the engineering college. When large numbers of students of widely divergent aptitudes and abilities and several instructors with varying experience and interests are involved, the only approach to objective comparison of student open-end design problems is through a common evaluation procedure, communication and comparison between evaluators, and coordination and control by qualified authority.

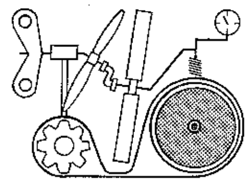
After a numerical raw score has been assigned to each solution, the raw scores must be converted to a form for reporting for record. Converting the numerical raw score to a percentage or letter grade can be most easily accomplished if a raw score histogram is plotted. The histogram for 900 to 1000 raw scores should approximate a normal distribution curve. Major deviations from a normal distribution curve suggest an investigation into the relative difficulty of the requirements, the manner in which the problem was presented, and the conditions affecting the students during the time allowed for solution. The problem may be too easy or too difficult for students at their current level of achievement. Insufficient time for solution or other heavy demands on the students' time will affect the shape of the curve. Conversion from raw score to percentage or letter grades should not be governed by fixed percentages or by other arbitrary rules, but must be made only after due consideration of all the factors. In some cases a very high percentage of high grades and no failing grades may truly reflect student achievement. In other cases, the top grade may not be given at all, simply because nobody has earned it. This is the time for giving and taking away the grade. If the manipulator of the grade conversion hears sleigh bells and awards a Christmas A to a large percentage of the total class, or if generally poor work forces the grades to range from C down, on a given problem, then the relative position of all the A, B, C, D, and F grades remains constant with all students being equally rewarded or penalized. This is about the nearest approach to objectivity that can be expected.

	Maximum Raw Score Value
FUNCTION and APPEARANCE	
Will the socket accept and support the pole and flag?	10
Is a means provided for securing the pole in socket, and is pole easily removable?	5
Are mounting holes provided and sufficient for mounting socket-bracket on the vertical masonry wall?	10
Will the finished product be pleasing in appearance and compatible with surroundings?	5
MANUFACTURING REQUIREMENTS	
Is fabrication feasible?	10
Can 50 socket-brackets of this design be economically produced?	10
GRAPHICAL PRESENTATION	
Is the exact shape of the object completely described?	15
Are the dimensions and notes adequate and sufficiently complete for construction of the socket-bracket?	15
Is the drawing (sketch) of professional quality?	10
*SUBJECTIVE EVALUATION	
Evaluator's general impression of total solution. These percentage points may be awarded as a bonus for superior work, withheld for minimum effort or as a penalty for late submission, etc.	10
TOTAL RAW SCORE	100

*Used in lieu of an ORAL PRESENTATION

Figure 1 - Grading guide

THE EVALUATION OF STUDENT CREATIVE DESIGN PROJECTS



ERNESTO E. BLANCO
Associate Professor
Tufts University

Introduction

Responsible teachers are characterized by their high degree of thoroughness, fairness, and objectivity in the grading of student works. They tend to feel uneasy when the grading procedure cannot be performed in a clear cut objective manner.

The grading of engineering design projects represents a typical case of very complex evaluation procedures. A great number of factors have to be weighed and analyzed before a conscientious value estimate is achieved.

The objective of this paper is to propose a series of guiding principles to help develop a grading attitude or approach, and thereby to simplify the task of evaluation.

Goals of Creative Design Projects

Evaluation implies comparison against an established standard. Before any evaluation is performed the standard has to be defined. In the case of design projects the standard is established by the educational goals of the projects.

The goals pursued through the involvement of students in creative design projects can be enumerated as follows:

a) To develop a constructive dissatisfaction with existing technological approaches.

b) To stimulate awareness of possible technological solutions to the problems of society.

c) To develop familiarity with all phases of the creative process as it relates to engineering design.

d) To develop proficiency in applying scientific and empirical knowledge to the analysis of engineering concepts.

e) To develop fluency in the uses of the graphical medium, both in communication and in analysis.

f) To develop familiarity with the preparation and presentation of professional engineering projects.

Many more items could be added to the list but the enumeration presented is enough to provide a frame of reference, or standard, to help perform fair and consistent evaluations.

Needless to say, the weight, or value, given each of the items during grading would depend on the importance attached to them during formal lectures which, in turn, depends on the individual organization of each course.

Assignment of Value for Grading Items

Assuming equal weight for the basic items we obtain the following value assignments:

The first three items could safely be grouped together under the heading of "Creativity" and assigned a value of 25% of the total grade.

The fourth item could be called "Engineering Analysis" and assigned a value of another 25%.

The fifth item deals with the use of graphics and could be evaluated under the heading of "Graphical Competence" and assigned another 25%.

The sixth item will be termed "Presentation" and assigned another 25% of the total grade.

As was pointed out before, the value assignments often have to be altered to give greater weight to some items. In grading the initial projects greater emphasis will probably be placed on the creative aspects, i.e., identification of need, writing of task specifications, development of concepts, and thoroughness of problem research.

Once the material on basic graphics has been covered in lecture a shift on emphasis will take place and more value should be given to the item of graphical competence.

The first project should not be graded too heavily on presentation since students do not yet have a clear idea of what is expected of them, however, enough critical observations should be made to insure a near professional presentation in all following projects. After the first project, students should be informed in no uncertain terms that in the future the presentation will be graded ruthlessly. Good organization and clear, neat presentation are essential to develop good professional habits in the students. If presentation is not emphasized enough, the student reaction will be to become sloppy and loose all respect for the course. In the student's mind good discipline and course quality are often equated.

Evaluation Methodology

What has been said before pertains to the establishment of the standard of comparison. We shall now turn to the more elusive aspects of the evaluation procedure, namely, how to determine the degree of compliance between the student's work and the expected performance.

Expected performance is in itself somewhat of an abstraction. We shall try to define it here as the teacher's estimate of top student accomplishment within a given course organization.

Most experienced teachers tend to be realistic about what to expect from students under a given system, but in case of uncertainty, it is better to be slightly on the demanding side than to succumb to student compassion. Let us not forget that the student is being trained to perform in the real world and that his future professional success will depend greatly on the effectiveness of his preparation.

In all fairness student grading should be based on the effectiveness of teaching and not on the teacher's expectations, but teaching effectiveness is also hard to estimate.

A practical method for estimating top performance level on a given assignment consists in examining the work of a whole class and selecting the top 5% of the papers as an approximate standard. That does not necessarily mean that 5% of the class will get 100% as a grade, but it will give the teacher some idea of the system effectiveness and therefore enable him to establish more realistically the expected level of performance. If the results are unsatisfactory it will then be the teacher's responsibility to improve his methods or reorganize the course.

Once the top performance level has been established the grading can be performed as a function of the student compliance with the standard.

Comments on Grading Creative Design Projects

Grading is not only an intended means for the reward or punishment of student performance. It is also the most effective feedback element in the teaching process. It serves to evaluate teaching as well as student performance.

The grading procedure should be treated as an integral part of the teaching process. When the grading operation is accompanied by appropriate comments on the papers the effectiveness of teaching is enhanced and the students' mistakes are seldom repeated. Students' papers should be considered as personal vehicles of communication between them and the instructor; almost approaching a tutorial level.

In the case of creative design projects every effort should be made to appreciate and help develop the student's natural creative ability. Comments regarding individual creativity should be considerate and helpful, stressing the positive aspects, rather than emphasizing the shortcomings.

In this type of project it is most important to encourage and reward the unusual approaches, the novel departures from conventionalism, and the grading methodology has to be adjusted to such principles.

NOTES ON SOLUTIONS OF STUDENT DESIGN PROJECTS

DR. HENRY O. FUCHS
Professor of Mechanical Engineering
Stanford University

"It is not where you go that counts but what you do along the way." Whether this saying of a Chinese philosopher is or is not true for human life in general is a matter for theologians to debate, but it certainly is true for the solutions to the design problems which we give to our undergraduate students. No matter what it is that we ask them to design we don't really care whether it would work well or not, and furthermore, we can't tell without executing and testing the design. If you don't believe this let me remind you of some automobiles which are excellent designs, but have been accused by some of being negligently deficient designs. I will also confess that I recently designed a stepladder and after building it found out that it should have been two inches greater in width to let me sit on it. We cannot really tell whether a design as a whole is successful or not without trying it and we do not have the time and facilities to build and test our freshman designs. Therefore, we cannot consider the successful product as the objective of our design solutions even if we would want to do it. But we can and do expect our students to learn a great deal by what they do along the way.

Let me use a simple example to explain more clearly what I mean. Black walnuts are our problem. We want to get at the meat but the shell is very hard. A class of freshmen came up with three dozen different solutions to this problem which ranged in complexity from a hammer and anvil, suitable for use at the dinner table, to devices which included hoppers and motors and cams and latches. In going through this exercise they may or may not have learned a good way to get the meat out of black walnuts, but they certainly did learn a great deal of other things.

They learned that before they can solve a problem they must define it. They must decide whether this device would be used in homes or in factories; they must inquire about imitations of size, complexity, and cost. They must do some experimental research to find out what it takes to get the meat out of the shell and they learn, in this research, that the data they will use in solving the problem are only approximate. Next they learn to use their creative abilities. We try to help them to loosen up so their ideas can flow more freely, and we insist that they should come up with more than one preliminary idea for the solution of the problem. We consider this to be so important that we would rather see five bad ideas coming from one student than a single good one. Of course five good ideas would be even better.

A man full of creative ideas is not necessarily a good engineer. He must be able to analyze and to evaluate his own ideas -- can it be made? can it be assembled? will it be pleasant to use? will it be safe ? is it strong enough? -- all these must be considered. The questions which should be considered must be found and must themselves be separated into groups of more important and less important questions. Criteria for the evaluation of the preliminary ideas must be developed by the student and he must proceed to the first iteration in which he improves one or two of his original ideas after comparing them to the criteria which he has set and on which we have agreed. We consider the iteration a very important ingredient of design and emphasize it by asking for a further iteration later on in the project.

In order to get as far as this a student has to communicate his ideas to himself and to record them in some way so that he can iterate. To do this he used a crude method of sketching which he may have learned in kindergarten and the additional sketching skill which we have practiced with him meanwhile in the graphics course. We now ask him to communicate his design by means of more formal sketches of the whole and by detailed drawings from which a mechanic might make parts. Detail drawings, by the way, are required of only a few parts, not necessarily of all those which make up the device. The student now learns to draw. He tests his skill by submitting the drawing to the instructor who looks them over and returns them with a request for a second iteration. At this point the student invariably wants to"explain" his drawings by talking and waving his arms. We tell him that we cannot permit this because adequate reproducible communication is a necessary part of designing in today's world where the conception of an idea and its execution may be separated by hundreds of miles. We also explain that we can see more of his design by spending a few minutes looking over his drawings than by spending hours studying his written description.

Before he has turned in his final set of drawings the student has learned a great deal about graphic communication -- about disciplined creative thought -- about the problems of problem definition -- about the necessity of iteration -- and very likely, has also improved his ability of space conception in the process.

The most important insight and skill which we hope the student has learned from this design exercise is the achievement of results by the use of available abilities and means. The student is aware and we are aware that he does not know nearly enough for a complete and perfect solution of the given problem. He learns that he cannot wait until all of the data have been collected and all the skills have been perfected, but must come up with a solution on a deadline. In this he is no different from engineers who constantly are faced with problems which must be solved with insufficient knowledge and all too limited skills.

What I have explained may sound like the design process or the methodology of design and you may ask why we do not simply tell the student that this is the method and ask him to learn it like he learned the laws of refraction of light. The answer is simple. We do not believe that design is a process which can be programmed on a computer, or carried out by following instructions. We believe that it is an activity which makes high demands on the human qualities of imagination, perserverance, critical analysis, intellectual integrity, and allowance for the shortcomings of the rest of humanity to whom the design must be communicated in a manner which they, with their limited abilities, can understand. The prime example of a person with limited ability to understand is of course the teacher, and my function of demonstrating this to the student is one role at least in which I always succeed.

THE DESIGN SOLUTION

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University of Washington

To complement Professor Fuch's discussion on what an individual student is expected to learn from participating in a design project, this discussion is directed to grading the individual student. It is assumed that his grade should be based on the evaluation of the project as well as his individual performance. Therefore, the following paragraphs outline in detail a method of evaluating a student's efforts, his performance and what he has learned in solving a design problem.

Background

The individuals referred to in this discussion are second-quarter freshmen engineering students at the University of Washington. Approximately 400 of them (25 to a section) do a three and one-half week design project in their second engineering graphics course. The project usually occurs in the middle of the quarter so the students can receive "live" feedback on their project efforts from their instructors.

Evaluation During the Project

One basis for evaluation each student in a design group is established early in the project. Following the NEED IDENTIFICATION and DEFINITION OF GOALS, the group chairman must submit a statement of each member's preliminary assignment for RESEARCH and his responsibility for specific portions of the TASK SPECIFICATIONS.

Another measure of a student's efforts is his activities log. A sample entry in a typical log is shown in Figure 1.

Sample Log

DATE	DESCRIPTION AND COMMENTS	TIME SPENT
4/27/67	Library Research - (Engineering Branch)-sought information on ball bearings - used card catalog - librarian (Mrs. Russo) showed me several manufacturer's catalogs - used TORRINGTON'S CATALOG	1 HR

Figure 1

He is told that his log should read in "newspaper" style; that is, it should tell what, when, where, why, who, how, results, etc. The time spent is to be recorded, also. The students are cautioned that it is just as serious to exceed the time they have available (25 to 30 man-hours/man) as it is to not use it.

After the IDEATION, CONCEPTUALIZATION and ANALYSIS steps the groups have private meetings with their instructor. At that time each member is required to report orally on what he has done, what he is doing, and what he is scheduled to do. (During longer projects, for example ten weeks, it is suggested that each member be required to give the group's report at weekly private meetings. Each member could also be required to submit a weekly written report.) Each member, including the chairman, is required to submit his log for preliminary checking.

Oral Presentation

Each group must present an oral report of their project and each member must participate in the presentation. The report is given to the class and invited guests. The skill in which the students field questions is a measure of how involved they were in the project. (Questioning is much more lively from the students if all the groups pursued the same problem.)

Final Report

In addition to requiring that each man's assignments be clearly defined and that his activities log be submitted, each student is required to write a page of comments and criticisms on the project. For example, he is asked to comment on the value of the project to him, suggestions for further projects, suggestions for alternatives to the solution of the group (this allows "loners" to exhibit their ideas) and criticisms of the project.

One further requirement is that each student must "totem" the others in the group. That is, who was most effective, next effective, etc.

Grading

Each student is given the group grade plus his individual grade. Group chairmen are given 15% of the group grade as a bonus. An example of the grading for a four-man group is shown in Figure 2.

Example Grading

Group Grade	= 80/100 : B		
Member A	= 60 + 80	= 140/200 : C	
Member B	= 85 + 80	= 165/200 : B	
Member C	= 95 + 80	= 175/200 : B+	
Chairman	= 90 + 80 +12	= 182/200 : A	

Figure 2

Each grade is based on 100 points and the usual results are that no individual grade deviates more than one letter grade from the group grade.

Written comments by the instructor are made on the group's efforts (letters, readability, sketches, organization, oral presentation, drawings, evidence of utilizing the design process, planning, and time budgeting). Written comments are also made on individual efforts (logs, comments and criticisms, oral presentation and observed cooperation). The "totems" are used essentially for confirmation of extreme cases of poor performance or excellent performance. The students have a final critique session with their instructor to go over the comments.

Testing

To measure how much of the design process each individual has absorbed a closed-book written test is given. Each student is required to discuss in detail how he would go about solving a design problem. He isn't expected to solve the problem, but to just indicate the steps he would take to solve it. He would be evaluated on the types of questions he posed, where he would seek information, what planning and decision making techniques he would employ, how he related his discussion to the Design Process, etc. (Case studies can be used very effectively for test questions.)

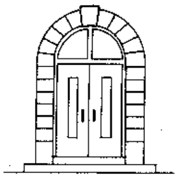
Preliminary Quiz

It should be noted that before the project portion of the course is initiated a short design question is given to the class as a quiz. They are asked to describe how they would go about solving the problem. This compared with the test can be used as a measure of how much each student learned during the project not only by you but most importantly, by him.

Conclusion

Evaluating students is not an easy task; however, the job can be spread over the duration of the project by using the methods described above.

THE WORKSHOPS



Material Edited by

KLAUS E. KRONER

Associate Professor, Basic Engineering

University of Massachusetts

One of the stated purposes of the Summer School reads:

> "To give educators intense coaching in curriculum planning, writing of case studies, writing of design projects, and the role of graphics in design education."

The "intense coaching" was amply provided by the program planners in the workshops which were scheduled on two successive afternoons. Participants were pre-assigned to one of eight workshops. With this number of groups their size could be kept to approximately fifteen persons, a procedure which assured active individual participation in the discussions and tasks. In these sessions the participants assumed the role of the student under the supervision of an experienced teacher.

The leaders in each workshop had been carefully pre-selected for their experience as teachers in design oriented graphics education. These eight highly capable men were:

Ernesto E. Blanco
Tufts University

Peter Z. Bulkeley
Stanford University

William S. Chalk
University of Washington

Alan K. Karplus
Western N. E. College

Borah L. Kreimer
Northeastern University

Ronald J. Placek
University of Illinois

William B. Rogers
U.S. Military Academy

Wilfred P. Rule
Northeastern University

Much of this material in this chapter was obtained from the notes which were taken by observers in the various workshops and from comments which the leaders offered subsequent to the program.

Procedure

The general pattern followed in all workshops during the first afternoon included an expanded discussion on the various aspects of the "Design Process" which Professor Percy H. Hill key-noted during the first morning session. Particular emphasis was given to certain steps of the process, namely:

1. Identification of need
2. Definition of goal
3. Task specifications
4. Ideation
5. Conceptualization

When assigning a design project, instructors should encourage students to outline each of these steps.

The leaders then asked the participants to offer some ideas for design problems which might be given to engineering freshmen for solution. It became evident from this phase of the program that there is no limit to the possibilities of projects. It had to be kept in mind, however, that the scope of the problems should be kept within the capabilities of freshmen whose knowledge of engineering concepts, materials, mechanics, and higher mathematics was limited. (Many of these suggestions are listed and discussed in the next chapter).

From this list of ideas, each workshop group selecte a few specific problems and proceeded to identify the need, and to express the goals for them. The workshop leaders stimulated these deliberations and gave proper direction to the progress of the design process. When each group had finally agreed upon a write-up of these steps, the work was submitted to another workshop group to continue with the design process on these projects.

The main concern during the sessions on the following afternoon was to write the task specifications and to progress further on this design concept. For this purpose the various workshop groups exchanged projects, so that on this second day every one was working on something new. Furthermore, three to five-man teams were established, and each team was expected to work out its own task specifications. It was stressed that in actual classroom situations this approach would produce the best educational results.

Thus, participants gained an intimate knowledge of the step by step approach to a typical design project in an educational framework. Since the workshop sessions were limited to two afternoons, the other steps in the design process were not carried out. Their significance had of course been explained by Professor Hill in his introductory presentation earlier in the Summer School program. Some of the projects actually considered during the conference are described in detail in the following chapter.

The Design Concept

Throughout the workshop sessions, the leaders interspersed their own ideas and philosophy on this method of introducing engineering freshmen to the concept of design while at the same time teaching them the fundamentals of graphical communication within an engineering environment. As an example, Professor Bulkeley pointed out that in evaluating a student's work, it is the problem-solving process rather than the actual design details which should be scrutinized. He commented further: "So long as a problem solution is realistic physically, i.e. so long as its proportion and the relative proportions of its parts are reasonable, and so long as no physical law is violated, the problem solution is taken to be acceptable. What I prefer to look at is the way in which the students approach their problem. Was it well defined? Were design criteria well outlined? Were a variety of problem solutions considered?"

The most valuable experience for the student is gained by conceiving and carrying out an original design idea, either alone or as part of a team effort. Care must be taken in setting up the problem in a way that a student's freedom in his choice of solution will not be restricted. With such open-ended design problems, the freshmen learn not only the successive phases of the design process but they are also trained to communicate with a new tool -- GRAPHICS.

Professor Chalk let his group assume that they were members of an R & D department of a manufacturing company assigned the task of developing a new product line for diversification. Such simulation, he explained, adds a sense of realism to a design situation. It is also good practice to require, at least with some assignments, prototype models. These, it must be recognized however, take up a considerable amount of time and student teamwork should be encouraged for such efforts.

A major objective of a graphics course should be communication, Professor Karplus commented in his workshop. During the discussion it was mentioned that today graphics must be taught as a means of communication through the medium of design problems rather than purely as subject matter. He added that in the pursuit of that objective one should not lose sight of the value of the English language as a means of communication. In evaluating student's design solutions it is important for the teacher to give recognition to their credentials, in the form of their experiences in social, economic, and engineering situations. Their capabilities are directly related to their individual inquisitiveness and awareness of their surroundings.

In formulating design problems for classroom use, Professor Rogers suggested that they could be grouped into three types: 1. a simple one or two piece item which is well within the scope of the student's past experience, 2. a device with several mechanical parts which must be individually designed and then related to perform a given function (although a more complicated situation, this is still within a student's capability), and 3. a device to perform some function completely outside the realm of the student's past experience utilizing both familiar ideas and elements and totally new design ideas. Rogers also answered a question which should be discussed in a class as soon as the design process is being introduced - "why design?". In extremely practical terms the answers could be (a) to fill a basic need (and make a profit), (b) to improve on an existing design (and make a profit) and (c) to make a profit.

Another group suggested that the word "design" should not be restricted to "mechanical" or "product" design, that the term should be given a broader meaning. Professor Rule cautioned that in the original problem statement given to the students design limitations and restrictions should be kept to a minimum. The students must be given the opportunity to let their minds roam freely for new, even unconventional, ideas. Instructors must warn their students of premature particularization, as this would hamper the whole design process. Not until the task specifications are considered should the alternatives be narrowed down and the project be "fenced in".

