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ABSTRACT

In the Engineering Case Program conducted by the Projects Board of the American Society of Engineering Education (ASEE), the ideal educational program is supported by: (1) content, science, and lore; lectures and programs; (2) observations of practice; case histories, plant tours; and (3) doing jobs; projects. This tripod model of engineering education requires that all three legs be present for the educational system to stand. This paper presents one way that the observation leg, the weakest element in most engineering education programs, can be strengthened. The use of engineering case studies, particularly at the graduate level, has been described as an academic/professional link which is an alternate way of defining the observation leg of the tripod. Case studies offer a way for students to learn about and empathize with the real world. At both the Berkeley and Davis Campuses of the University of California, students can choose to write a case study as a portion of their Master of Engineering program. After meeting several times with their faculty advisor and the project engineer, they write the case study. An appendix includes portions of two student prepared case studies and a list of student-written cases. (LS)

Event 2645

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Ft. Collins, Co. 80521

STUDENT PREPARED CASE STUDIES - THE MISSING LEG

Jerald M. Henderson
Associate Professor of Mechanical Engineering
University of California, Davis

Introduction

"Faculty, students and a classroom program do not in themselves an engineering education make! Another essential ingredient is a well-selected engineering case studies program. In the Engineering Case Program conducted by the Projects Board of A.S.E.E., the ideal educational program is supported on this tripod:

- Content, science and lore; lectures and programs
- Observations of practice; case histories, plant tours
- Doing jobs; projects."

This tripod model is presented by Cornelius Wandmacher, President of the American Society of Engineering Education[1]. He discusses how engineering education must be a central function

"Of the profession, for the profession, by the profession... those phrases express the ideal views that any engineering practitioner might have of engineering education."

This content-observation-doing tripod model of engineering education requires that all three legs be present for the educational system to stand. I submit that the observation leg is the weakest element in most engineering education programs, and it is the prupose of this paper to present one way this leg can be strengthened.

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[1] "Engineering Education and the Engineering Profession," Cornelius Wandmacher, President of A.S.E.E., Agricultural Engineering, Vol. 56, No. 2, Feb. 1975.

The Academic/Professional Link

The use of engineering case studies, particularly at the graduate level, have been described as an academic/professional link[2] which is an alternate way of defining the observation leg of Wandemacher's tripod. An engineering case study is simply a history of an engineering project. Case studies offer a way for students to learn about and empathize with the real world. Wandmacher[1] also states:

> "All signs point to increased participation by the engineering profession in the total processes of engineering education. Engineering faculty appointments are being made more attractive to experienced members of the profession. Interest in 'case-study' teaching is growing--the necessary talent and information for this bold new approach are becoming more readily available."

He further observes that:

> "To be a highly effective engineering teacher...one must be first and foremost a highly competent, up-to-date ENGINEER."

Herein lies one of our basic problems in engineering education.

The ideal engineering educator has (1) a complete and current grasp of the subject matter he is teaching (he has a Doctor's level degree), (2) knowledge of and experience with engineering practice

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[2] "Engineering Case Studies - The Academic/Professional Link," Jerald M. Henderson and Robert F. Steidel, Jr., Proceedings of the 1974 International Conference on Frontiers in Education (London), July 1974.

and (3) an understanding of and ability to utilize good educational and teaching techniiques. Let's face it--most engineering educators are only strong in one of these three areas--the subject matter area. We are never formally given or required to take work in such subjects as educational psychology and in most academic environments are encouraged, but not required to have a solid backgroung in engineering practice. It may be unrealistic to consider training somebody completely in all these three areas.

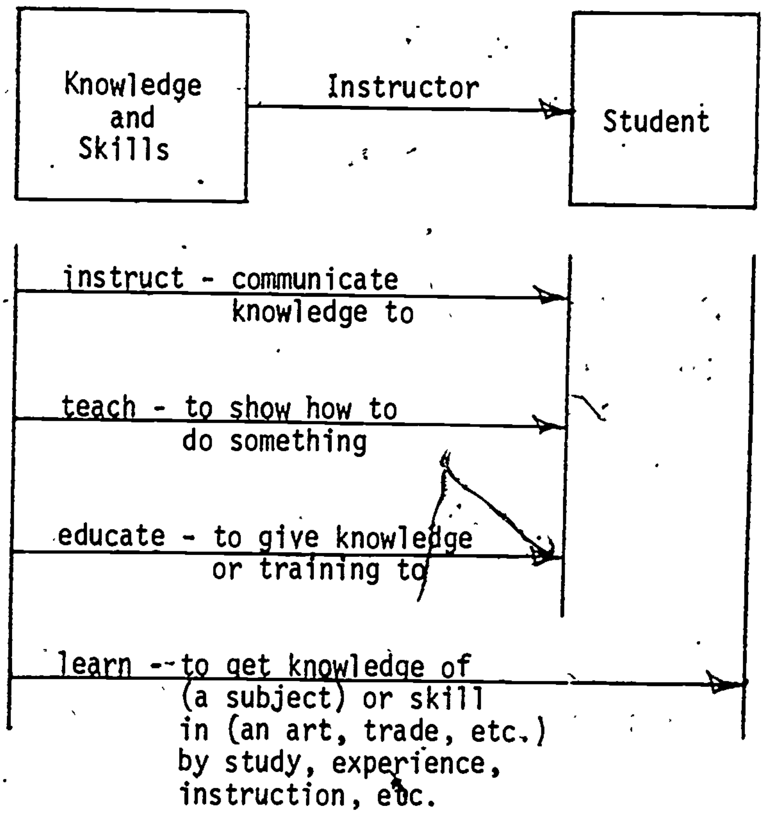
Figure 1 presents a very simplified model of engineering education and some definitions of associated terms. Note that the instructor acts primarily as a catalyst; we as instructors instruct, teach and educate, but many times lose sight of the fact that our primary goal is to help students learn. It is our job to see that this circuit is completed instead of just "throwing" the material at the student in the hope he will absorb it. The question of and concern for how students learn is something we often avoid. We must give more attention to what I choose to call the First and Second Laws of Engineering Education:

First Law of Engineering Education

The benefit a student receives from a course of instruction or other educational activity is proportional to the effort that he or she puts into it.

Second Law of Engineering Education

The efficiency of the benefit-effort relationship stated as the First Law is directly related to the structure provided by the instructor.



(definitions from Webster's New World Dictionary of the American Language, The World Pub. Co., 1954.)

Figure 1 - An Engineering Education Model

Figure 2 presents my comparison of the relative merits of techniques used to help students learn about the art and science of engineering. As a general rule the more involvement that the student has in the educational experience, the better off he is; but the learning by first-hand experience whether it be on the job or with a number of projects in school is very time consuming and costly. Therefore, one of the best ways for students to learn about the art of engineering is through written case studies, which will be discussed in detail in the next section.

The use of case studies in engineering education has been introduced by such pioneers as the late Professor John Arnold of the Massachusetts Institute of Technology and Stanford University and Professor Henry Fuchs of Stanford University. A significant experimental activity in the use of case studies was carried out at the University of California, Berkeley, by Professor Robert F. Steidel, Jr.[3]. The focus of this activity was the preparation of case studies by graduate students. I was privileged to participate in this program which was the beginning of my experience, primarily at the graduate level, with case studies. Much has been written about how one uses engineering case studies in the classroom[4]. My experiences with this specific activity are documented in a recent paper[2].