Several leaders commented that although the participants did not lack enthusiasm for learning this approach to graphics education, one could sense a reluctance to make sketches - certainly an unexpected criticism considering the make-up of the "students". Two reasons for this pehnomenon were offered: (1) a desire on the part of individuals not to expose their graphical techniques to their peers, and (2) perhaps an actual lack of sketching experience on the part of many participants. If the latter be the case, this program has undoubtedly served notice that individual improvement is in order if "mechanical drawing" courses are going to give way to modern "engineering graphics" curricula.

Evaluation

At the outset of the program Professor Hill insisted that the conferees should not sit passively through the series of lectures and demonstrations, that they should actively participate in the proceedings. The workshops certainly accomplished this classical educational concept. In addition, they enabled graphics teachers to work together on a common cause in a manner which they as a group have rarely before demonstrated. There was an obvious enthusiasm in being challenged with an educational tool by which engineering graphics programs can be revitalized, reshaped, and designed to provide leadership for the modern engineering curricula.

DESIGN PROJECTS

Material Edited by
W. M. CHRISTMAN, JR.
Professor
University of Wisconsin

In Part III attention was directed to one of the purposes for conducting the ENGINEERING GRAPHICS and DESIGN Summer School, namely:

> "To give educators intense coaching in curriculum planning, writing of case studies, writing of design projects, and the role of graphics in design education."

That portion of the statement .... "Writing of design projects" .... was accomplished through the medium of two workshop sessions, each one lasting at least three hours.

Workshop I - Identification of needs, writing of design projects, writing of case studies.

Workshop II - Writing of task specifications and conceptual design.

Each workshop was guided by a leader who had had experience in experimenting with the teaching of full semester engineering design courses or engineering design units within regular engineering graphics courses.

During the first hour of the first workshop the group leader developed an extended expansion of certain of the twelve items in the sequential guide to design listed in Professor Hill's paper entitled "The Design Process." Special attention was given to the following five items:

1. Identification of Need
2. Definition of Goal
3. Task Specifications
4. Ideation
5. Conceptualization

The members of each workshop group then spent about an hour in identifying needs by drawing upon their own personal experiences, identifying as problems things and situations about which they were disturbed or which they thought could be improved, or for which a need existed. Along with this were developed goal definitions, in general terms, for a system or a device to satisfy a need. Near the close of this first workshop period the ideas were pooled, and, by general consent, agreement was reached on what probably were the best ideas for further development at the workshop on the following day.

At the start of the second workshop period each group was given the output of one of the other groups from the day before, - an exchange. Thus confronted with brand new challenges, task specifications were written and the ideation and conceptualization stages of the design process were followed. The results of this procedure are documented in the following pages of this chapter. The reader must bear in mind that the ideation lists, the conceptualization steps and sketches are the result of only approximately two hours of workshop time after the participants had been handed, in exchange, the suggested design projects compiled by a different group the day before. There are few, if any, final polished workable designs. In fact some of them likely would not work, as sketched, without refinement. But the sketches do show vividly one of the steps in the design process, - graphical communication with oneself and with others to portray an idea.

In preparing the raw material of these workshop sessions for publication, every effort was made to retain the spontaneity of the sketches as submitted by the originators. Where they used pencil or ink or nylon tip pen, the same medium was used for preparing the publication drawings.

The format of Part IV is arranged as follows:

Section 1. Several of the design ideas are treated in detail showing an outline of the need identification, task specifications, ideation, etc., followed by sketches made by the various members of a team or teams within the workshop group.

Section 2. Several additional design ideas are presented with task specifications, etc., listed but having no accompanying sketches.

Section 3. A list of short statements of some of the many other design topics suggested during the first workshop session.

The following are problems which show in one way or another the sequential steps of

1. Identifying Need
2. Problem Statement
3. Formulating Task Specification
4. Ideation
5. Conceptualization

(Sketches of some of the innovative ideas suggested in item number 4.)

AUTOMOBILE LIFTING DEVICE

NEED IDENTIFICATION

A need exists for a device to be used to lift an automobile high enough for a tire to be changed. It must be stable, positive acting, safe, convenient to use, and as inexpensive as possible.

HISTORY

Current models of such devices are found among various mechanical and hydraulic jacks. But mostly these are inadequate, allowing the elevated automobile to sway; a separate device is required to prevent the car from rolling; they are cumbersome, heavy, unintelligible to the non-mechanically minded person; the mechanical type is susceptible to a reverse action which can cause injury (Example, a handle can knock out an operator's tooth), and the mechanical jacks require too much force for an older person, a woman, or young person (with her) to operate.

PROBLEM STATEMENT

Design a better and safer automobile lifting device than exists presently.

TASK SPECIFICATIONS

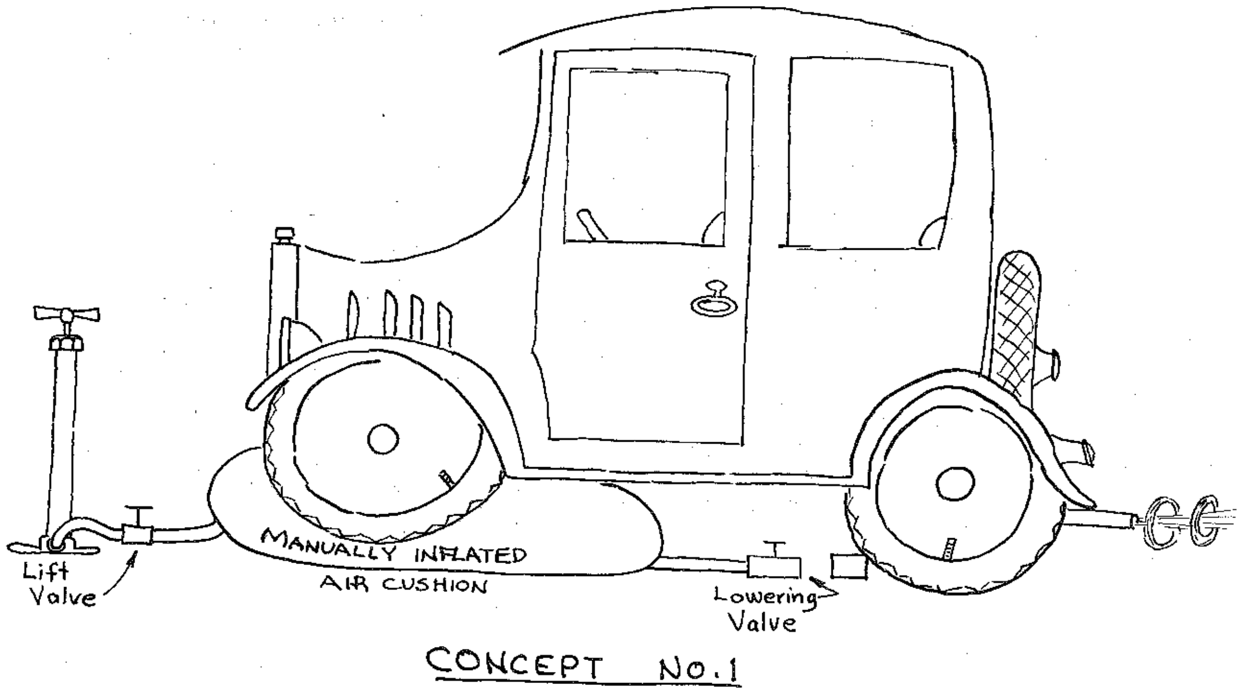
1. Easily operated (force)
2. Sales - approximately 10,000,000
3. Rigidity - no sway
4. Must not roll forward or backward
5. Capacity - 2,500 lbs. and 4,500 lbs. (two models)
6. Adaptable to various terrains or surfaces
7. Life - 100 to 150 cycles of operation
8. Manual, hydraulic, or electric power

IDEATION

1. Pneumatic cushion - manually inflated
2. Exhaust operated cushion
3. Axle mounted - power link
4. Individual pneumatic cushion mounted. Power or manual
5. Rear or front cross mount, - hydraulic or electric power
6. Mechanical cam mount-roll on
7. Positive cam follower, anti-kickback

CONCEPTUALIZATION

See Figures 1, 2, and 3.



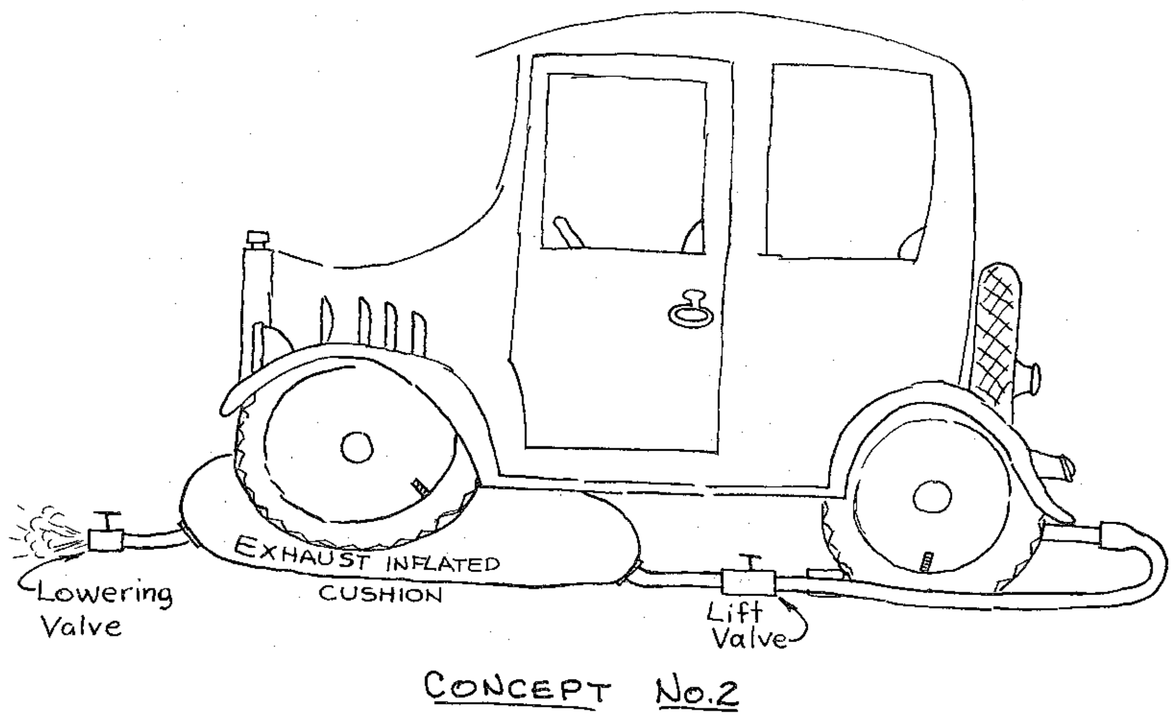
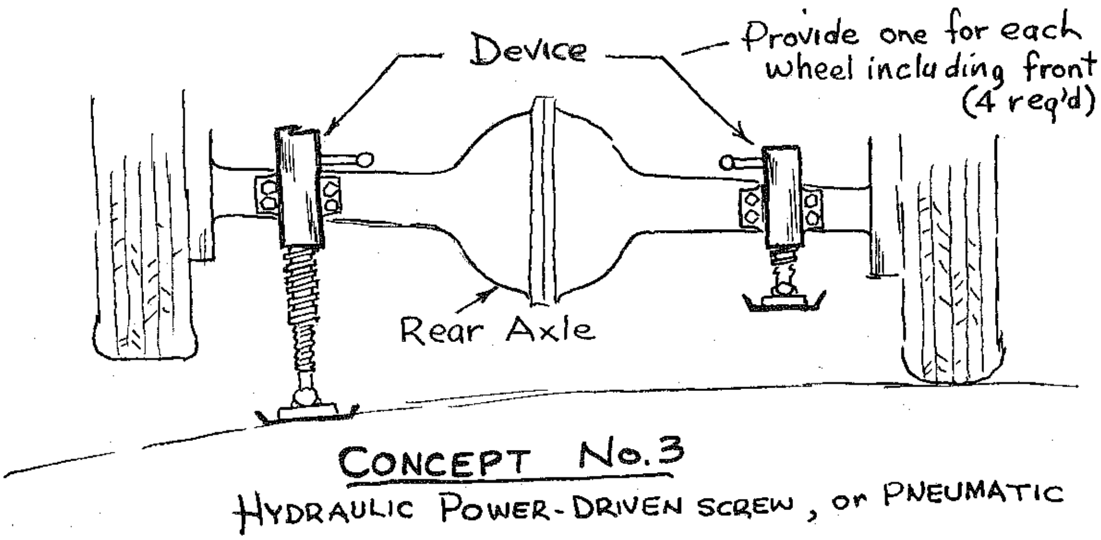


Figure 1 The inflated cushion idea executed with a bit of olde tyme body lines - fun sketching.



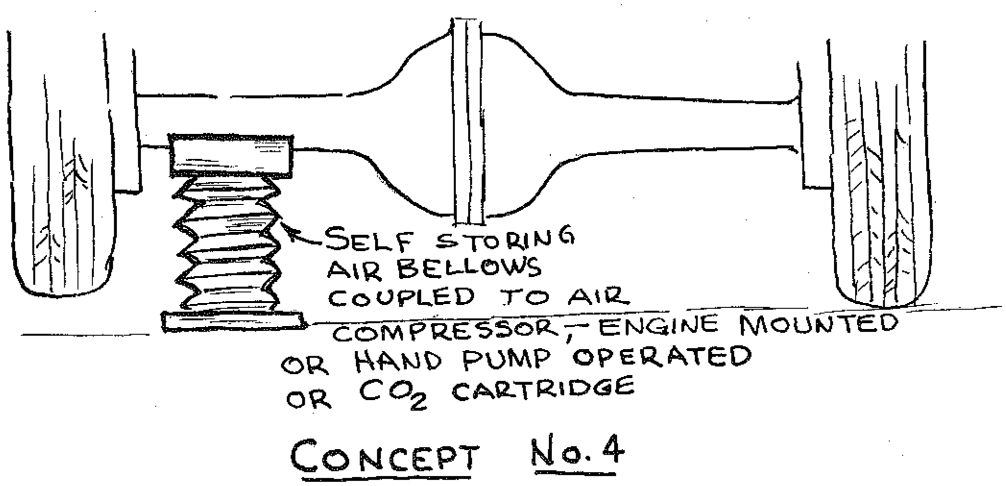
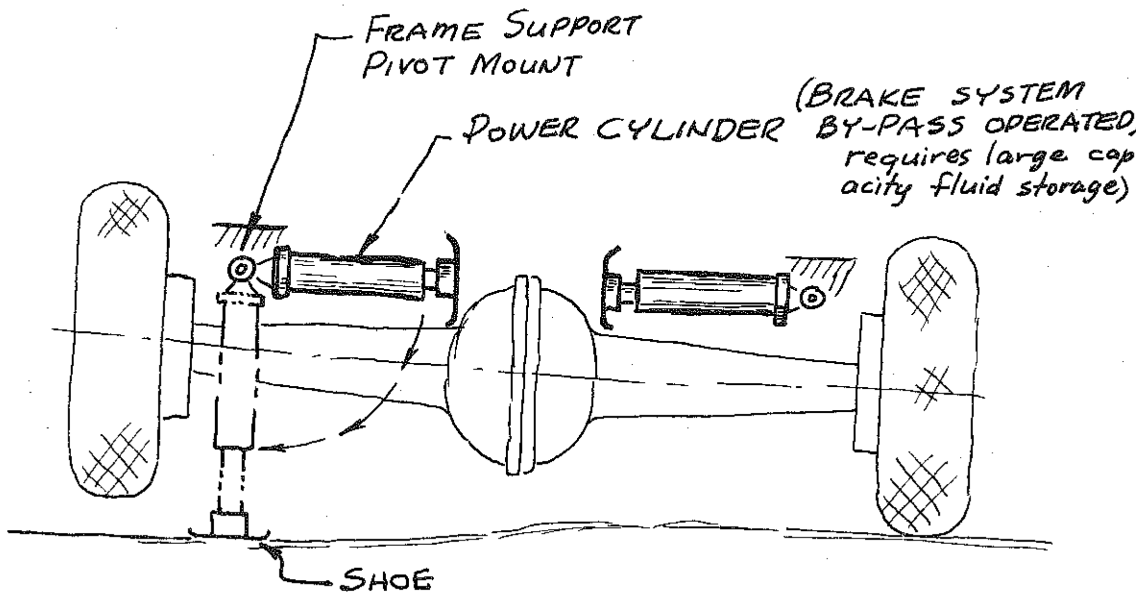
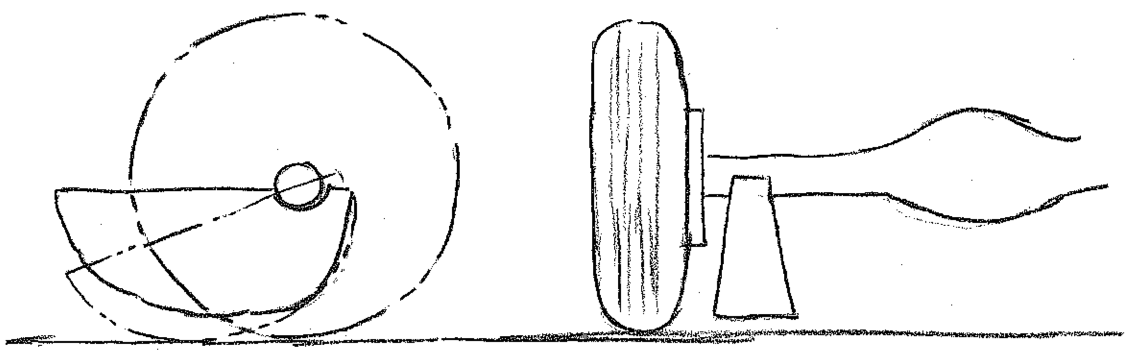


Figure 2 Power driven screw and inflated bellows ideas.



4 REQ'D – ONE EACH CORNER

CONCEPT #5



CONCEPT #6

MECHANICAL CAM MOUNT ROLL-ON

Figure 3 Power cylinder jack and mechanical cam ideas.

STUDENT DESK QUICK CHANGE FROM RIGHT HAND TO LEFT HAND

NEED

Left handed school children write and draw in the usual normal manner of right handers during the time they are in the lower grades where they sit at regular school desks. When high school is reached where arm chairs are everywhere present, the left handers develop contorted writing positions as they try to find support for their left arms on right hand arm chairs.

PROBLEM STATEMENT

Design a chair to be used in a classroom or lecture hall with a tablet arm easily convertible from right to left hand position to accommodate both right and left handed persons.

TASK SPECIFICATIONS

1. Horizontal top at least 11 x 15 size
2. Must be durable
3. Must not interfere with people getting into and out of seats
4. May or may not have to provide book storage
5. Quick change from right to left and back again
6. $50.00 per unit - 214,000 units potential sales

CONCEPTUALIZATION

See Figures 4, 5, 6, and 7.