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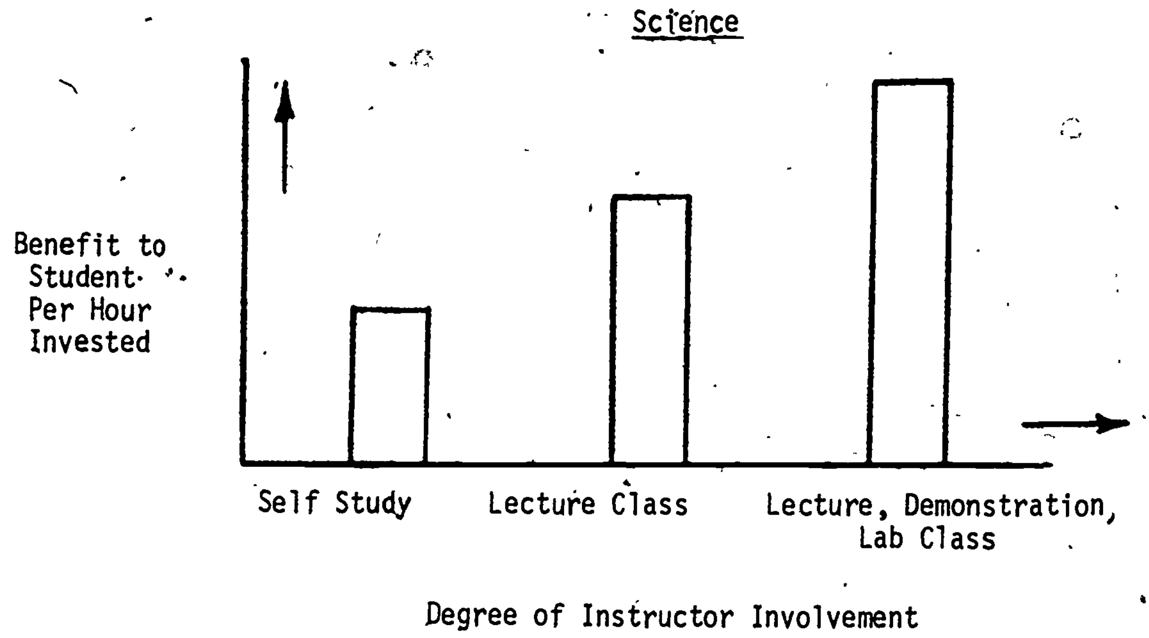
[3] "Engineering Case Method Experimentation at the University of California, Berkeley," Robert F. Steidel, Jr. and Richard K. Pefley, presented at the A.S.E.E. Annual Meeting, Los Angeles, June 1968.

[4] Engineering Cases (A catalog of case studies and related literature), Engineering Case Program, Room 500, Stanford University, Stanford, California 94305.



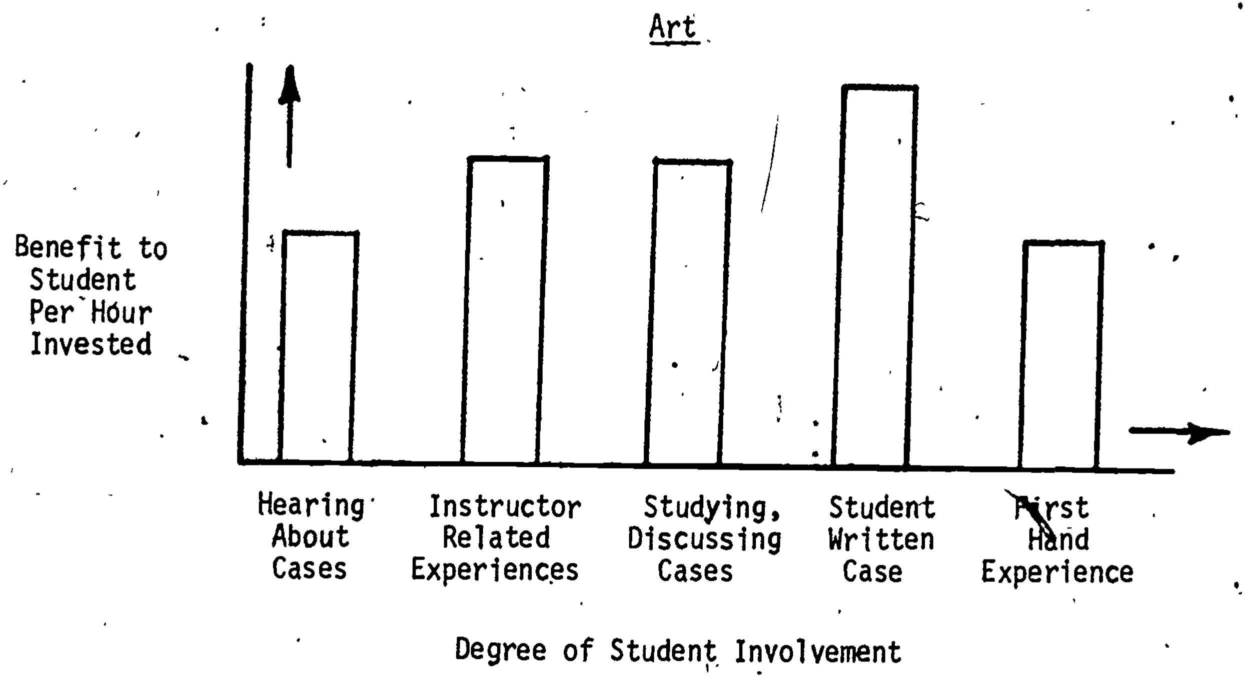


Figure 2 - A Comparison of Several Methods of Obtaining the Art and Science of Engineering

Student Written Case Studies

At both the Berkeley and Davis Campuses of the University of California, students can choose to write a case study as a portion of their Master of Engineering program[3]. A recent engineering project in industry is selected by the faculty member and a team of graduate students. The team is usually made up of two, three or four students. Usually the initial contact with the project leader from industry is made by the faculty member a term before the case study is to be written. The students and the faculty member then go to the industry and start to discuss the many details of the project for which they are going to prepare a case history. Experience has shown that after the first meeting it is best to have the faculty member stay at home since the project leader tends to talk to him rather than the students. The students meet with the project engineer and other people related to the case about once a week for six to eight weeks. The students also meet with the faculty advisor each week, discuss that they have learned and formulate questions and areas they want to investigate during the next meeting with the project leader. The end product is then a written case history of the project. The Appendix of this paper includes sample portions of two student prepared case studies and a list of student written cases. Note how realism is maintained by including actual documents (Exhibits) in the cases.

The advantages of student authored case studies are significant:

1. The student observes engineering practice first hand.
2. The student deals directly with and therefore learns from a leader in engineering practice (project leader).

3. The student has a chance to investigate in considerable depth without any commitment an industry (the source of the case) which he/she may be interested in joining.
4. The student is put in a team situation much like what takes place on the job.
5. The student gains the experience of formulating and documenting a technical activity. The primary justification for the thesis requirement in a typical Master's program is to force the student to formulate, carry out and communicate an engineering project. The preparation of an engineering case study allows the same type of experience.
6. The faculty member benefits right along with the students - the observation of engineering practice and specific industries, and contact with the profession.
7. The faculty member also benefits by obtaining a case study with which he is thoroughly familiar which he can then use in the classroom[2].
8. Some schools have gone to courses-only Master's programs in order to be able to handle the large number of students in their program. The student written case study activity allows the faculty member to supervise more students than if the program required a thesis, but at the same time gives the student experience with a project-like effort.

The disadvantages of student authored case studies can be short lived (changes discussed in next section) if we are willing to learn from our past experiences:

1. One criticism which I receive from my colleagues concerning this activity is the fact that the case history does not represent independent thinking by the student authors. Admittedly the written case history is the most tangible result of the effort, but the intangibles listed in the advantages are the real benefit and can't thoroughly be realized without direct participation. The faculty member must structure his ongoing discussion with the students in a way which does require some independent thought and action on the part of each student.

2. The logistics of arranging for and carrying out the visits to the respective industries can be troublesome, especially if the campus from which you are operating is not located in an industrial area. Seeking participating industries and practitioners and matching these with the interests of the students requires some planning, coordination and effort on the part of the faculty member.

This direct contact with the so-called "real world" is a benefit which is hard for people to realize if they haven't participated directly. One criticism companies have of universities' and colleges' product (students) is their lack of knowledge of the real world. Industrial people are very enthusiastic about this program which allows contact and communication between the graduate students, the faculty, industry and the University.

A recent book[5] on the engineer and engineering devotes an entire chapter to the question, "Is engineering really a profession?" A popular pastime of engineers is to compare themselves to medicine and law. Without concerning ourselves with the results of such a comparison, I suggest we can learn from the actions of law and medical educators. Students studying law and medicine are required to observe and participate in actual practice; case studies offer a very effective way of giving engineering students clinical types of experience.

Future Improvements

The degree of use of case studies, studying prepared ones and writing new ones, is related to an instructor's past teaching experience and style of teaching. Since the technique is relatively new and sometimes misunderstood we need to do a better job of informing educators of the benefits and techniques of case study teaching (and learning). My experience with engineering case studies leads me to believe that significant improvements can be made in engineering education in the follwoing three ways:

First, we must pay more attention to what I will call, for lack of a better term, teaching technique. We must be more cognizant of the First and Second Laws of Engineering Education which I discussed earlier. Case studies, by their very makeup and utilization, provide the type of structure and involvement called for in the two Laws. Instead of worrying about what we do <u>to</u> the students, we must be more concerned about what we do <u>for</u> the students. Our job is not to instruct

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[5] <u>The Engineer and His Profession</u>, John D. Kemper, Holt, Rinehart and Winston, New York, 1975.

it is to help students learn.