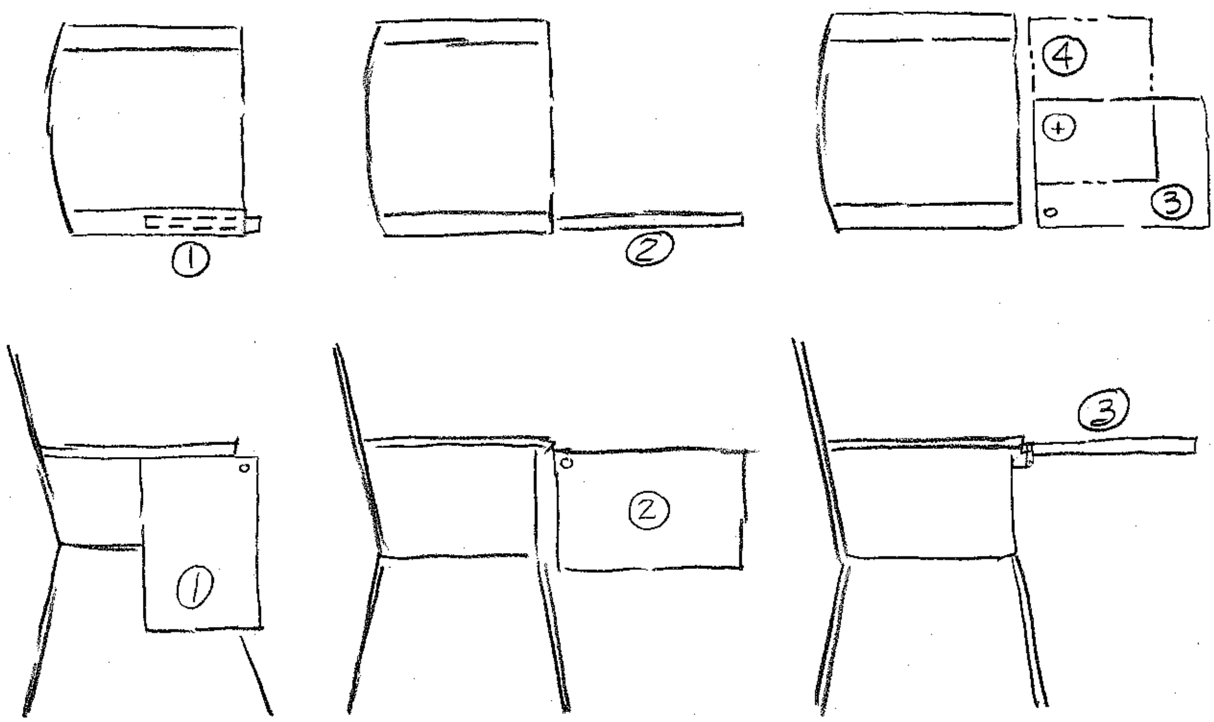
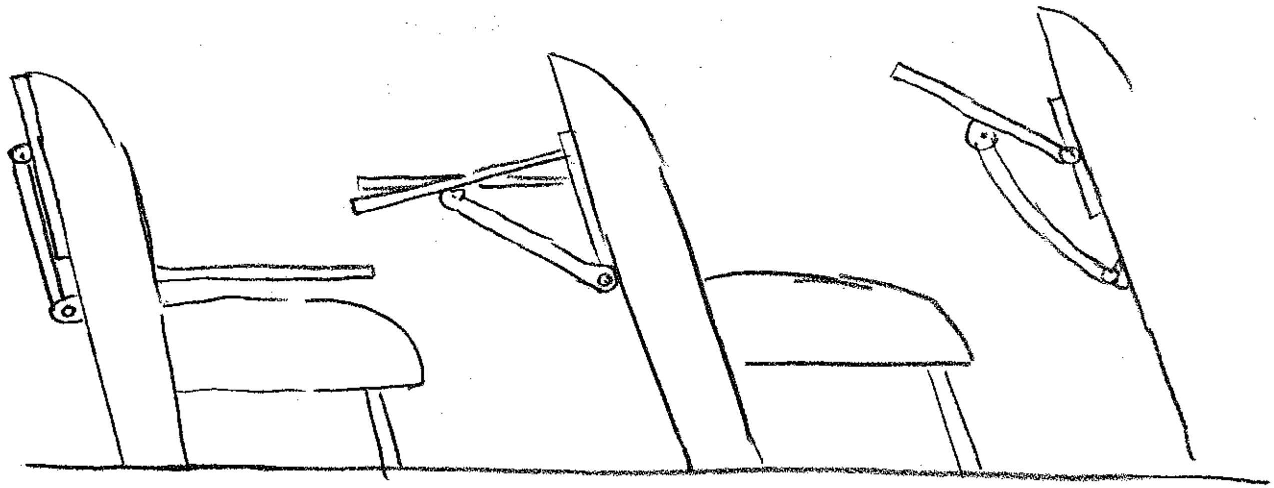


Figure 4(A) A configuration sequence sketch



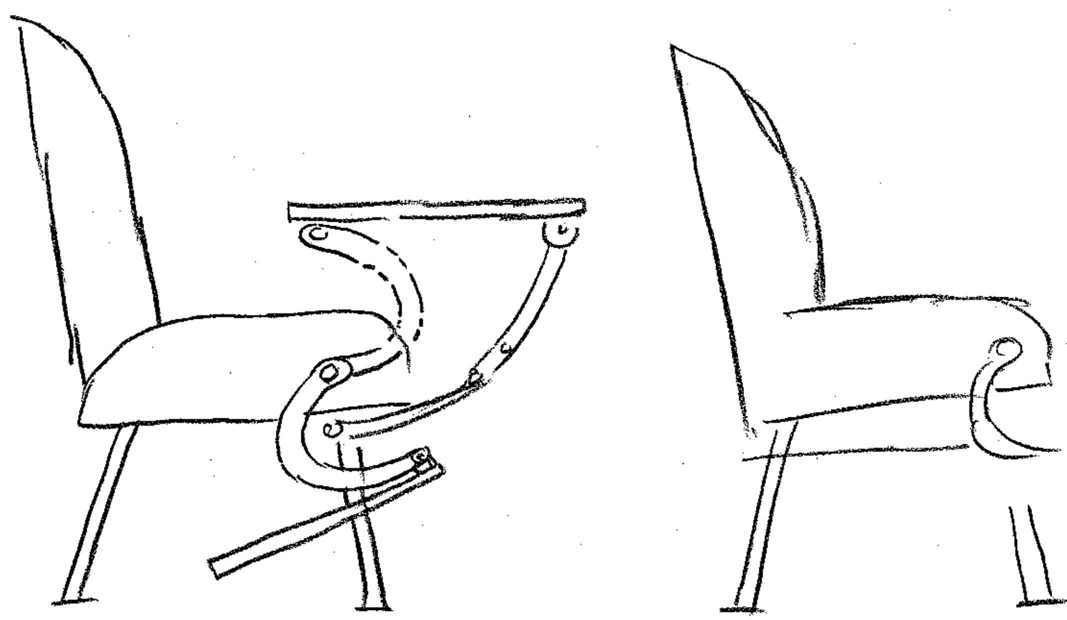


Figure 4 (B) An "environmental feel" sketch

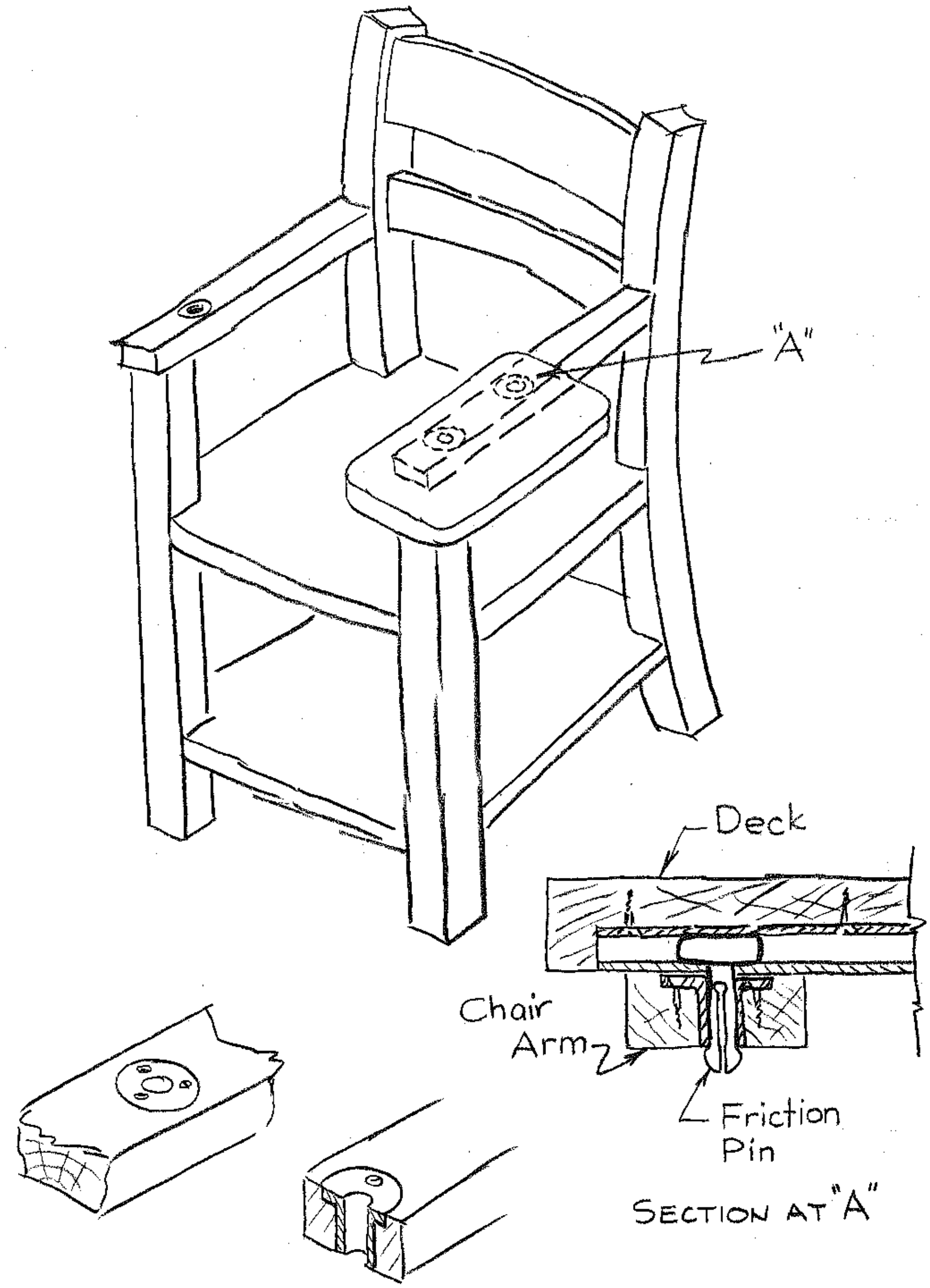


Figure 5 A quick change idea. Writing board pulled free to move it right or left.

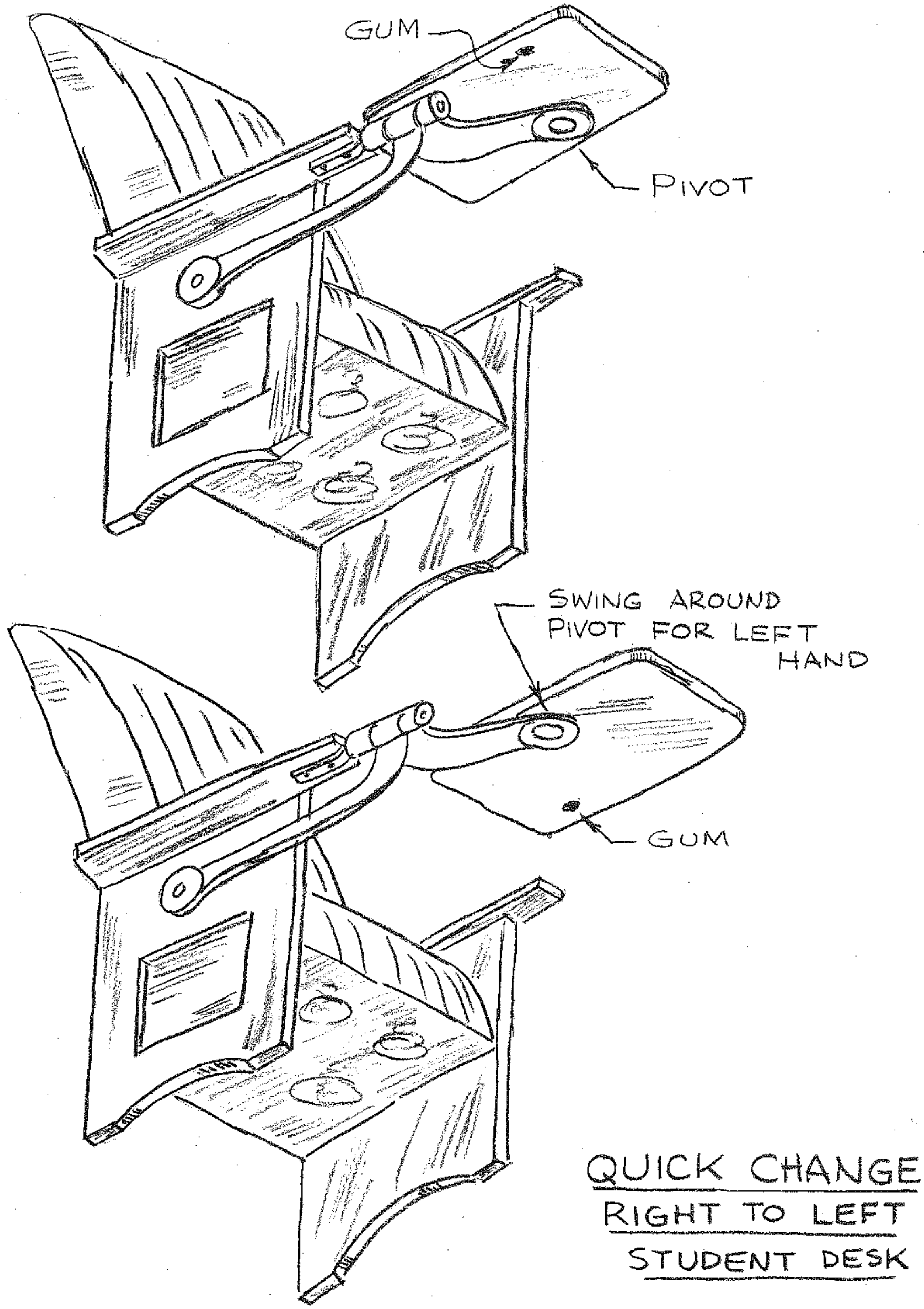
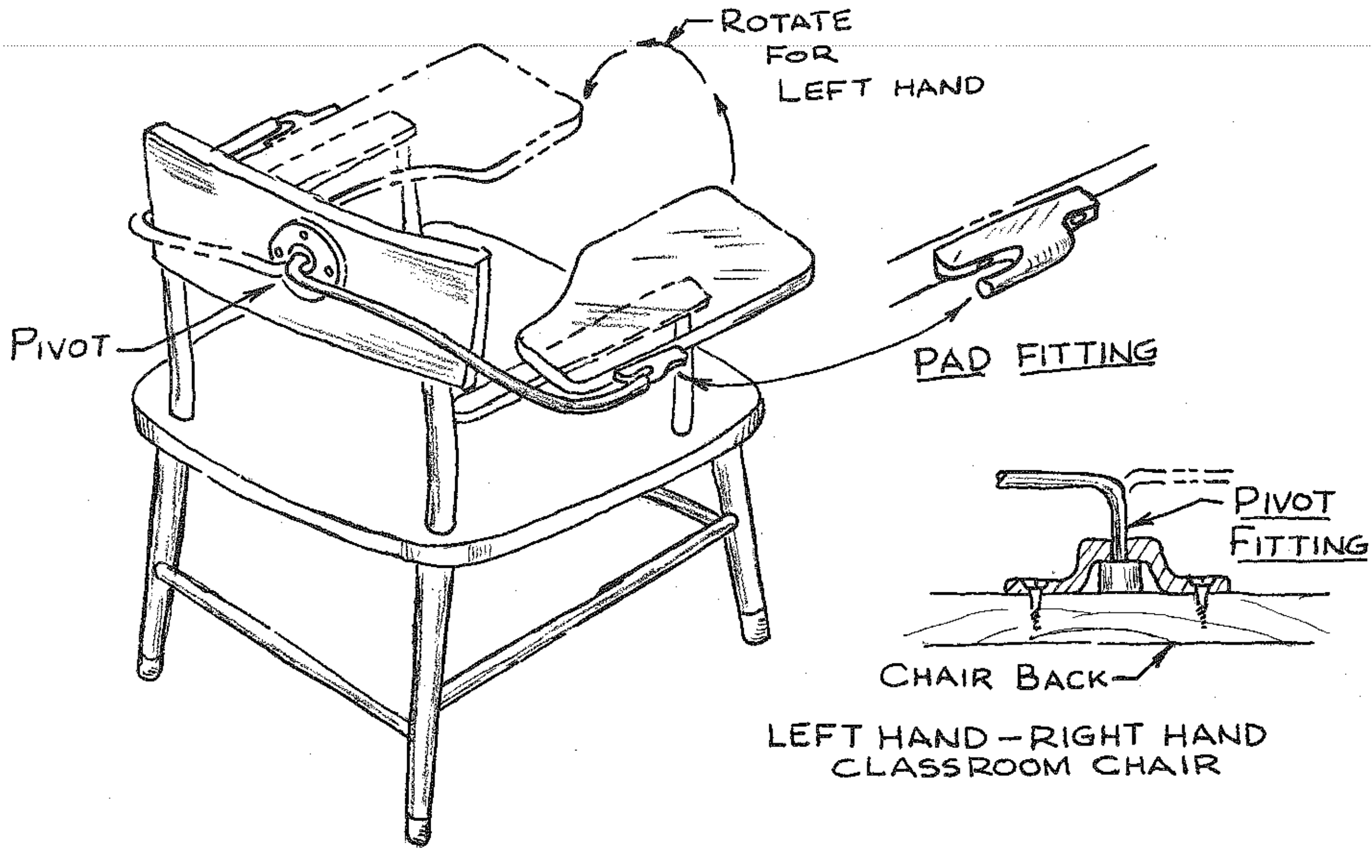
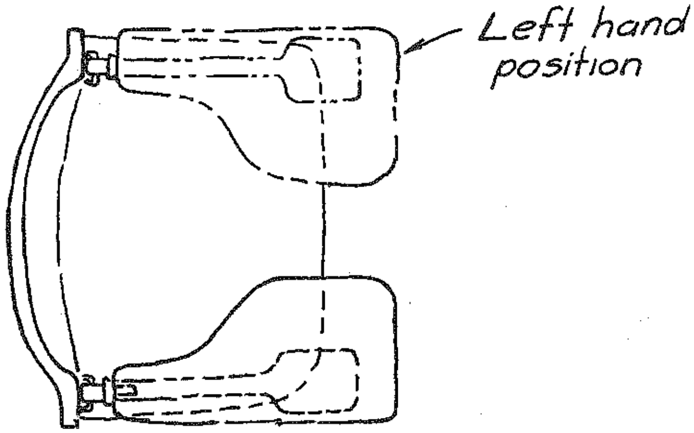


Figure 6 One bracket with pivot for changing writing board from right to left.





QUICK CHANGE STUDENT DESK

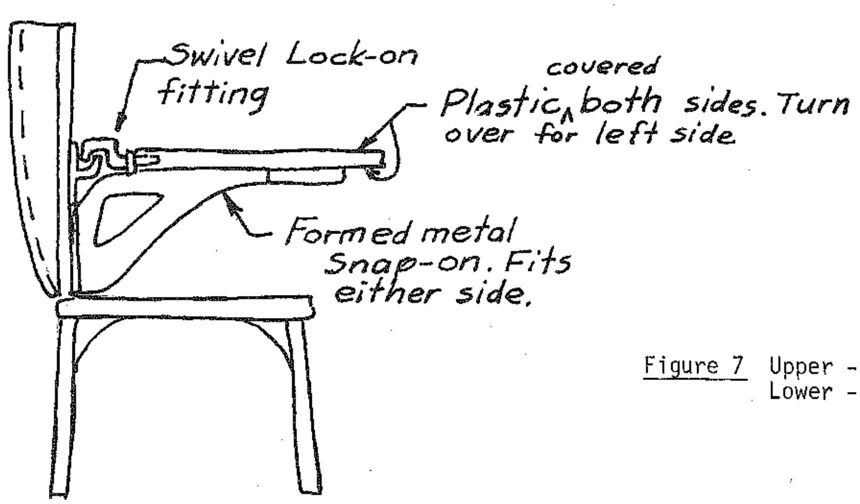


Figure 7 Upper - Overhead swing frame attachment.
Lower - Snap-on and -off quick change.

VENTILATED ALL-WEATHER SHOE

NEED

Many people do not like to carry rubbers and overshoes in anticipation of inclement weather.

GOAL PROBLEM

Design an attractive all-weather shoe or foot covering.

TASK SPECIFICATIONS

1. Styles for both men and women
2. Must be waterproof and warm
3. Should permit ventilation and air circulation about the foot

RESEARCH

1. Materials for bootmaking, especially the newer materials
2. Popular sizes
3. Color preferences

IDEATION

1. Disposable shoes
2. Molded exterior
3. Walk on cushion of air
4. Use of foot motion as air pumping system
5. Use of foot motion as energy to activate heating system
6. Thermal-type lining with double wall-interior wall "breathers."

CONCEPTUALIZATION

See Figures 8 and 9.

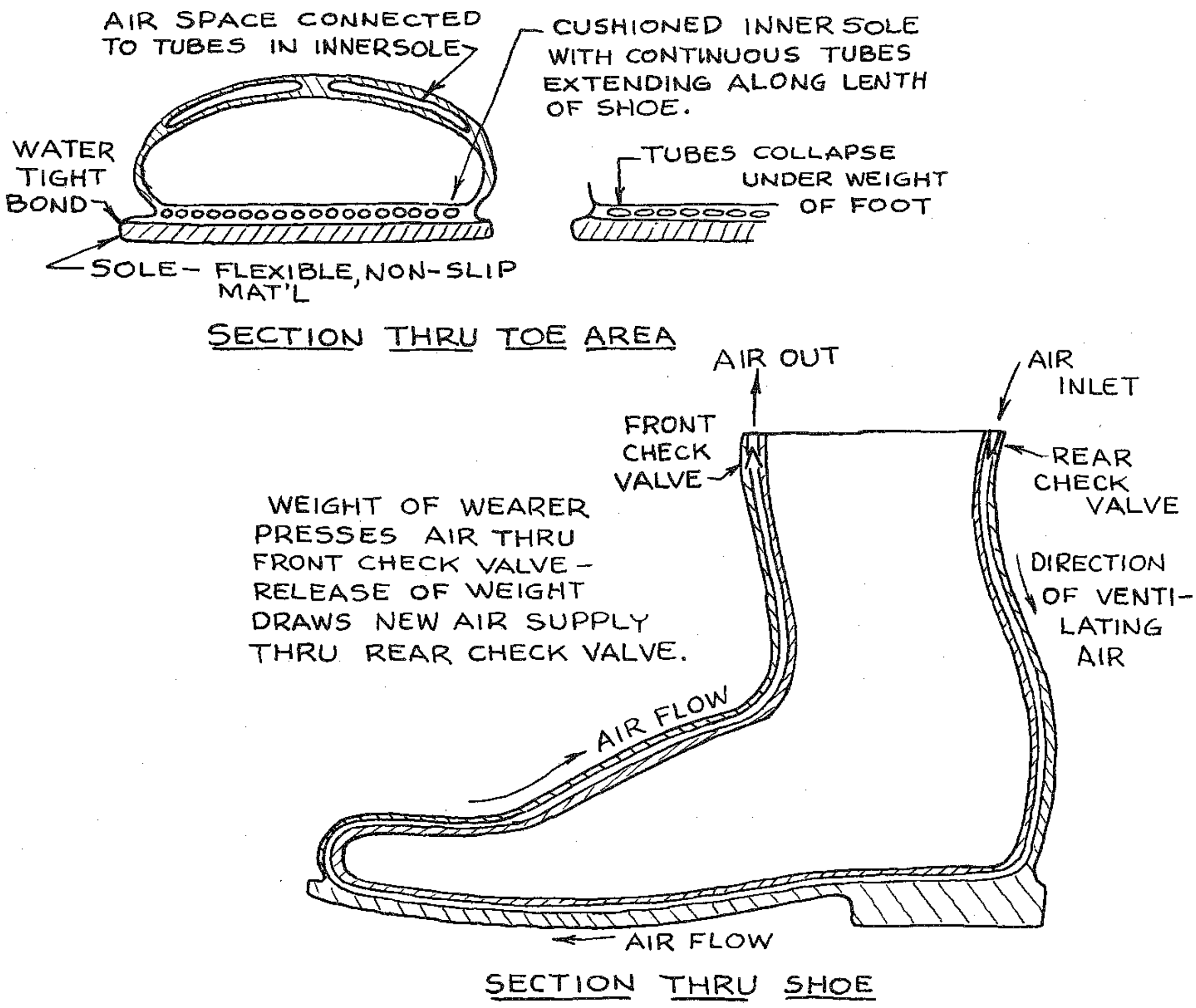


Figure 8 Built in tubes for air circulation.