Second, we need a more serious effort to prepare cases for use in engineering education. A significant start is the Stanford Case Library[4] which has over 200 prepared cases available. Add to that the approximately 30 student prepared cases available from the University of California (see list in Appendix), miscellaneous papers and cases prepared by others, and the recently published case study textbook[6]. We need more books like this one. If we could get the cooperation of various engineering societies, significant progress could be made. Societies, e.g., A.S.M.E., could take it upon themselves to help produce case studies in several ways: encourage members to write-up their own experiences, make available suggestions of projects and companies which could be sources of information for student or faculty written cases, and support through recognition of efforts in preparing cases much like what takes place in Region IX of A.S.M.E. under the leadership of Henry Fuchs. Much attention is paid to research contributions of Society members with paper awards, etc.; why not similar recognition for contributions to engineering education, the case study area being a prime candidate.

Third, more integration of design and professional engineering is sorely needing in our educational programs. Design courses are typically senior electives or nonexistant. What I wish to try next is an integrated design sequence at the Master's level. I believe a repackaging of what we do now will be benificial. We don't help students "put it all together", so to do this I suggest a two-quarter or

[6] 10 Cases in Engineering Design, H. G. Fuchs and R. F. Steidel, Longman Group Limited, London, 1973.

full year course which includes:

a. Study and discussion of prepared cases[2].

b. A student written case

c. The carrying out of student projects which could include what they are doing for their Master's project.

d. Study of selected topics, such as optimization, economical analysis, and personnel problems.

Mixing all these activities into one course forces the students to integrate and compare the material and experience. We tend to segment education which is of course directly opposite to actual engineering practice.

Acknowledgements

My interest in trying to help students prepare for engineering practice was influenced greatly in my early years by my father (an engineering educator). Through graduate school and the initial years of my teaching career my focus was sharpened through association with colleagues such as Professor Lath Meriam, then of the University of California, Berkeley, and Professor Henry Fuchs of Stanford. But relative to my special interest and belief in the case method I must single out and praise Professor Bob Steidel for his influence, help, and encouragement.

Appendix

Case Studies Prepared by Graduate Students

University of California, Berkeley

THE 72 INCH HYDROGEN BUBBLE CHAMBER, at the Lawrence Radiation Laboratory, Berkeley. J. Bass, B. Clawson, K. Markolf, June 1965.

THE HYDRO-CONSTANT PUMP, FMC Corporation. A. Klain, R. Ikegami, T. Sandukas June 1965.

AUTOMATIC POURING FURNACE AT QUALITY CASTING SYSTEMS, Berkeley. R. C. Desai K. Dutta, A. K. Goyal, A. R. Vora, August 1965.

THE REDESIGN OF AN AUTOMATIC POURING FURNACE, Quality Casting Systems, Berkeley, California. B. Subramaniyan, V. P. Jhaveri, June 1966.

THE MARINER C SOLAR PANEL AND RELATED HARDWARE, R. Kerr, R. Weitzmann, C. Yokimizo, June 1966.

PRESSURE SUPPRESSION AS A MEANS OF REACTOR CONTAINMENT FOR HUMBOLT BAY UNIT NO. 3, the Pacific Gas and Electric Company, San Francisco, California. M. Desai, R. E. McKechnie, B. M. Shawver, June 1966.

THE DESIGN OF A HIGH ONSET CENTRIFUGE, the Rucker Company, Oakland, California. A. V. Munson, Jr., R. L. Piziali, S. E. Wilson, H. Zaklad, June 1966.

4,400 HP ELECTRO-MECHANICAL BALL MILL DRIVE SYSTEM, Kaiser Engineers, Kaiser Steel Eagle Mountain, Ore Benification Plant. F. Locatell, S. Ghose, J. Morehouse, S. Sohrabpour, June 1967.

DEVELOPMENT OF A BIN LOOP TAPE TRANSPORT SYSTEMS, Ampex Corporation, Redwood City, California. S. Ambekar, K-D. Bodack, P. Delp, June 1967.

THE DESIGN OF THE 88 INCH SECTOR FOCUSED CYCLOTRON, Lawrence Radiation Laboratory, University of California, Berkeley, California. S. Subramanian, P. G. Abraham, F. M. Miller, June 1968.