WATERPROOF SHOE TO ELIMINATE NEED FOR BOOTS OR RUBBERS.

THE DRI-SHU CORP.

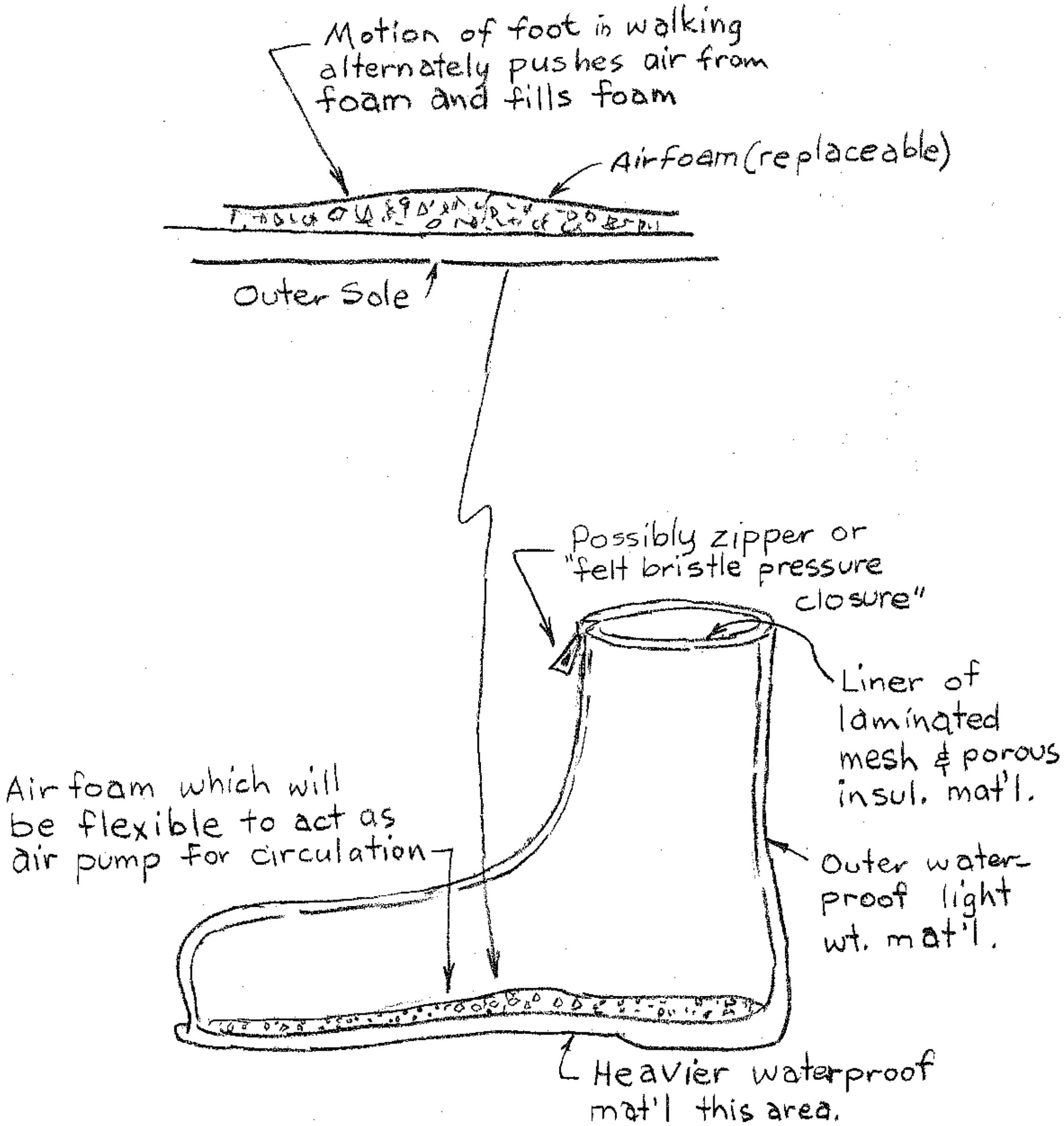


Figure 9 Airfoam application to provide "breathing".

WIDE RANGE REAR-VIEW MIRROR

NEED

Present rear vision mirrors whether inside or outside of the vehicle limit the area or range of observation of the driver because of inherent blind spots in the body design and because of cargo or passengers.

PROBLEM

Design an improved mirror device to provide an automobile driver with wide range vision in both horizontal and vertical plane directions.

GOAL DEFINITION

The new mirror device should

1. Make it impossible for passengers to interfere with rear view vision
2. Enable the driver to observe other vehicles about to pass him. This desirable condition is possible for only a limited duration of the passing time with present mirrors.
3. Lessen or eliminate blind spots at rear of the automobile
4. Reduce eye movement of driver
5. Be aesthetically acceptable

TASK SPECIFICATIONS

1. Provide vision angle of 90° in a horizontal plane
2. Should enable the driver to see the roadway for 20 feet behind the car when on a level surface
3. Consider sun visor relationship
4. Method of attaching to existing models
5. Should retail at less than $25.00 (Consider method for introducing to the public)

IDEATION

1. Mirrors
   (a) concave
   (b) parabolic
   (c) spherical
   (d) staggered
2. Strip of mirrorized plastic full length inside above windshield
3. Multi-view periscope mirrors and reading console

CONCEPTUALIZATION

See figures 10, 11, 12, 13 and 14.

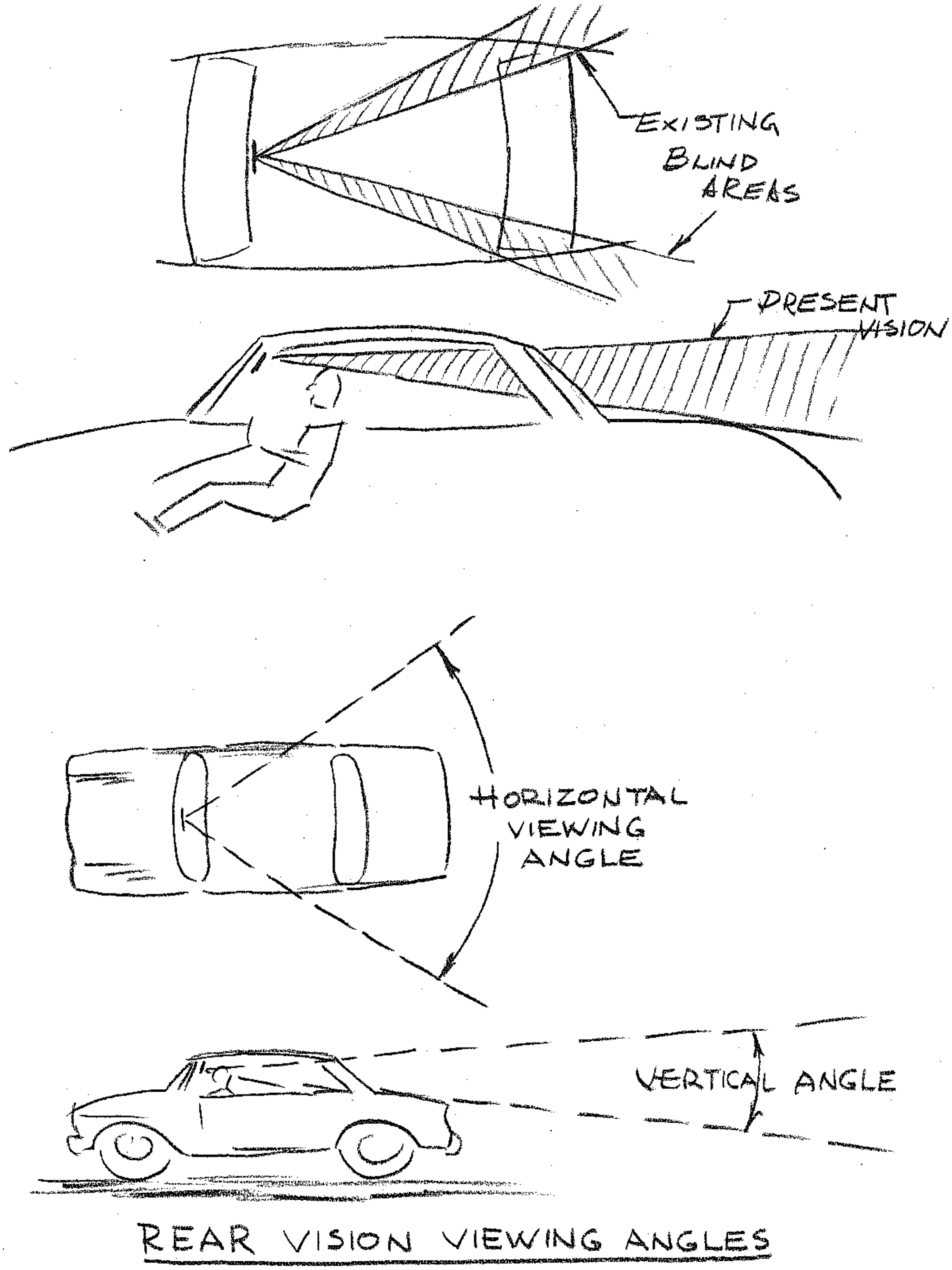
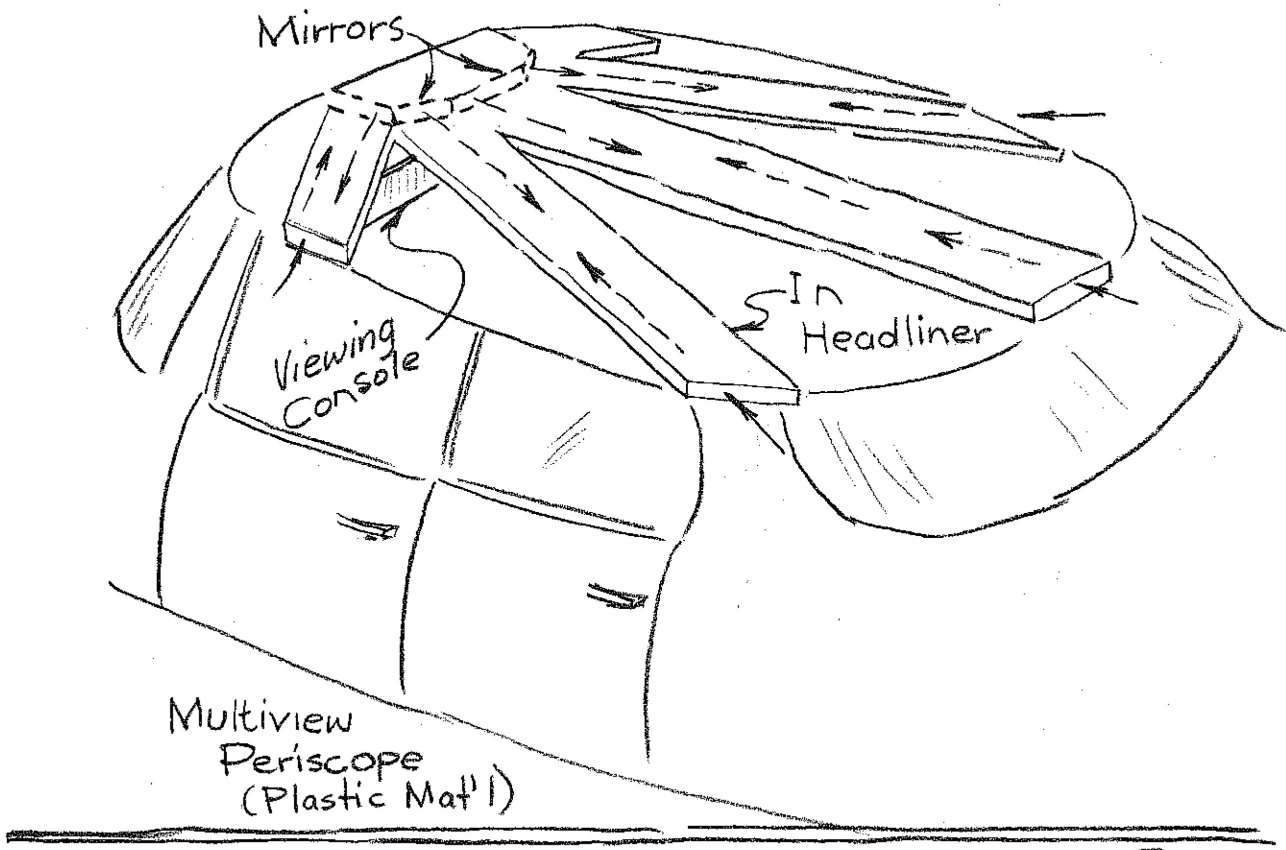


Figure 10 Sketches suggest the nature of the problem.



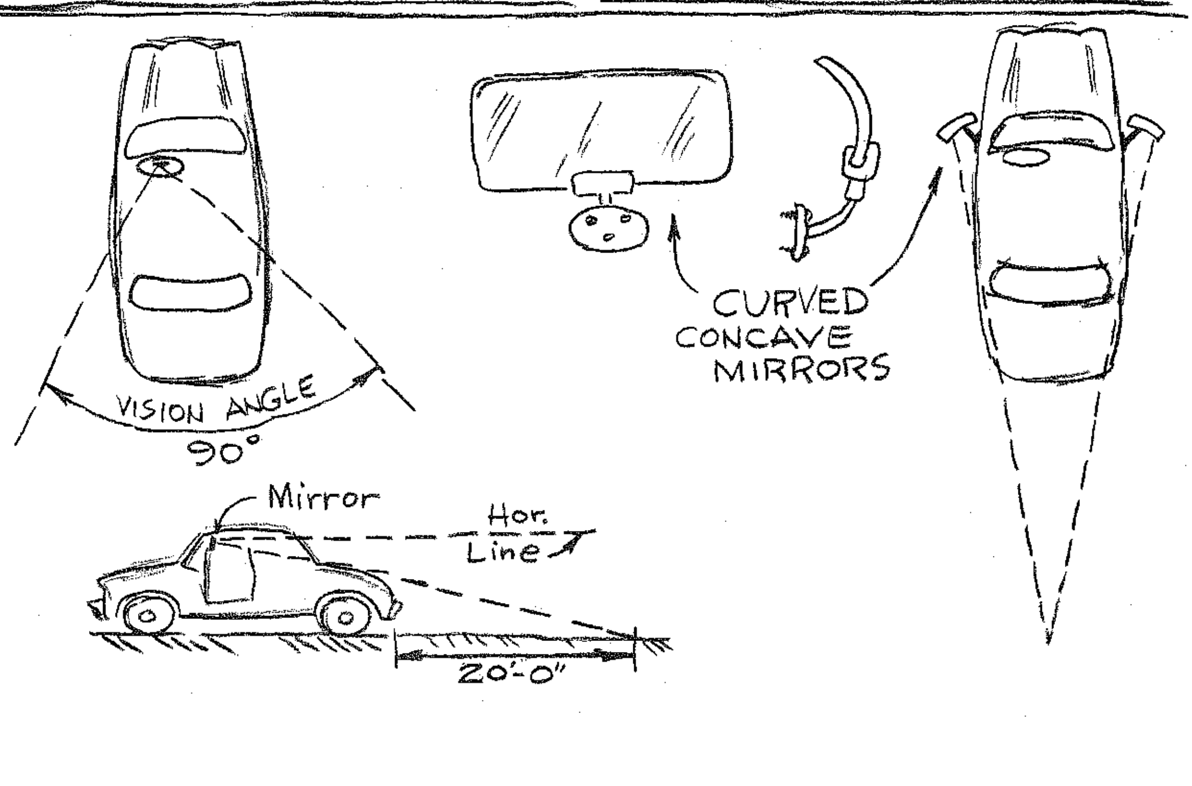


Figure 11 Two ideas. Upper - Periscope with mirrors and viewing console
Lower - Use of concave side mirrors.

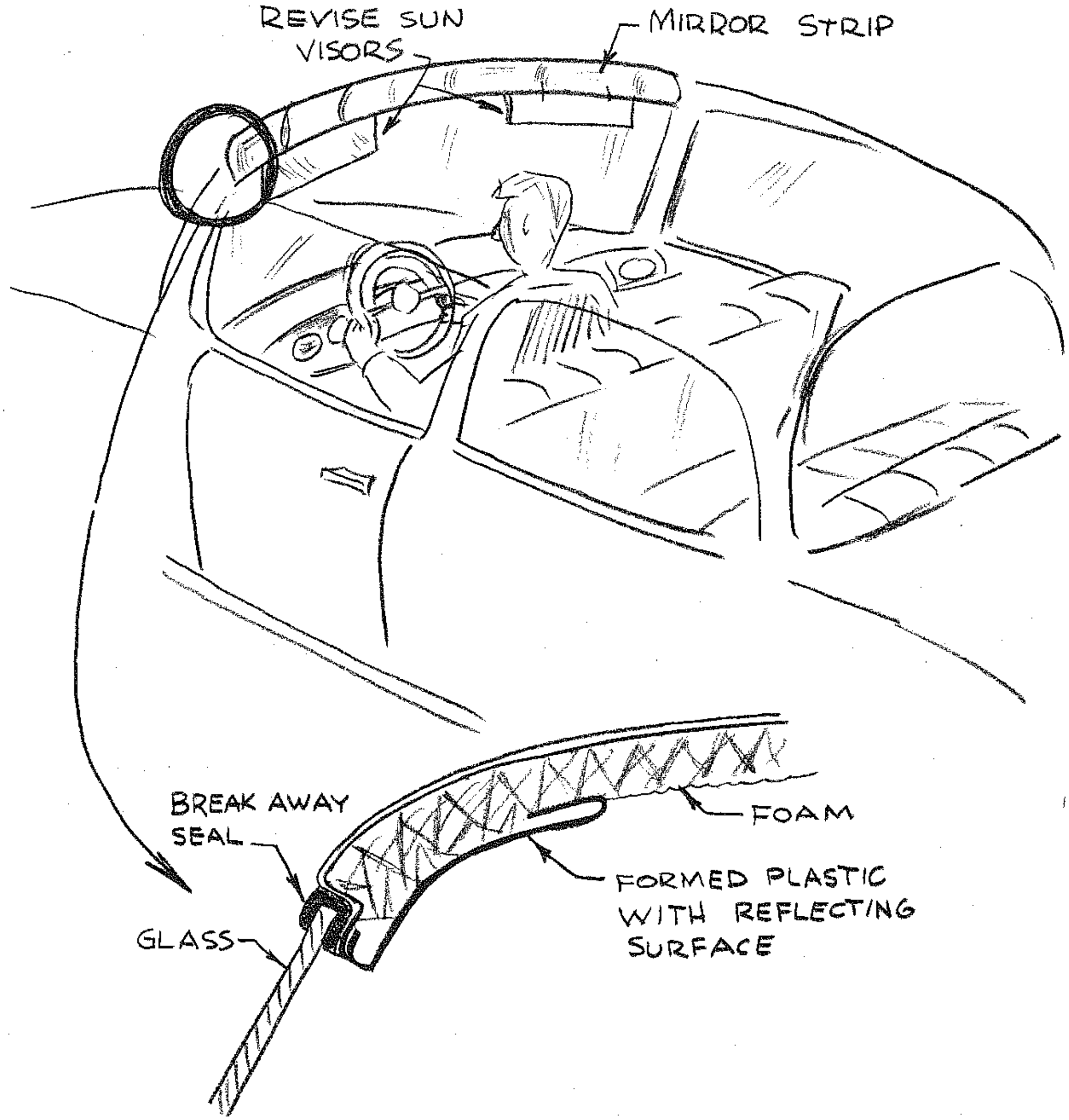


Figure 12 Full car width mirror strip.

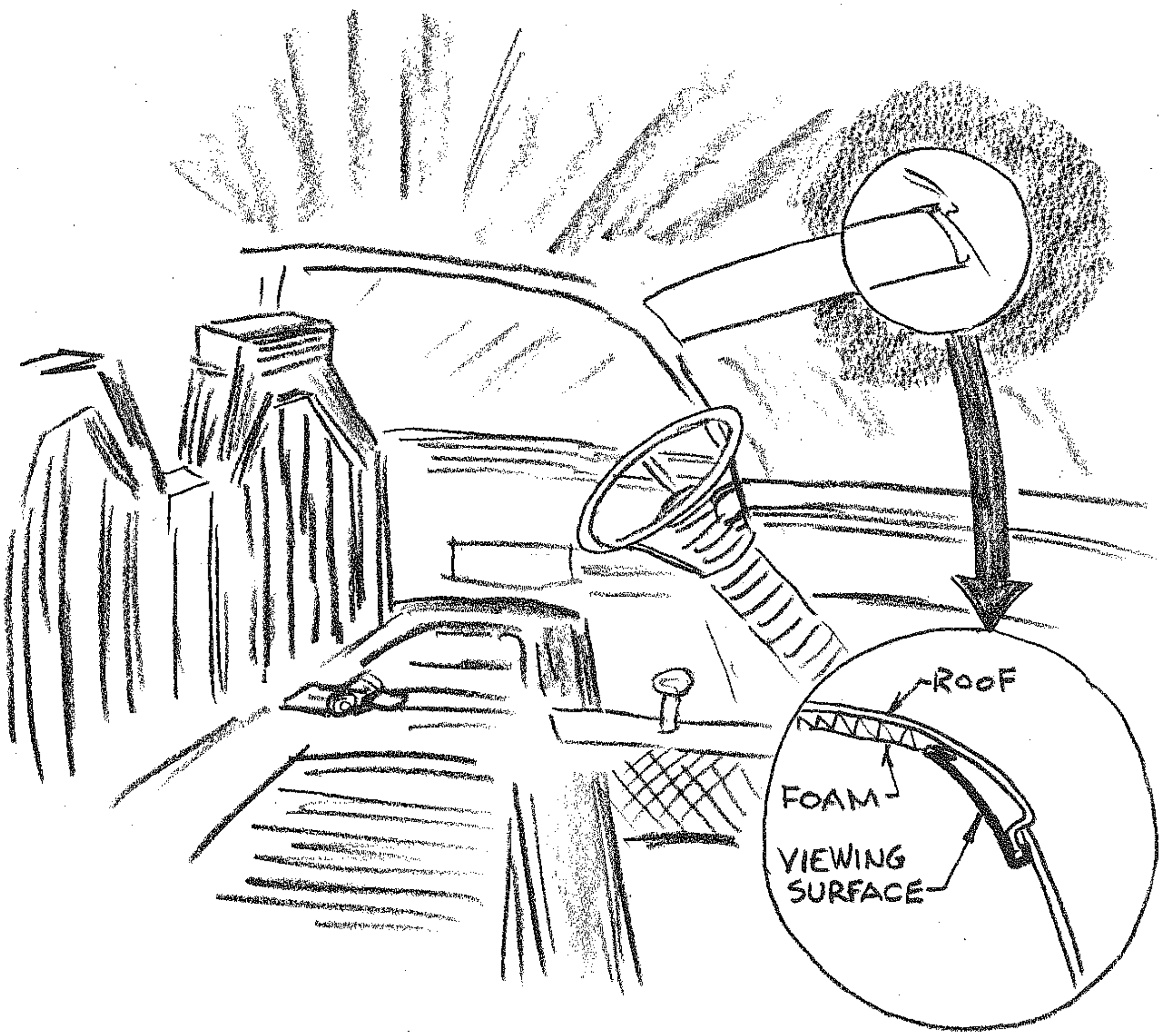


Figure 13 Another sketch of the full width mirror strip.

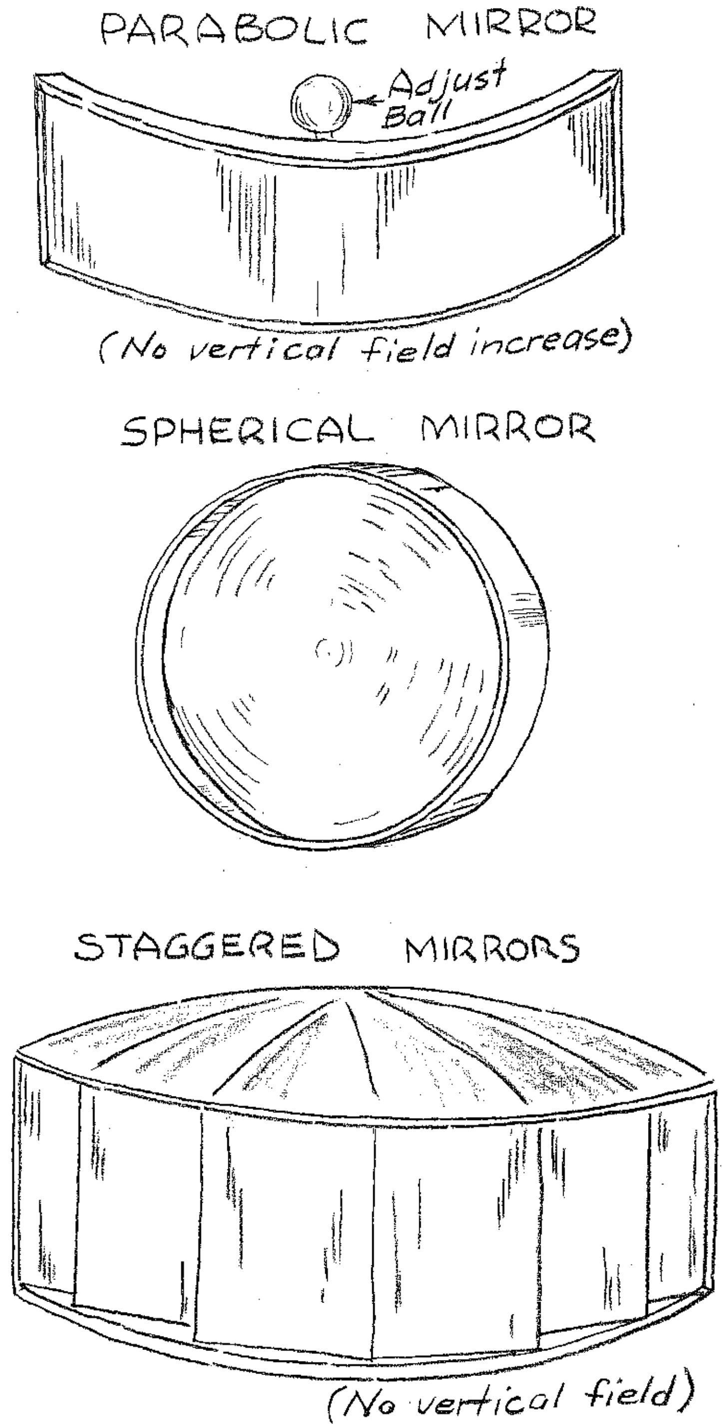


Figure 14 Various types of mirrors.

CHILD-PROOF LOCKING SYSTEM

NEED

Children from ages 1 to 2 or 4 are fascinated by drawers and doors in the kitchen, bath, bedroom and elsewhere, and are too young to understand the dangers associated with doors and drawers.

GOAL AND PROBLEM STATEMENT

As a design engineer you are to design a child-proof locking system for drawers and doors which can be installed on most kinds of existing and new cabinetwork.

TASK SPECIFICATIONS

1. A system adaptable to existing cabinetwork
2. Not too expensive
3. The device should permit a housewife to open the cabinet doors and drawers with one hand
4. Adaptable to metal and wood cabinets
5. Easy to install, sturdy, foolproof

IDEATION

The locking device would depend upon

1. The strength of the child
2. The manipulative ability of the child
3. The distance a child can reach
4. A device requiring several movements such as:

   a. in
   b. out
   c. sideways
   d. press
   e. pull

   (In general it seems that a 3 year old ca[n] soon figure out these systems unless the[y] get very complicated. If too complicate[d] a housewife cannot open with a utensil i[n] her hand.)
5. Interconnected drawers
   (Damage to drawers and again housewife ca[n]not operate with one hand.)
6. A dial system (too expensive)
7. A simple key used as a trigger device, (although inexpensive, key misplacement when cooking, etc., makes the system undesirable. Also some holes may have to be drilled in existing cabinets.)
8. The knob is compressed with thumb in front and two fingers in back as shown. The releasing mechanism is inside the drawer. Main disadvantage is cost. Main advantages are:

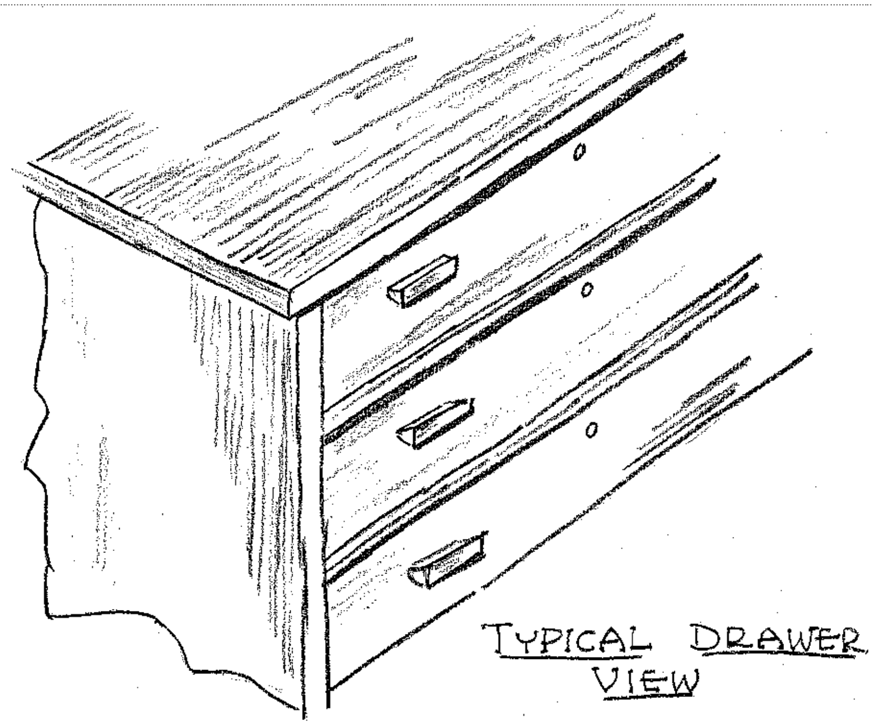
   a. fulfills need
   b. looks good
   c. can be adapted to existing cabinets and drawers

9. Solenoids and Touch Switches

   System requires two hands; pressure must be maintained against switch plate until door or drawer is opened unless a delay device could be built into each switch plate so that only one hand is required to open doors and drawers. One switch plate may be used to operate several solenoids at once. System is best adapted to new construction, but may be installed in existing construction with aid of an electrical contractor.

CONCEPTUALIZATION

See Figures 15, 16 and 17.



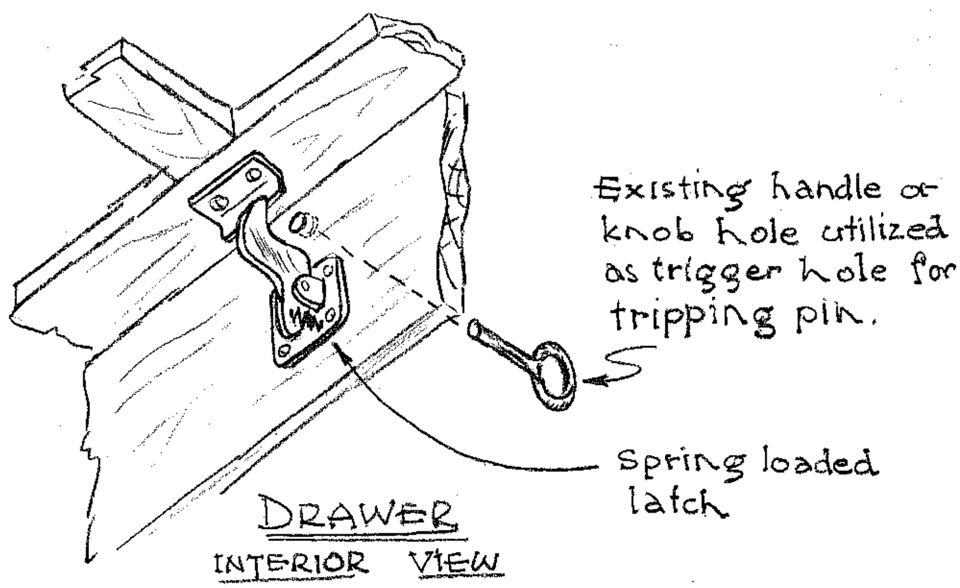


Figure 15 Pin type trigger for releasing latch.

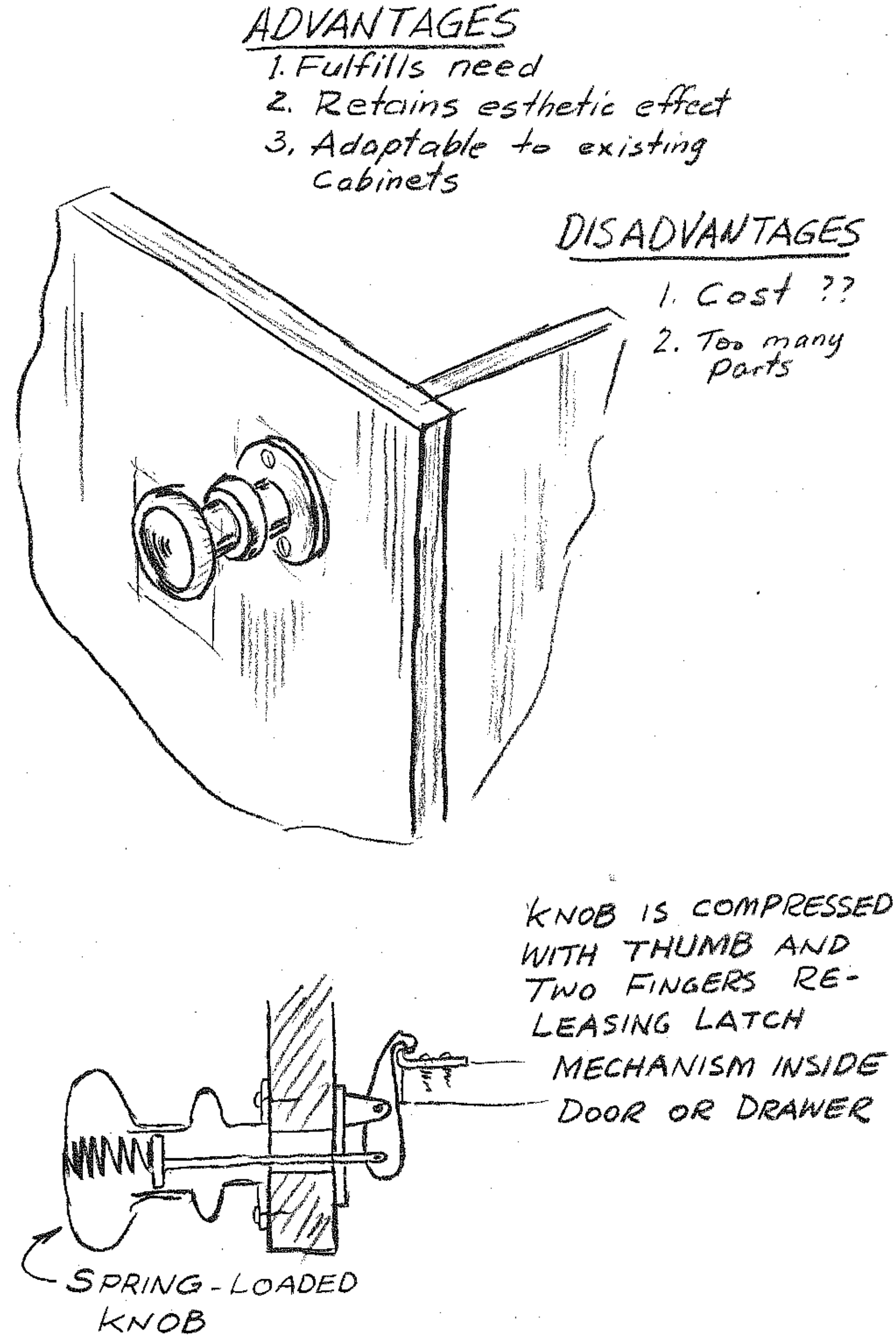
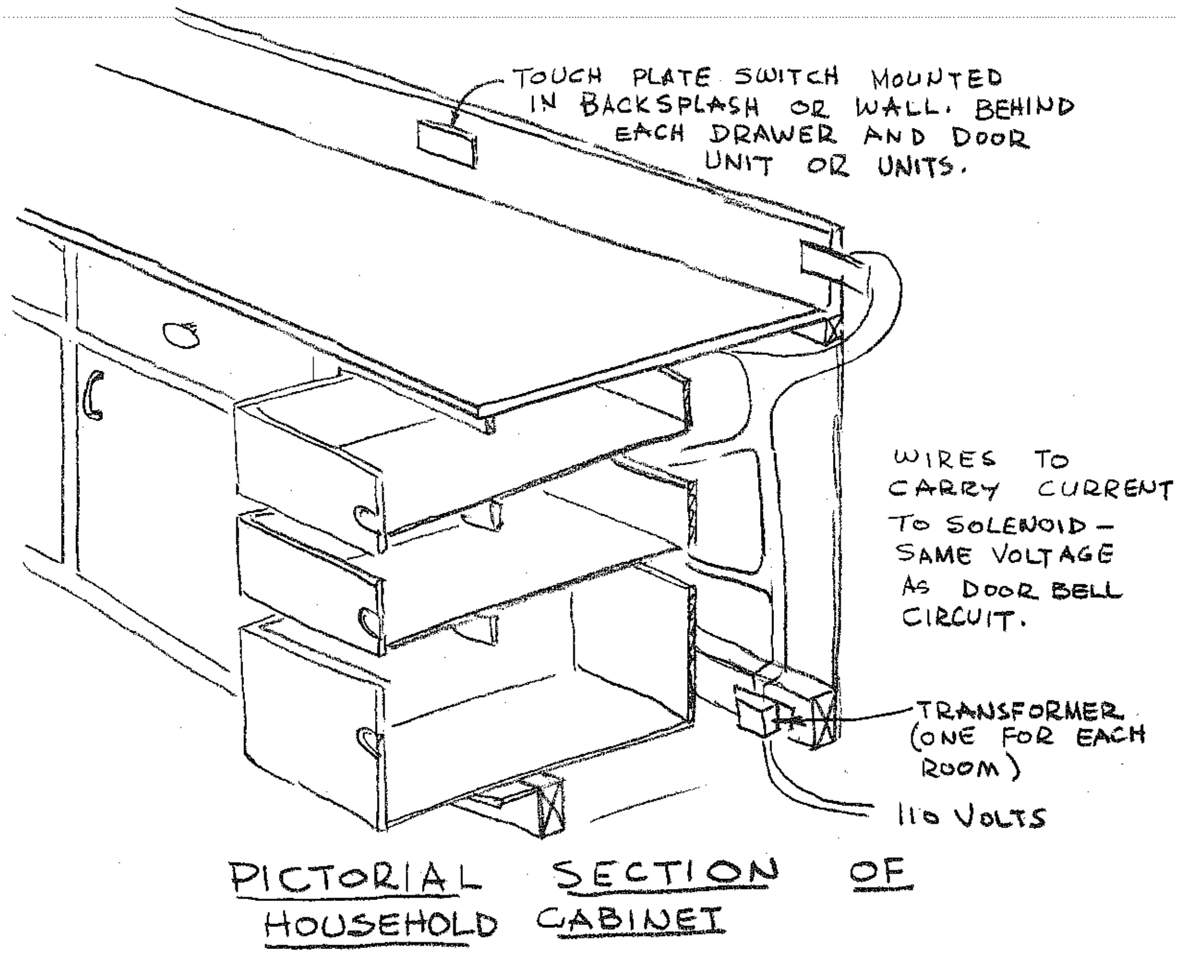


Figure 16 The compressible knob idea.



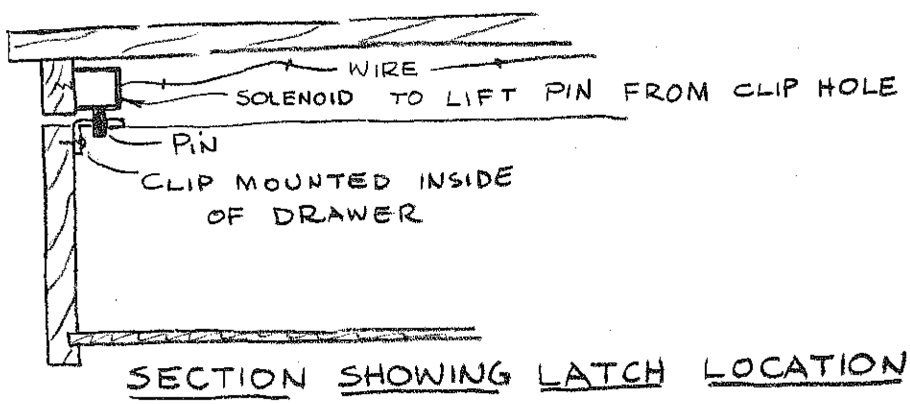


Figure 17 Sketch of the touch plate and solenoid actuated latch release pin.

EDUCATIONAL TOY

NEED

Many preschoolers are bright enough to learn kindergarten material but are too young to attend and too restless to satisfy mother.

PROBLEM

Design a self teaching toy to teach colors, numbers, animal identification, alphabet, etc. Incorporate a "reward" for successful effort.

TASK SPECIFICATIONS

1. Easily operated
2. Short "success" sequence (5 min. max.)
3. Colorful
4. Safe
5. Stand on floor or on table
6. Not very expensive
7. Light weight
8. Either manual or electrical operation

IDEATION

1. Rotating discs, drums
2. Bell, gum, recorded sentence, sound tape praise reward
3. Telephone dialing idea
4. Key operated devices

CONCEPTUALIZATION

See figures 18, 19, 20, 21, and 22

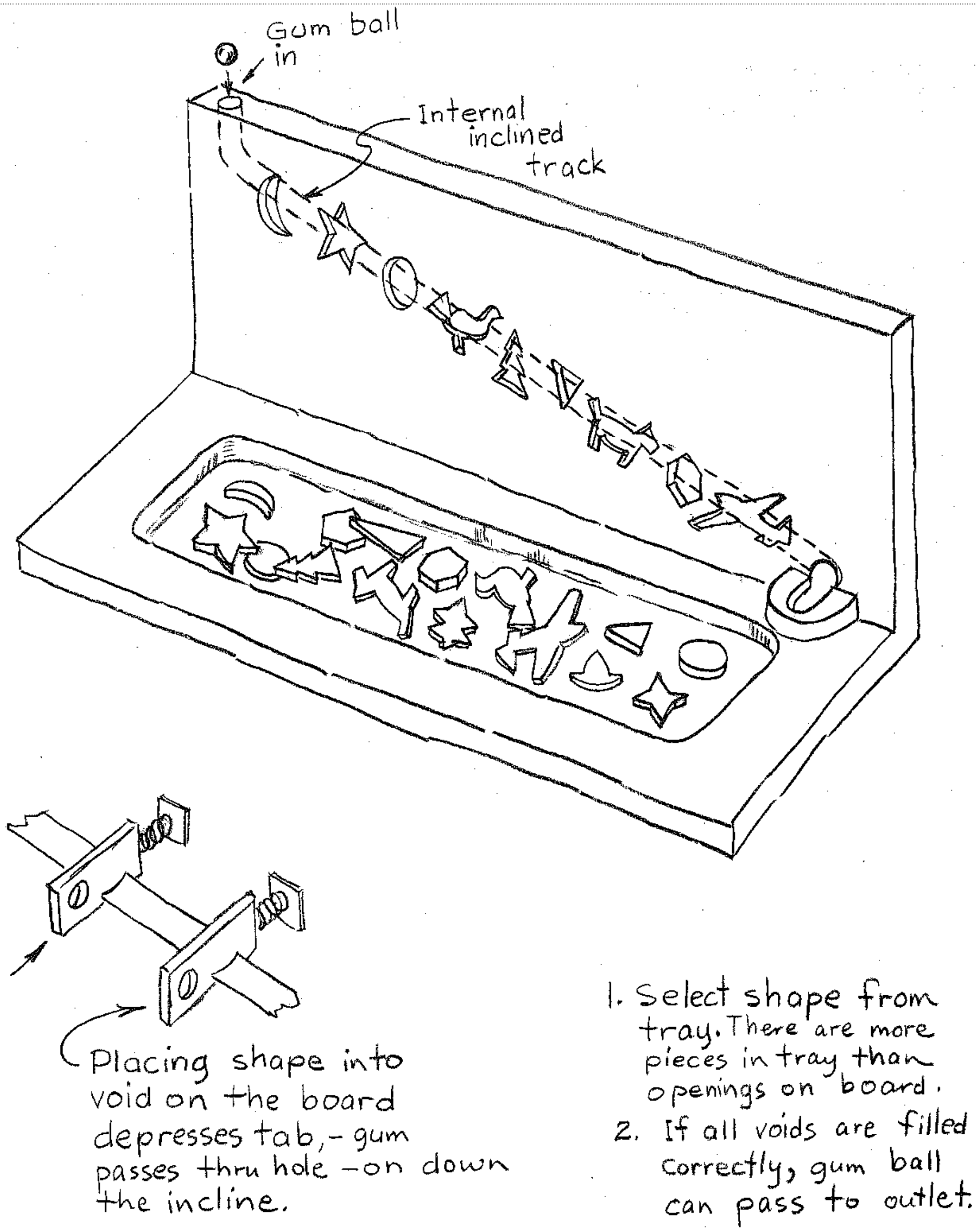
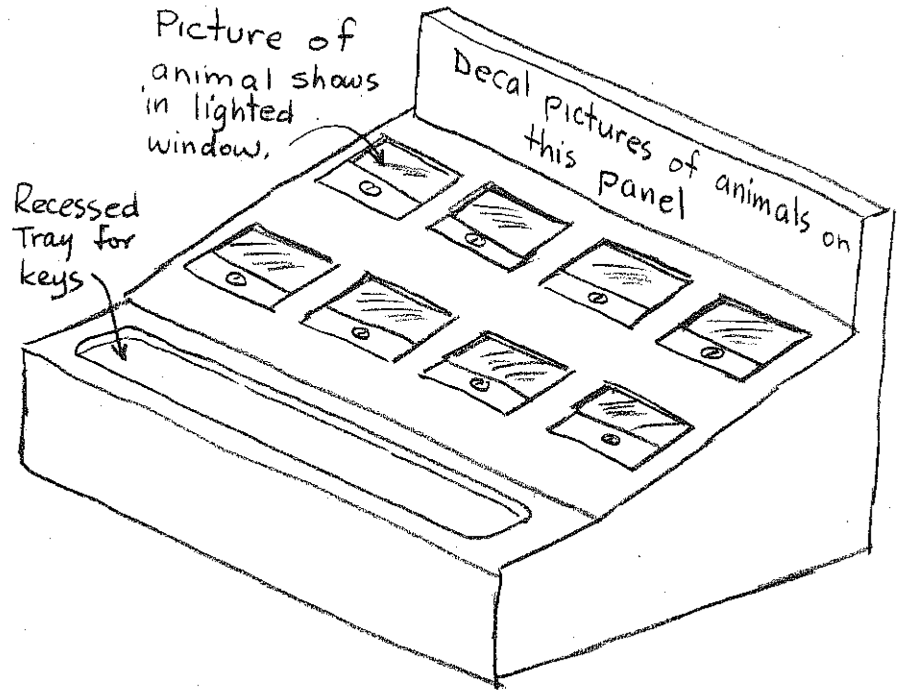
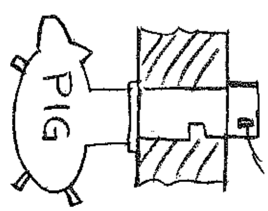


Figure 18 A configuration matching toy.



1. Box with animals, words, colors, etc
2. Key turns only in hole corresponding to the picture, color, or etc. on the key
3. Squares can be moved to different places on board to prevent child from memorizing location.



Contact completes circuit on light when proper key is inserted

Figure 19 A toy to teach identification of animals, words, colors, etc.

EDUCATIONAL TOY

Problem as given to the group was simply to design an educational toy. The group restated it as:

> Many preschoolers are bright enough to learn kindergarten material but are too young to attend and too restless to satisfy mother. Design a toy to interest such a child.

Need Design a self teaching toy suitable for a four year old to help him learn to identify the primary colors (or figures, alphabet, etc)

Goals Toy must be light wt., consist of no (or few) loose parts, cost to not exceed $3.00, simple to operate, colorful, safe. The entire success sequence must be quick. (5 min. max.) Must be "parent-approved".

Research Interest span of 4 yr. olds, available similar toys.

Task Spec. Elect. operated (D.C.), push button, approx. 18×22×2 thick, cover, cardboard. Stand on table or floor at approx. 75°/horizontal

Ideation Toy could be extended to include drums, selection windows to teach alphabet, figures, 3-letter words, etc.

Concept

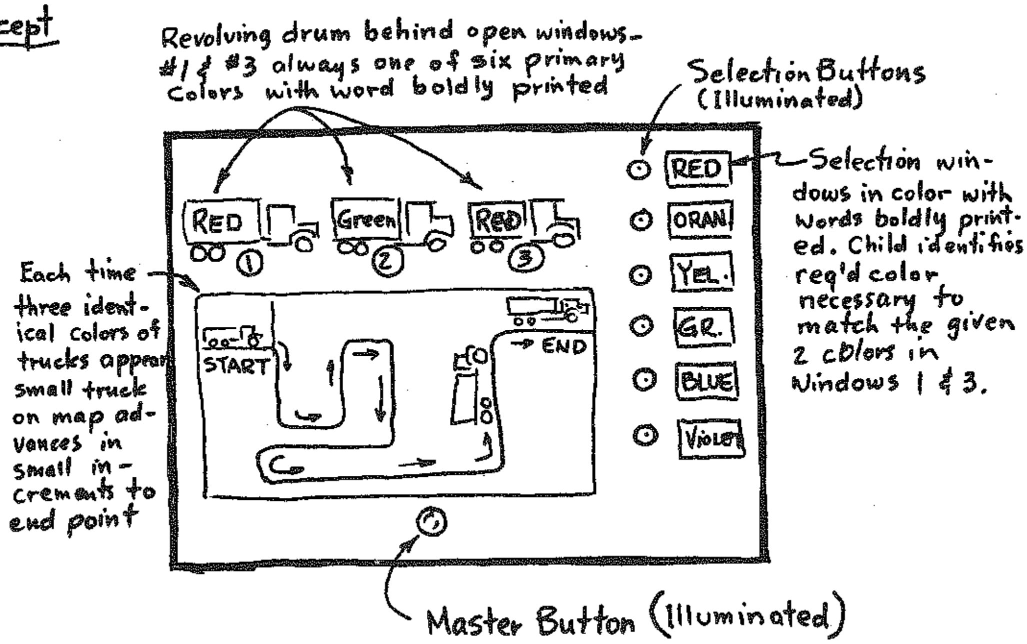
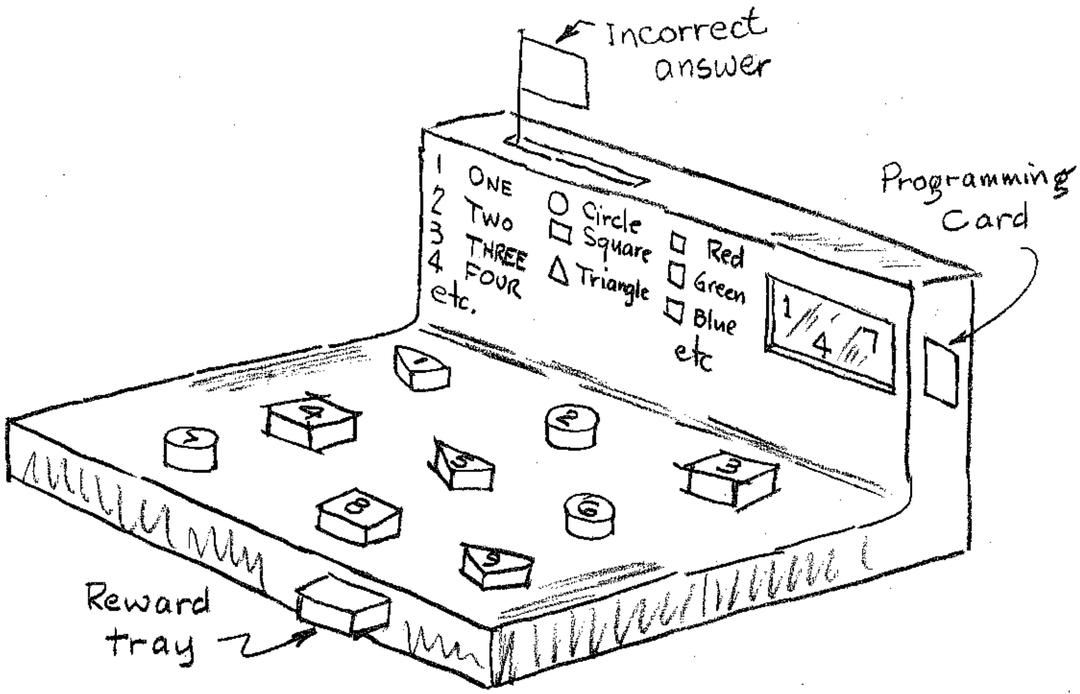


Figure 20 A toy to teach color identification.



1. Child selects one of a number of program cards and inserts into display window.
2. Child pushes pegs to correspond to program card receives reward for correct completion

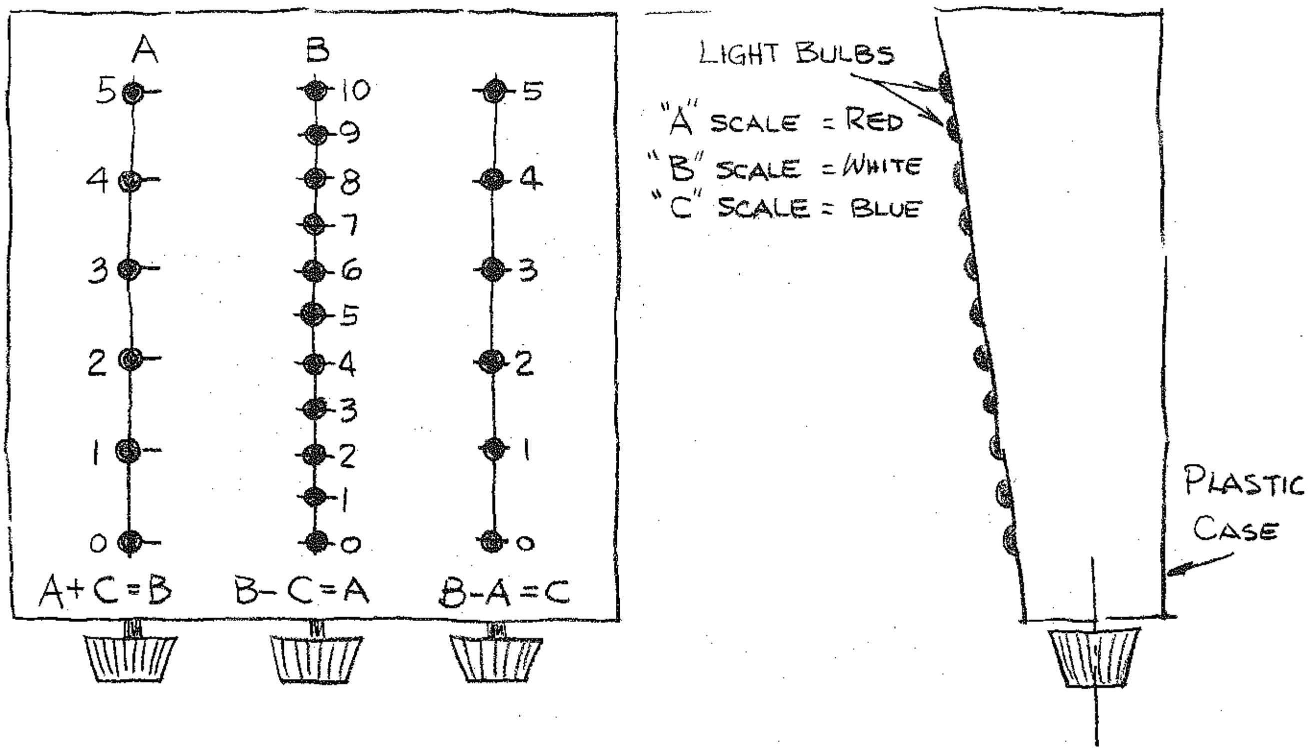
Program cards contain numbers, colors, shapes

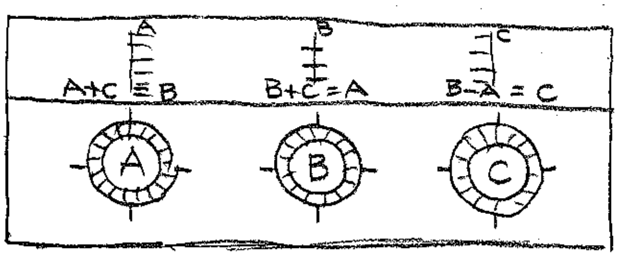
Program Card

Number sequence
Color sequence
Number-color
Shape sequence
Shape-number

Figure 21 A toy to teach colors, shapes and numbers.

PARALLEL SCALE NOMOGRAPH
FOR ADDITION & SUBTRACTION





SWITCHES "A" & "C" ARE 3-GANG, 5 POSITIONS

SWITCH "B" IS 3-GANG 10 POSITION

POWER SUPPLY 4 "D" CELLS

CASE COLOR – YELLOW

NO'S & LETTERS – BLACK

OPERATION

A+C=B

TURN "A" SWITCH TO LIGHT UP DESIRED NUMBERED BULB FROM 0 THRU 5.

TURN "C" SWITCH TO LIGHT BULB OF THE NUMBER TO BE ADDED TO "A".

TURN "B" SWITCH UNTIL ANSWER BULB LIGHTS UP.

SIMILAR PROCEDURE FOR OTHER TWO EQUATIONS

LIGHTED BULBS WILL ALWAYS DESCRIBE A STRAIGHT LINE ACROSS FACE OF TOY.

Figure 22 A toy for teaching addition and subtraction.

SECTION II

The following problems are outlined in a manner similar to Section I. No sketches are included.

I. PLAYGROUND SAFE DRIVING PRACTICE RANGE

IDENTIFICATION OF NEED

1. Increasing number of serious and fatal automobile accidents.
2. Reliable sources say most of these accidents are due to driver error
3. Any significant improvement in driver training should help reduce accidents
4. Good driving habits instilled at an early age should carry over to teen age and adulthood

GOAL

Design a playground layout with equipment to be used to teach safe driving practices to children in the age group of 5 - 10 years.

TASK SPECIFICATIONS

1. Playground layout should be such that a child can use it intelligently with a minimum of adult supervision
2. Playground equipment items should be simple and rugged in construction. Electrical and complicated mechanical equipment should be avoided.
3. Should be attractive to children and in the nature of a serious game.

II. FENCE GATE

NEED

A fence building firm has observed the need for a device to open and close large range-fence gates to permit passage of vehicles.

PROBLEM

You are assigned the project of designing and developing an all-weather apparatus that is mechanical in nature. The apparatus shall be triggered by the vehicle, not by the operator.

TASK SPECIFICATION

1. Vehicle triggered
2. All-weather proof
3. Overhead clearance required

IDEATION

1. Double swinging about vertical hinge
2. Inclined pivot with swingout gate
3. Inclined track with rolling gate
4. Pivoted and vertically operated gate

III. BLACKBOARD CLEANER

NEED

Everyone is familiar with dirty blackboards or chalkboards. They are supposedly clean but really are streaked, discolored, dusty; there are dusty chalk rails, dust on handkerchiefs and clothing; janitor's water pails with dirty water, rags, and sponges are in evidence. In spite of "new erasers", dustproof chalk, and "perfected" washing machines, these blackboard conditions are with us today.

GOAL - PROBLEM STATEMENT

Develop a system, device or machine to obtain clean chalk boards.

TASK SPECIFICATIONS

1. Must remove all colors of chalk markings
2. Must operate without dispersing dust
3. Shall produce a uniformly clean surface
4. Shall operate on plane surfaces only
5. Must not damage or cause excessive wear to the chalkboard surface
6. Must clean the corners and up to the extreme edges of the writing surface

IDEATION

1. Brush, - rotary
2. Vacuum device
3. Pad-type wiper
4. Chemically treated pad or cloth
5. Power to operate rotary parts, - 110-115 volts AC
6. Possible friction power source, hand or motor operation
7. Friction brush
8. Liquid cleaner with blower to dry the board
9. Operate on a track

IV. MESSAGE RELAY SYSTEM FOR PRIVATE RESIDENCE

NEED

Many types of messages need relaying every day in our homes. There are a number of separate systems in existence for relaying of routine and emergency messages. Much duplication of components exists in present systems. Many devices could be combined into an integrated system for efficiency and economy in price and size.

PROBLEM

Design a convenient home system for relaying messages of all kinds.

TASK SPECIFICATIONS

1. Easy to install in an existing or a new home
2. A basic system with flexibility for additions
3. Retail selling price of basic unit $250.00 (sensors and installation extra)
4. Easy maintenance access
5. Should have a circuit continuity test provision
6. Two-way communication at all stations
7. Types of message sensors
   (a) Emergency:
       fire
       trespass (theft-vandalism)
       weather
   (b) Routine
       awaken family
       meal call
       mail call
       telephone message
       monitor rooms
       entertainment
       record messages
       monitor mechanical equipment
8. Compact and aesthetically pleasing
9. Operate on 110V-60 cycle if electricity is required
10. Must conform with Underwriters, Uniform Building Code, National Electrical Code, and FHA

IDEATION

Fire: thermocouple set for different temperatures in various rooms

Trespass: pressure switches, light beams, trip wires, broken contacts on doors and windows

Wind: Generator or anemometer to trip switch when wind velocity exceeds gale (45 MPH)

Mail: pressure switch

Efficiency Lights: instrumentation to actuate light when an air conditioning, water pump, or combustion unit is operating below efficiency, thus indicating needed repair

V. NEW RIDE TO SUPPLEMENT BACKYARD GYM SETS

NEED

The consumer service department of a large nation-wide store has had requests for a new ride to supplement backyard gym sets or playground equipment. New items would provide additional variety and help to up-grade the existing product line.

PROBLEM - GOAL

Design a new piece of playground equipment to provide a new and novel play movement. May either attach to present standard equipment items or be used independently.

TASK SPECIFICATION

1. Age range - 3 to 12
2. Cost - maximum $100.00
3. Environment - backyard of a private home
4. Design requirement
   (a) compatible with our existing line of equipment
   (b) can be used without supervision of children

IDEATION

1. Eccentric glider type
2. Spiral - conical - helical slide or ride
3. Modified parachute drop
4. Para-glider
5. Revolving teter-totter
6. Air ride around yard, - monorail
7. Spinning saucer
8. Trapeze glide

SECTION III

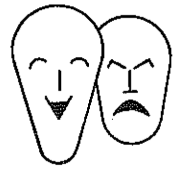
The following list of problem statements was originated in the workshops. These were not developed because of time limitations.

1. Design a handle-latch for a one-way door such that it is obvious which way the door opens without having to read the words PUSH or PULL.
2. Design a device to open a can and form a pouring spout out of its own material.
3. Design a device for aiding an arthritic patient to fasten shirt or any wearing apparel buttons similar to the way a shoe horn simplifies putting on shoes.
4. Injuries incurred when farm tractors overturn are not uncommon. Design a device to warn the operator of impending overturning danger.
5. Design a device for the automobile which will signal and warn a driver that he is following too close to the car ahead of him.
6. Design self-illuminating signs which at night will be visible to highlight critical signs beyond the illumination range provided by headlights.
7. Design a fence tensioner holder to make it easier to install the end support.
8. Design educational devices that could be used in Project Headstart to develop cognitive and manipulation skills in scientific principles for pre-school children.
9. Design a seat belt which a driver can fasten with either left or right hand without taking the other hand from the steering wheel or his eyes from the road.
10. Design the arrangement for a two-car garage for a space so restricted that the automobiles must be stacked one above the other and so that entry to both spaces must be made through one and the same garage door.
11. Design a device to maintain registration of transparencies that are used with overhead projection equipment.
12. Design a water pitcher that will prevent ice cubes cubes from falling into the water glass and which will discourage the ice cubes from disturbing the water flow while pouring.
13. Modify the design of a standard collapsible wheel chair so that the width may be fixed at one or two values (in addition to the standard width) to enable use of the chair through slightly narrower doorways such as are encountered occasionally.
14. Design a vandal-proof automobile radio antenna.
15. Camping kitchen equipment and food supplies usually are disorganized and carried in variour containers. Design portable rain and windproof containers sufficient in volume to accommodate utensils, canned goods, dry staples, and miscellaneous items. Equipment to be compartmentalized and capable of being set up independently and level.
16. Various size soap boxes on a conveyor are being filled from a hopper. Design a device to transfer the on-coming empty boxes into exact position under the filling spout and then remove them. The linear transfer should be limited from six inches to ten inches in increments of one inch.
17. Devise a method of construction to provide a smoother and more durable roadway at railroad crossings.
18. Design a highway emergency kit to enable stranded drivers to communicate with other motorists by signs such as: NEED GAS, NO SPARE, SEND POLICE, etc.
19. Design a silencer for a power lawn mower.
20. Design a fail-proof system for closing of a fire door and/or a method for pin-pointing location of the fire.
21. The company you work for manufactures various types of fasteners. Design a souvenir to be distributed at a convention illustrating one or more of your company's products.
22. Design a device for use on an antomobile to determine, while in motion, which wheel is out of balance.
23. Design a device to hold and quickly rotate an automobile through 90^0 to allow easy access to the bottom of the car.
24. Design an aircraft fuselage escape window that will come loose and pop out or lift out with the use of one button instead of the two or three procedural steps or operations now required and which may be forgotten or fouled up by frightened passengers during an emergency.
25. Devise an automatic cut-off for directional signals which are still "blinking" when the driver of the vehicle does not intend them to be operating.
26. Design a device for changing light bulbs in rigid open sockets and which face downward on 10 foot ceilings.
27. Design a tricycle that incorporates the adjustments necessary to meet the requirements of a young child of almost any size and age.

PROGRAM

The Seventh Summer School for Educators of Engineering Graphics

ENGINEERING GRAPHICS AND DESIGN



June 15, 16 and 17, 1967
Michigan State University

WEDNESDAY, JUNE 14

	5:00-8:00	Registration and Coffee

THURSDAY, JUNE 15th

A.M.	8:00-9:00	Registration
	9:00-10:30	Welcome, Edward W. Jacunski
		Introduction, Percy H. Hill
	10:45-12:30	A Design Case History, William S. Chalk
P.M.	12:30-2:00	Lunch
	2:00-4:30	*Workshops-Identification of needs, writing of design projects, writing of case studies.
	5:00-6:00	Informal discussions

FRIDAY, JUNE 16th

A.M.	8:00-9:00	Review Assignments, Peter Z. Bulkeley
	9:00-10:30	The Task Specifications Phase, Paul W. Hait
	10:45-12:30	The Concept Phase and Graphics, Paul W. Hait
P.M.	12:30-2:00	Lunch
	2:00-4:30	Workshops-Writing of Task Specifications and Conceptual Design.
	4:30-6:00	Informal discussions

SATURDAY, JUNE 17th

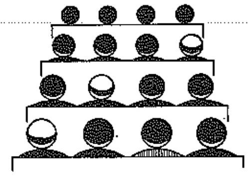
A.M.	8:00-9:00	Review Assignments, Peter Z. Bulkeley
	9:00-10:00	Design Solutions and Graphics, Paul W. Hait
	10:30-12:30	Curriculum Planning and Course Outlines
		Jerry S. Dobrovolny Henry O. Fuchs Wilfred P. Rule George C. Beakley
P.M.	12:30-2:00	Lunch

2:00-3:00	Evaluating a Design Project	
	William S. Rogers Ernesto E. Blanco	
3:00-4:00	The Design Solution	
	Henry O. Fuchs William S. Chalk	
4:00-4:30	Summary and Conclusions	
	Edward W. Jacunski Percy H. Hill	
6:00-8:00	Dinner-Automotive Safety Research	
	Francis M. Coffee	

* Workshop Leaders:

Ernesto E. Blanco, Tufts University
Peter Z. Bulkeley, Stanford University
William S. Chalk, University of Washington
Ronald J. Placek, University of Illinois
Alan K. Karplus, Western New England College
Borah L. Kreimer, Northeastern University
William B. Rogers, United States Military Academy
Wilfred P. Rule, Northeastern University

CONFERENCE ATTENDEES



Almfeldt, M. W.	Iowa State Univ.
Ackert, Hugh	Univ. of Notre Dame
Arnold, J. Norman	Purdue Univ.
Autore, Donald	Arizona State Univ.
Baggs, William	Rochester Inst. of Tech.
Barylski, John R.	Southeastern Mass. Tech. Inst.
Bauer, Emory A.	Corning Community College
Beukeman, Henry	Western Mich. Univ.
Binder, Kurt	Univ. of Mich.
Bissey, Charles R.	Univ. of Mass.
Blevens, Craig	Univ. of Miss. @ Rolla
Black, Earl	General Motors Inst.
Blanco, Ernesto	Tufts Univ.
Bosscher, James	Calvin College
Botkin, Kenneth	Purdue Univ.
Brach, Philip	Northern Virginia Community College
Bryenton, David C.	Wright State Campus
Bulkeley, Peter Z.	Stanford Univ.
Butler, Robert	Iowa State Univ.
Byers, Roland O.	Univ. of Idaho
Burnett, James R.	Mich. State Univ.
Bynum, Maury L.	Triton College
Casey, Frank J.	Univ. of Colorado
Chalk, William S.	Univ. of Washington
Christenson, Robert J.	General Motors Institute
Christianson, L. C.	Univ. of Missouri
Christman, Webster M.	Univ. of Wisconsin
Clark, Yvonne Mrs.	Tenn. A & I State Univ.
Cole, Victor B.	Univ. of Hartford
Coleman, Ralph M.	Univ. of Texas
Cooley, C. C.	Univ. of Detroit
Covvell, George J.	Univ. of S. Florida
Davis, James M.	U. S. Military Academy
De Guise Claude	Ecole Polytechnique
De Jong, Paul	Iowa State Univ.
De Serres, Charles	Ecole Polytechnique
Devereaux, Alfred	Ohio State Univ.
Dixon, James D.	East Tenn. State Univ.
Dobrovolny, Jerry S.	Univ. of Ill.
Dowling, Wayne C.	Iowa State Univ.
Earle, Jim	Texas A. & M.
Eide, Arvid	Iowa State
Eller, Margaret Mrs.	Ferris State College
Eubanks, William	Mississippi State Univ.
Facey Betty (Mrs. Thomas)	Univ. of N. Dakota
Felbarth Wayne	Univ. of Detroit
Foster, Robert J.	Penn. State Univ.
Fuchs, Henry	Stanford Univ.
Giannetti, Frank	Penn. State Univ.
Goss, Larry	Oklahoma State Univ.
Griswold, Edward	The Cooper Union
Grubb, G. C.	Univ. of Texas
Hammond, Robert	North Carolina State Univ.
Hartt, James P.	Univ. of Windsor
Heppinstall, Robert S.	Univ. of Mich.
Hill, Ivan	Ill. Inst. of Technology

Hill, Percy	Tufts Univ.
Houghton, James E.	Univ. of Notre Dame
Jacunski, E. W.	Univ. of Florida
Jenkins, Herbert T.	Univ. of Mich.
Johnson, William C.	Kent State Univ.
Karplus, Alan K.	Western N. E. College
Keith, Charles	Kent State Univ.
Kollin, John	Penn State Univ.
Krause, Henry	Mich. State Univ.
Kreimer, Borah	Northeastern Univ.
Kroner, Klaus	Univ. of Mass.
Larue, F. L., Jr.	Univ. of Southwestern La.
Lewis, Rlaph	Duke Univ.
Lindsey, Clifton	Univ. of Alabama
List, Kurt	Valparaiso Univ.
Lutz, Paul	Univ. of Louisville
Lux, George	Valparaiso Univ.
Luzadder, Warren J.	Purdue Univ.
Manner, Ernest F.	Univ. of Wisconsin
Marginson, Kenneth F.	Dalhousie Univ.
Marken, Marzale	Lake Superior St. Col of Mich. Tech. Univ.
McDonald,A. P.	Rice Univ.
Metcalf, Henry B.	Univ. of Maine
Mosillo, Francis	Univ. of Ill.
Muehlhauser,	N. Dakota State Univ.
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Northrup, Ralph T.	Wayne State Univ.
Packer, Jack	Purdue Univ.
Pare, Eugene	Wash. State Univ.
Pankratz, George	Univ. of Toledo
Pfeffer, Charles	Wichita State Univ.
Phillips, Robert V.	Univ. of Wisconsin
Pidgeon, Clarke W.	Queens Univ.
Placek, Ronald	Univ. of Ill.
Porsch, J. H.	Purdue Univ.
Raouf, Abdul	Univ. of Windsor
Reed, Eldis O.	Ohio State Univ.
Reynolds, R. W.	Calif. State Poly. College
Rising, Jim	Iowa State Univ.
Rogers, Hugh	Penn. State Univ.
Rogers, William	U. S. Military Academy
Romeo, Al	Ohio State Univ.
Rule, Wilfred, P.	Northeastern Univ.
Ruzekowicz, Donald	Onondaga Comm. College
Sales, Paul H.	West Virginia Inst. of Tech
Sanders, C. Gordon	Iowa State Univ.
Sautter, Eckhardt	General Motors Inst.
Sauvageau, Marc	Ecole Polytechnique
Schwebke, Howard J.	Univ. of Wisconsin
Slaby, Steve M.	Princeton Univ.
Smith, Frank	Univ. of Mich.
Smith, Thomas C.	Univ. of Nebraska
Spinney, Fred	Univ. of New Brunswick
Stinson, William	Queens Univ.
Street, W. E.	Louisiana State Univ.
Streitman, H. William	Georgia Tech.
Thompson, Richard	Purdue Univ.
Thornhill, Robert	Wayne State Univ.
Watkins, Fairfax	Ohio State Univ.
Wierzbicki, Lawrence J.	Rio Hondo Jr. College
Wilks, Ira Edwin	Georgia Institute of Technology
Williams, Herman	Univ. of Florida
Woodworth, Frank	Univ. of Detroit
Wrenshall, Clayton	Univ. of Toronto
Xistris, George D.	Sir George Williams Univ.
Yankee, Herbert W.	Worcester Polytechnic Inst.
Yard, Clifford	Millersville State College
Yencso, William R.	General Motors Institute
Zacher, Clarence H.	Purdue Univ.
Zemke, Wayne	Univ. of Wisconsin

SUMMARY
ENGINEERING GRAPHICS SUMMER SCHOOL

EDWARD W. JACUNSKI

Chairman, 1966-1967, Engineering Graphics Division, ASEE
Assistant Dean, College of Engineering
University of Florida

The words that you have just heard and the few more that I will add will bring the workshop portion of this 1967 Graphics Division Summer School to a close. The dinner tonight will be in the nature of a toast to your participation.

But, let us not feel that what we have attempted here should also come to a close -- instead let it be the beginning of a new and responsible role for graphics.

I am therefore, going to leave you with a charge. Each of you are left with a charge of responsibility! You represent about one-half of the some 270 accredited engineering schools in the country. Yours is a dual mission.

Each of you should go back to your respective schools and begin to experiment with design in your courses. Ask for an audience with your immediate supervisors.

Secondly, you should try to be influential in your area and set up regional conferences or hold discussions on graphics and design modelled after the summer school.

I know that each of you during these last three days of participation have been thoughtfully relating the proposals of this program to your own problems back home and have been wondering how to make applications. We know that many of you are merely representing your departments or division -- and that you are not in a position of command to make changes -- that unfortunately you will merely bring back a report that may fall on ears which have always been deaf.

In this case you will have to work from within. Maintain your enthusiasm, try to infect your colleagues, ask for permission to experiment with one or more sections of engineering graphics courses. Your success may prove infectious. Enthusiastic students are, especially in this day and age, the best propaganda medium on our campuses. You should remember that the goals study's recommendation states that experimentation should be encouraged. The division in turn will try to support you by publicity and continuous instruction. It just may happen that your leaders will get the word. We know that many of your courses have been pared to the bone timewise and some of you have lost your graphics identities by being absorbed by another department. If this is so - you will simply have to do the best you can within the limits of your confinement. You may have to abridge or skeletonize your efforts. But in your abbreviated presentation do not waiver from the goal that graphics is, and should be, presented as an integral part of the design function in engineering -- your bunt may turn out to be a hit!

Another question in your minds is, when? When should you start making changes? This year? Next year? Or should you wait awhile and see how others will make out?

My most sincere and serious advice is to do it now! Start immediately! Plan to have something going this fall! Enough time has already been lost and if you delay you will just be waiting for someone else to tell you what you should do. Some of you are on vacation or will not be back in your classrooms until next fall. But don't use this absence as an excuse not to think and plan -- when school does start you can alter your course outlines to incorporate some of the summer school work and thereby be in a better position for next year's more complete overhaul.

The Goals interim report is now out - it was published in April. The final report will be out late this fall and there will be very little in its recommendations that will be changed.

Make no bones about it - its impact on engineering education will be massive. Your various engineering departments are prepared to implement the Goals recommendations. If you have no tangible and acceptable proposal to justify your graphics goals, you may very well be wiped out in the ensuing time shuffle.

I repeat that this year is our year! Your year! By basing your planning, on what you have picked up here, you can present something solid and saleable. Graphics, as a terminal course in drafting, is dead! Graphics as a ladder to design makes sense, is very much alive, and will be bought.

The Goals Report has given us a new lease on life, but it also has given us a new hurdle. It has recommended two degrees. The four-year baccalaureate and the five-year master's. In many schools the five-year master's degree is an anachronism - particularly when they are now requiring five years to earn a B.S. To comply with the Goals study and to produce a four-year B.S. will require another time squeeze and another overhaul of all pre-engineering courses. Material that is considered unimportant will necessarily be thrown out. By having a substantial graphics introduction this fall, you will be anticipating this challenge for extra time, and by associating yourself with the design theme, you will be in a position of strength.

It has been reported that some of our best friends and big brothers are in the mechanical engineering departments, and those of you who are already divisions within mechanical engineering should congratulate yourselves for the additional strength and protection -- just cozy up a little closer and let them look over your shoulder.

The mechanicals are the one discipline that will be in the forefront in implementing the design concept. If they insist that graphics is important in pre-engineering preparation, other disciplines will probably go along with them.

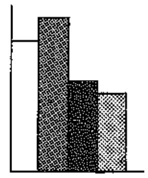
The division, through its Journal and other means, will strive to assist you with additional information and additional help. The Summer School Committee will remain active during the next year and will stand ready to help you in your efforts to organize and to organize others.
GOOD LUCK!

FOLLOW-UP SURVEY

19 ASEE 67

GRAPHICS SUMMER SCHOOL

RESULTS OF THE FOLLOW-UP SURVEY



Material Edited by

EARL D. BLACK

Product Engineering Department

General Motors Institute

Undoubtedly the ideas and concepts involving creative design gained from the Summer School participation should provide the basis for further development of profitable ideas which can also be used. One of the main values of attendance was the opportunity to examine the point of view of others. Many admitted that participation helped to stimulate creative thinking about creative teaching as well as what can be injected into diversified teaching methods. The workshop sessions divided the participants into eight groups. There were also eight different approaches as no group leader introduced his subject in the same way that others did. Introductions varied from the use of a student demonstration of a design project team solution to over a full hour lecture on design principles and teaching methods. Various procedures were also followed.

Most workshop sessions placed the participants in a student situation. Analysis of the problems took several directions within groups as well as differences between groups. Numerous options were offered as a solution for many problems. Most workshop sessions used the open-end design project approach with group analysis and choices in functional attainment, material proposals, and manufacturing processes necessary to production. Marketing problems and customer value based on probably use was often a part of group discussion.

Most returns of the questionnaire answers indicate at least some integration of basic design concepts into current courses in engineering graphics are in plans for the future at least on a trial and examination basis. A minority of participants indicated some doubt as to whether more than one or two units of creative design could be integrated into their current first semester engineering graphics courses. Others had previously used creative design to increase student interest in their basic courses and expect to use more. The majority of participants have used creative design in later courses especially prepared for advanced classes. All were interested in better methods of teaching and greater use of creative design at the earliest feasible time in the student's experience.

Remarks by individual members of the Summer School Committee and by members of the Project Selection Committee indicated that problem selection difficulty, in many cases, is mainly in reducing projects to the age, interest, and experience levels of the class group. Many of the design projects proposed required scientific and mathematical knowledge beyond the attainment of the average freshman engineering student. In some instances, this difficulty was just enough to challenge the student to greater learning. And there were numerous design project proposals which the Project Selection Committee reviewed that were appropriate for both beginning and advanced students.

General sessions of the Summer School not only provided review discussions but also guides were developed for both methods of teaching creative design and grading criteria for evaluating student progress.

The Project Selection Committee used a seven-point outline as a guide to project selection. The seven steps follow a project <u>from the abstract to actuality</u>.

1. Defining design objectives -- analysis (background, known facts).
2. Ideation -- creativity and solutions --
   a) How many ways can it be solved?
   b) Thought starters - making a list of values.
   c) Similarities, environmental requirements, inversions
   d) Check list, brainstorming, material options.
   e) Is there a simpler way?

3. Synthesis -- application, functional requirements evaluation
   a) What makes a good design good -- economy, simplicity, reliability, ruggedness, usefulness, attractiveness, easy to fabricate, easy to promote in sales, easy to service.
   b) What are the alternatives.
4. Optimization -- materials selection, interchangeability, economical manufacturing processes, easy to operate, use of standard parts, final decisions.
5. Detailing -- development, checking.
6. Testing -- debugging, improvement and redesign for aesthetic refinements.
7. Marketing -- staff training, servicing and special tools at a minimum cost, getting the most for the least, low maintenance costs, customer acceptance.

Remarks during general discussion indicated that engineering graphics should be taught as an effective method of communicating engineering intent, especially for today's computer drafting and design requirements, and projects should be used as a vehicle for increasing student interest and enthusiasm in graphics courses. Students are likely to learn more effectively if they see a need. It was generally agreed that there should be no let-up in teaching fundamentals of projective geometry as a basic science to communication of design and engineering idealogy.

Quoting from the Interim Report of the Committee on Goals of Engineering Education *

> "The engineer should be able to visualize spatial relations and to supply graphical techniques for the analysis and synthesis of complex relationships . . . . Interest in thie important area has been renewed as a result of the expanded use of the computer as a graphical tool ---" and "Throughout the curriculum the student should have experiences with synthesis and analysis in research and design ..... The aim is to encourage creativity . . . . judgment and innovation should be encouraged. In the design project the student should gain experience in the use of optimization techniques and decision theory which require consideration of performance, scheduling, reliability, and cost.
>
> "The importance of creative design in both the undergraduate and graduate programs deserves the immediate attention of engineering educators.
>
> . . . . Analysis and synthesis in the design and development of complex engineering systems dealing with problems as a whole must have greater attention and emphasis."

---

* Interim Report - April, 1967, page 73

This extract from the Goals Interim Report places the teaching of creative design high on the list of engineering education objectives. The future and direction of the Graphics Division will be just what we make it.

Eighty-six participants in the Divisional Summer School answered the request to fill out and return a twenty-one question form with explanations and remarks. A few returnees did not answer all the questions and some had mixed answers (answering some questions more than once and in conflict). Perhaps answers were scored as yes answers in the composite which follows.

1. What were the most significant ideas or concepts you personally gained as a result of your attendance at summer school?

- Change in the field of 4-year level design possibilities.
- Chance to talk to experienced men.
- It gave us a chance to compare our own work with others.
- That creativity can result from concentrated effort.
- Nature of design and how to teach it to freshmen.
- The Division was placed on the correct road!
- An awareness of "things around us" which could be used for creative design problems.
- Design projects are powerful motivators but will succeed in telling very little if the knowledge of engineering drawing is lacking.
- The various approaches to teaching design and opinions when design should be taught and the workshops.
- Statement of the problem situation for the student has been made much easier.
- Various methods to arrive at a design project from students.
- The change in attitude toward graphics.
- Gained more confidence that this is a workable approach.
- The teaching of design processes early is practical.
- Discussion of current programs and examples of what others are doing were valuable.
- Probably new ideas for design projects.
- Development of design problems by systematic listing of steps in design process.
- Detailed lab experience through workshop sessions.
- The concept of creative design introduced at an early stage of the engineering curriculum.
- That this has worked at other institutions at the freshmen level.
- The how and why of design concepts from identification to solution.
- Ideas of design can be of value although they come from beginners without knowledge and background in materials and processes.
- Stimulating and a new approach to teaching graphics.
- A unified approach to the teaching of engineering design.
- Gained some backing on a local administrative level for adding a course in design at the freshman level.
- The wide divergence of opinions between engineering educators on what to teach and how to teach creative design.
- Enthusiasm of discussion leaders for design.
- I couldn't "feel" that the majority were going "home" and do something about design.
- I put in a unit on creative design.
- I am now convinced that creative design courses should be offered but at a junior-senior level.
- Let the student see a need.
- Show the student how to find information needed.
- Such a task specification enhances the desirability.
- He should have some training in use of engineering tools (graphics, stress analysis) first.
- Almost complete agreement on the responsibility for teaching design in graphics.
- I was sold on creative design courses -- this confirmed and enhanced it.
- I got a valuable assortment of the intellectual background of graphic teachers.
- The workshop sessions went a long way to illustrate how a sequential guide works in application.
- The ease with which design can be introduced in a graphics course.
- The "good old days" are gone and we are finally changing teaching methods.

2. Do you subscribe to the contention that a unit on creative design should be included in your present graphics courses? =

	Yes	No
	72	6

Explain:

- I believe that the worth of a unit on creative design lies in its value to let engineering students get an early look at the total overall process of engineering design.
- Should be a separate course following engineering graphics.
- In many schools time is so limited as to make it difficult to teach basic fundamentals.
- The freshman learns about the need for his other subjects.
- To the extent that all problems should be "open-end" in nature and graduated in complexity.
- Should be integrated into sketching and instrument drawings to sell the importance of graphics as a means of communication, synthesis and analysis.
- To get across the design concepts for future use.
- Only a single assignment after the basics are taught.
- I would like -- but the Engineering School which I serve wishes me to give only communication.
- Our program is already scheduled, however next year we do.

- Would have been very helpful to us four years ago as a practical example of engineering.
- We use small equipment design.
- Puts drawing in its proper context.
- The design problem is a motivating force.
- Is not necessary.
- I like the idea very much but our college is trying to eliminate course work.
- Freshmen and sophomore students are all we have in graphics and they have not had sufficient engineering education.
- Some knowledge of basic fundamentals must precede the design project.
- Graphics is the proper vehicle for instruction in creative design.
- It adds interest in graphics and most important, meaning to graphics and engineering.
- Excellent and realistic use of graphics training, real-life experiences.
- The design project should also include a report from students.
- Junior College transfer of credit has kept us from getting into creative design.
- Our freshmen have not had enough engineering background to do a good job.
- Design is integrated into the present course but not a specific unit.

3. Have you, within the past two years, exposed your students in graphics courses to creative design experiences in a similar manner to that which constituted the theme of the 1967 summer school? = Yes 48, No 36

Remarks:

- Not the experience, but the processes were included in the lecture.
- We teach a full 12-week course in design as well as integrate design with beginning graphics.

4. What percentage of time (see selections) do you feel should be allotted to freshmen in creative design?

	Per cent	Clock Hours
One 10-week course	10 to 15 = 18	30 = 10
Two 10-week courses	20 = 17	20 = 7
Three 10-week courses	25 = 11	24 = 5
One 15-week course	33 = 6	60 = 5
Two 15-week courses	50 = 6	18 = 4

Remarks:

- I am not sure any time should be a general statement.
- Design should be the theme of the courses with necessary disciplines taught which are not covered in other courses; for example, graphics.
- The concepts of design should be introduced but no large amount of time should be devoted to pointless problems.
- It should be a substantial component of every engineering course.

5. If you have not previously included creative design in your graphics courses, will you now include it as a result of your summer school attendance? =

Yes	No	Uncertain
41	7	2

When?
1967 = 16
1968-69 = 12

6. If your answer is YES to #5, how will you compensate for the additional time requirement imposed by including creative design in your graphics courses? Please explain.

Remarks:

- Cut down on repetition and less pertinent items.
- More effective teaching methods and self study aids.
- By elimination of "practice" problems,
- Reduce formal topic presentations, work more on a need-to-know basis.
- Integration with other courses being revised.
- No additional time needed -- design is the vehicle which carries the graphics if planned right.
- Designing creates a need for communication that automatically will bridge the gap if proper planning is done.
- Increasing time allotted to graphics in first year; second-year graphics to be entirely design oriented.
- Integrate with unit on mechanisms and with unit on structural drafting.
- Almost completely omit "techniques" and skills.
- Should not be cook-book steps

- By a change in approach to some traditional material.
- Between descriptive geometry and technical drawing the last suffers most.
- We would balloon our offerings to include as an elective and if the response is good, then enter it as a required subject.
- Redesign the course content.
- Decrease descriptive geometry and graphical math.
- By incorporating creativity into the course material and deleting some skill exercises -- working drawings, dimensioning, and complicated intersections.
- No additional time needed -- design is the vehicle which carries the graphics if planned right.
- Designing creates a need for communication that automatically will bridge the gap if proper planning is done.
- Increasing time allotted to graphics in first year; second-year graphics to be entirely design oriented.
- Integrate with unit on mechanisms and with unit on structural drafting.

7. Will you include a unit of creative design on an experimental basis in an experimental section? = Yes 36, No 22

Remarks:

- Would like to do so.
- School is too small.
- During summer school.
- Upon approval of department head.
- All classes receive design as regular part of course.
- Not experimental in our courses.
- Not as a fixed part of our course.
- Plan to institute a one-semester, two-hour course as an alternate to descriptive geometry.
- In mechanical engineering only.
- Depends upon individual instructor.
- Expect to enter it 100 per cent when we begin in 1968.
- We are not going to just experiment; we are committed.
- About 60 per cent of our students have not had drawing and must be taught basic graphics also.
- Will lead all sections through a small project "by the numbers."

8. If on an experimental basis, how many sections will have this exposure?

A. Number of experimental sections planned =

Number of experimental sections planned	1	2	3	4	5
=	9	7	3	3	2

B. Total number of graphics sections per year =

Total number of graphics sections per year	2	3	4	5 or 6	8	10	11	15	16	17
	1	1	1	4	3	1	2	1	2	1
	18	21	22	30	35	50	65	85		
=	2	1	1	3	1	1	1	1		

C. No definite plans to date = 2

9. Will you (or do you) assign one design project to all of your graphics sections? = Yes 35, No 41; Plans not yet made = 3

Remarks:

- These questions assume a "design" format which may or may not exist.
- There are usually several projects assigned to each class.

10. Will you (or do you now) assign a different design project to each of your graphics sections? = Yes 31, No 42; Plans not yet made = 3

Remarks:

- Now each student selects one project.

11. Will you (or do you now) provide your students with a list of recommended design projects from which a selection must be made? = Yes 41, No 34

Exact plans not made = 3

Remarks:

- We allow student ideas also.
- The faculty member chooses the project.
- Special projects may be selected with instructor's approval.
- This is my goal.
- Two projects are free, two are specified.
- Might consider.
- This complicates things for the future.
- Students submit individual projects from which group projects are selected.
- First project only.
- In the future.

12. If Yes to #11, will you (or do you now) narrow the selection down to one design per section? If no, how many projects per section?

Yes	No
13	35

1 to 3 = 1
2 or 3 = 6
3 or 4 = 7
4 or 5 = 9
5 or 6 = 2

- Exact plans not yet made = 2

13. Will you (or do you now) divide your sections into organizational working groups for their design projects?

	Yes	No
(For one project = per section)	25	33
(For more than one = project per section)	29	23

Not sure = 4

Remarks:

- Have tried but does not work as well as each student working alone.
- Have had much success with team projects at junior and senior levels.
- I allow my students to work in teams of 3 to 5 members and we use a minimum of formality
- We use competition between students to stimulate creativity and use industrial people as judges.

14. Will you (or do you now) permit students to originate their own design projects? Please explain. Exact plans not yet made.

Yes	No
52	25

Remarks:

- If possible.
- It depends on the student and the type of subject.
- If student's interest in a particular project is high.
- Problems are all from a workbook having a variety of projects, but none which require student organization.
- It takes too much time for a group of students to get started if they must first select a project from their respective interests.
- Expect to follow methods developed at summer school.
- Only if they have advance experience in an aspect of engineering.
- Probably one assignment will be of this nature.
- Ideas will be brought in by individuals; they will be listed and discussed, then reduced to at least 2 and worked on by teams.
- Allow students to work on some ideas or design what they choose, otherwise assign projects.
- There must be a "control" here and if no reasonable project is suggested, then the instructor must suggest.
- Our first project is introduced this way so that the student has a drill on the design process.
- A very few allow some choice.
- They get out of hand.
- Not usually.

- In advanced course only.
- I will attempt to do this in the future.
- We asked for project suggestions from which some selections are made by the faculty.
- This was tried and dropped.
- We do it for at least one project per year.
- Design is too much a pedagogical tool to leave selection to students.
- Gives the student a chance to decide if he is interested in engineering.
- Must be approved by graphics staff.
- Allow C. E. students to choose one project at end of course at present.
- Their choices are usually too complicated for time available.
- One original project during the year.
- Have permitted them in past but results not impressive.
- We teach them to identify and select needs.
- If they do not like the assigned project, they are free to select one of their own.
- Probably not, unless an unusually good project is proposed.
- Should encourage students to develop a list of human needs.
- Perhaps on later assignments.
- A creative design must by definition be, to some degree, more or less spontaneous.

			Yes	No
15.	If Yes to #14, will you (or do you now) discourage the development of design projects which do not for any reason meet your approval? Please explain.	=	38	14

- Our ambitious projects are reduced or replaced to suit time limits.
- We do not discourage them but they may not receive credit for it.
- Try to avoid too easy and too hard projects.
- Give them wide latitude and fatherly advice which they may ignore.
- If they do not fall within the design criteria assigned.
- Many students over-extend themselves.
- A suggested project can easily be beyond the ability of the freshman student because of previous requirements.
- The instructor should reserve the right to screen ideas as is true in industry.
- The instructor should try to avoid influencing the student with his own ideas.
- No project will be discouraged if it seems to show possibilities.
- Most of those turned down either have selections on the market or are too simple.
- The idea is more important than the execution.
- For the first time I would accept it to give less imaginative students a better chance to develop.
- I hold problem within limits of available information and student knowledge and ability.
- We try not to destroy individual initiative.
- I will listen.
- If too involved for their maturity, will be a waste of time.
- If a student suggests a good design project, I ask his permission to assign it to others as well.
- Only best projects are completed.
- We have no experience as yet.

		Yes	No
16.	Would the fact that a freshman has only a limited background in mechanics, materials, processing, etc., prevent you from introducing a unit on creative design in your graphics courses? Please explain.	8	76

- You have to start somewhere.
- I feel that freshmen can be taught much about creative design with the limited tools he has at this level.
- Care should be taken that the student will not be called upon to absorb so much material and background that he loses sight of the project.
- To carry the project to a satisfactory conclusion.
- Learn by doing.
- Avoid complicated concepts; instructor should help the student with unfamiliar concepts.
- Let the student see a need.
- This would only inhibit creative expression.
- We all have limited experience.
- The design process can be followed on the simplest project and yet create interest in methodology.
- It would at least cause the student to think.
- They are required to do some research.
- Creativity and imagination is stronger with freshmen than seniors. We do not wish to suppress this talent.

- I hint at what to expect, but do not tell the student this.
- Limitations can be practically overcome by conference and study.
- Conceptual design requires imagination basically.
- There are many creative design projects that do not require engineering experience.
- I plan design problems around available standard parts.
- Projects encourage independent research and investigation.
- I would try to exercise some control over students who "get in too deep."
- Material information can be presented as needed.
- Would select projects not requiring a full background for engineering design.
- He knows much; can learn as needed (real designers are in same fix).
- Can use graphics without engineering background for communication of creative design.
- Gear it to student background and rely on realistic research to fill our background.
- The units we use are done with the idea of using graphics, not a deep study.
- Too much time taken from basic courses.
- The assignments can be structured to account for limited background.
- Design by nature is partly grouping and seeking.
- We would want the final design based on sound engineering judgment and choice.
- We do not expect a manufactured product, just an experience.
- Creative design can be involved without complete kit of design tools.
- The problem solving process is the key here, not the project.
- Design need not be limited to "mechanical" devices.
- We will ask other departments to work with us.
- They are aware of many of needed areas from other experiences.
- Generally help is given so as not to frustrate the student.
- We must all work within our limited backgrounds.
- Designs which are essentially visual in their solutions can be readily handled.
- The type of design project need not concern itself with mechanical details; lack of knowledge of processes is a limiting factor in design solution.

17. <u>Do you feel the workshop sessions were vital and worthwhile experiences? Please explain.</u> = <u>Yes</u> 81 <u>No</u> 3

- While I may not at present, there is a future.
- To be able to apply.
- If I thought they were necessary: a) working with other people, b) give insight on some of our solutions with which a student is faced.
- They gave opportunity for give and take of ideas.
- Many methods, devices, and testing were considered.
- A better feel for objectives.
- The ideas were good; our problem is where to use them.
- For demonstrating and explaining the design process.
- Need more such meetings.
- Presented an organized approach to teaching design.
- Worthwhile, but not vital.
- New insight.
- I think they jammed in effectiveness.
- Lacked continuity.
- It could not have been done otherwise.
- It placed me in the position of one of my students.
- The actual involvement was important.
- Too much close-mindedness on the part of workshop leaders.
- Procedures and methods of supplementation were of great value.
- These sessions brought the general ideas down to practical specific cases.

18. <u>Would you have changed any phase of the summer school in order to increase its effectiveness? Please explain specifically.</u> = <u>Yes</u> 42 <u>No</u> 36

- Perhaps a week's duration would have enabled us to have a complete lab experience to work through one design concept.
- I feel that we are going into a great upheaval in handling situations and ultimately make or break the graphics department as a major part of the engineering schools.
- Family accommodations were extremely expensive; this is vital to E. G. section.
- Increase industrial participation.
- We would welcome ideas as to what to eliminate to make room for this kind of instruction.
- Effective as it was.
- Pace was too fast; wore me out on Friday.
- Widened concepts of design projects.

- Why not give a few "instructors" instruction on instructing!
- Don't know.
- Hold in conjunction with annual meeting rather than before.
- Could have been longer!
- All preliminary work should have been available to each individual.
- I am afraid that a lot of worthwhile ideas will be lost in reporting.
- I would have arranged for more time during workshop sessions.
- I would have included more material on case studies.
- I think it was prepared with care and executed extremely well.
- Perhaps more active participation in solving design problems would be desirable; however, time from where?
- Extend to 4 or 5 days, carry design projects in workshops through to conclusion.
- Reduce speakers and papers to one day.
- Bit more specific instructions on redesign suggested.
- Too brief to be useful to graphics instructor as a first introduction to design.
- A more detailed discussion of the curricula offered by other institutions.
- Too much talk from platform.
- There was sufficient variety without limitation.
- Speakers with archaic and regimented thinking should have been left off the program.
- Design procedures seemed to have been over stressed.
- The use of graphics in design should have been the main emphasis.
- Reading assignments could have been assigned before arriving at MSU.
- More homework could have been required.
- The rigor could have been increased with night sessions.
- Put the group teams in competition with each other.
- Why not award the top three solutions.
- Charge each group with requirements such as a 10-minute presentation of idea, document proposal with sketches, and making of paper models.
- I think the time I spent in workshop was informative and helped me decide that a properly proportioned "creative design project" is not for freshmen.
- Improve presentation on grading projects.
- Provide some 5-minute breaks.
- Each department head should have an instructor along who does the teaching.
- Expand the concept of design to include all engineering effort, not just mechanically oriented devices.
- Increased opportunity for participants to know each other and faster start on projects.
- The session leaders should have had more specific instructions as to what they were to do.
- Give a couple of basic design project examples before the workshop group sessions.
- I think in general our problems are "people problems."
- Some of the late afternoon offerings on the last day did not measure up to the standards set by the rest of the seminar.
- Should have had more one-hour case studies with a speaker format to follow.

19. Do you think we should plan another summer school with the "Creative Design Project" as its theme? =

Yes	No
76	7

When? 1968 = 17
1969 = 37 1970 = 24
1971 = 8 1972 = 6
As soon as possible = 2

Remarks:

- We should know more about this and be allowed to talk over our failures.
- If it is in the South or West.
- My not being allowed to use it at the present time does not dampen my enthusiasm.
- It would be good for various section meetings over the country to hold sessions on teaching creative design.
- Other themes should be developed such as "Relations with Community Colleges," etc.

20. If it were offered again, would you attend? =

Yes	No
76	6

When? 1968 = 17

1969 = 29 1970 = 25
1971 = 18 1972 = 10

Remarks

- If new courses were offered.
- A member of the department can attend any time when held in eastern part of U.S. Budget will not stand for distances.
- I would send the other graphics teacher.
- I will bow to the majority.

21. Please summarize briefly your general opinion (pro or con) of the 1967 Graphics Summer School.

- Enjoyed it a great deal (listed by most).
- This program was quite different from what I expected.
- I feel that the 1967 conference was only a start; we should follow up with frequent such conferences.
- We need more young instructors participating.
- More time should be allowed for workshops and less to one-way presentation.
- Too many department heads or personnel ready to retire with the idea "Why Change Now?"
- Stimulating all around.
- Interest created in the freshman student may influence him to stay in engineering.
- Physical layout, efficient.
- My past problems were perhaps too specialized in scope to generate interest.
- Workshop sessions offered tremendous communication advantages.
- The give and take of ideas not explored in lectures is priceless.
- Papers could be sent to participants for advanced study.
- Was stimulating because participants were permitted freedom.
- The Summer School was a ready source of ideas.
- Summer schools in graphics are fine but should not be devoted to one phase nor dominated by one personality.
- I was glad to see some new faces in the graphics hierarchy.
- I feel that more attention should be given the two-year technology institutes. Time allotment is greater here.
- Could a similar program on computer graphics (practical) be given?
- This is the 4th summer school I have attended; the 1967 one was the best.
- Speakers were tops and well prepared.
- Should set up a post mortem committee -- pick out both good and bad.
- The workshop leaders know what they were doing and moved and worked with the situation.
- The workshops were the heart of the program.
- The theme of this summer school was essentially what we do with seniors.
- The program was well planned and administered smoothly.
- I would rather see graphics move in direction of mathematics.
- I do not believe any major and/or widespread changes will occur soon as a result of the summer school.
- It did not make a number of people consider design at the freshman level.
- I imagine that most of us have taken a new look at what we are doing.
- There may well be a long-range impact as graphic courses are gradually oriented more toward design.
- The Summer school was a great relief from sitting and listening to papers being read.
- A "design" project at the early freshman level may be just a high school "science project."
- The student should understand engineering processes first (graphics, etc.) then assigned practical problems.
- Perhaps a wider variety of people giving presentations would have broadened the scope of content.
- It helped answer the question, "What's wrong with the traditional graphics courses?" for many.
- The attitude of participants seemed more objective than in previous years.
- Participants seemed to be less scared of being misunderstood by professional colleagues or "the Great White Father," the Dean.
- Should evaluate results of experiments conducted in teaching design concepts at a later time.
- The summer school committee gets an A+ from me.
- The high degree of agreement on the general theme "Design as a Part of Freshmen Graphics" among the speakers and workshop leaders contributed to its success.
- It's always stimulating to meet others and discover how they solve the same academic problem you are having.
- It was an eye opener.
- Participant responsibility somewhat vague in workshops.
- It was difficult to evaluate the underlying objective.
- The summer school program was aimed almost exclusively at the design process, with only brief passing mention of graphics.

- I would much rather have discussion on methods of working design problems into a basic graphics course.
- Some of the summaries were good but may have been reduced in length.
- Design projects suitable for our own situation might have been pinpointed more accurately if some workshop sessions could be more homogenous -- split between technical and engineering.
- Local institution conditions vary so much that a series of brief presentations should have been given on various time and schedule circumstances.
- Too much time was spent in lecturing and setting stage in workshop I attended and the assignment for that day was not clearly stated.
- One day 15 minutes was left for creative effort among the team members that should have had several hours.
- I did not gain much from the work sessions.
- We would all benefit in future meetings from sharing experiences in integrating graphics in design projects.
- How can we get graphics and creative design in other engineering courses?
- The usefulness of the summer school is not to perpetuate dominance.
- The grading session was of little use on such a program.
- In some sessions too much time was spent on unimportant subjects.
- No real uniformity in how creative design instruction is being accomplished.
- The workshop was indispensible for a conference of this type.
- There were some "flags" and "towels" both in the audience indicating that design is to replace computer, mathematics and analytical of a few years ago.
- We should not have another summer school just to rehash what was presented in Lansing.
- Convinced me that experiments in creativity with freshmen excite an interest in everything and supports graphics in the curriculum.
- More specific information on how present users of the design approach actually adopt first year graphics would have convinced more people of the feasibility.
- The sequential outline provided a good guide.
- The leaders should have spent some time together in defining terms in common language; this should be done yet.
- The workshops provided a laboratory experience in trying out ideas and gave each participant a bit of the "feel."
- I have never been as impressed with a summer school, seminar or convention in my life.
- Too much time was spent on "how I do it at Podunk U."
- Before the Division can reach this stage, everyone should know what is being recommended and the terms being used.
- The speakers in the future should be honest in how much time they give to this material and other topics.
- Some speakers gave the impression that creative design took up all the time with other topics being discussed only as needed -- but, when pressed, admitted just the opposite.
- Next time get some good outside help on how to teach design who have not been inbred.
- It opened new horizons for my teaching.
- Needed a bit more detailed planning.
- Design courses should not be called graphics.
- Will need to be continued for program to bear fruits.
- Much more effective, as presented, than when similar material is presented at regular ASEE Graphics Division meeting.
- I would like to see a continued participation of industrial people.
- It is difficult to avoid attempting to try design after being in this Summer School.
- A uniformed observer looking in on the Summer School might have had a mistaken idea that design is a word description due to the absence of graphic application.
- The reviewers could have improved their presentation by following an actual design case from need to production.
- I was surprised at the low engineering background level seemingly possessed by some of the participants.
- One should be careful to differentiate between engineering design and vocational arts design.
- Too often we think the designing of window props and pole holders is engineering design when it may be the type of thing properly done in a trade school.
- Future summer schools should naturally benefit from the experience gained.
- What is needed now is a free exchange of ideas for workable projects on the freshman level.
- For the first time in years graphics teachers gathered and were given a common objective and how to go about achieving that objective.