POWER RECOVERY SYSTEM FOR FLUID-BED PROCESSES, Shell Development Company, Emeryville, California. K. Parekh, A. Sorathia, A. Tailor, June 1968.

A LIGHTWEIGHT SUPERCONDUCTING MAGNET SYSTEM FOR A BALLOON-CARRIED PARTICLE PHYSICS EXPERIMENT, Lawrence Radiation Laboratory, Livermore, California. J. C. Carrioggia, E. T. Cull, Jr., R. J. Erust, B. T. Feerick, June 1968.

A FOUR-BARREL STEP-AND-REPEAT CAMERA, Friden Research Center, Palo Alto, California. C. J. McMills, G. R. Mehta, F. A. Wile, June 1968.

FUTURE URBAN TRANSPORTATION SYSTEMS, A FEASIBILITY STUDY, The Stanford Research Institute, Menlo Park, California. P. J. Guest, R. F. Petersen, June 1968.

DEVELOPMENT OF AN AIRCRAFT WASHING SYSTEM, The Rucker Company Control Systems Group, Oakland, California. F. M. Melsheimer, K. O. Pimentel, W. C. Smith, June 1968.

PROJECT PIMO - A TECHNICAL DATA PRESENTATION CONCEPT, Synergistic Associates, Los Angeles, California. S. L. Rice, V. Kumar, K. Y. Harano, June 1969.
THE DESIGN OF A SEVEN STRAND PLANETARY CABLER, Raychem Corporation, Menlo Park, California. G. D. Doré, A. W. Williams, July 1969.

RELOCATION OF LIQUIFIED PETROLEUM GAS FACILITIES, Standard Oil Company of California, Inc., Richmond, California. R. R. Ghosh, D. L. Holeman, R. E. Laine, R. F. Moore, June 1970.

APPLE COLOR SORTER, FMC Corporation, San Jose, California. P. J. Cowgill, J. G. McIntire, June 1971.

SELECTION OF A GROUND LAUNCH SYSTEM FOR A PILOTLESS AIRCRAFT, Teledyne Ryan Aeronautical, San Diego, California. R. R. Fray and A. A. Goldspiel, Univers of California, Berkeley, June 1971.

THE ISOTHERMAL CUP, Ryan Enterprises, Los Angeles, California. G. A. Sousa and T. W. Tesche, University of California, Berkeley, June 1971.

THE DESIGN AND DEVELOPMENT OF A LOCKING COLLAR, The Schlage Lock Company, South San Francisco, California. T. P. Frangesh, A. E. Johnson, 1972.

THE DESIGN AND DEVELOPMENT OF THE RESIDUAL HEAT REMOVAL SYSTEM, SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2, Bechtel Corporation, San Francisco, California. Y-C. Chong, W. C. Clark, J. A. Klee, 1973.

THE DESIGN AND DEVELOPMENT OF THE AIRBORNE INFRARED TELESCOPE, NASA, Ames Research Center, Moffett Field, California. G. Shiflett, R. Yaspo, F. Yung, June 1974.

HYDROGEN SULFIDE ABATEMENT AT PACIFIC GAS AND ELECTRIC'S GEOTHERMAL PLANT, Pacific Gas and Electric Company, San Francisco, California. B. Payette, M. E. Long, R. Payette, June 1974.

DESIGN OF A PIPE WHIP RESTRAINT SYSTEM FOR NUCLEAR REACTORS, General Electric Company, San Jose, California. J. Cherry, T. Flower, R. Mancin, June 1975.

University of California, Davis

PACKAGING OF DEHYDRATED ONIONS IN PLASTIC PAILS, Basic Vegetable Products, Vacaville, California. C. Wang, Package Engineering Case Study, University of California, Davis. June 1972.

DESIGN OF AN IMPROVED AIRCRAFT SEAT, NASA, Ames Research Center, Moffett Field California. R. S. Ball, W. B. Goodman, W. J. Kennish, University of California Davis, June 1972.

DESIGN OF A FAST REACTIVITY EXCURSION DEVICE, General Electric Company, Sunnyvale, California. M. P. Lew, M. J. Plimley and A. D. Wyckoff, University of California, Davis, June 1972.

DESIGN OF A HOTEL LOCK, Schlage Lock Company, San Francisco, California. R. Allen, D. J. Zuffi, University of California, Davis, June 1973.

MANUFACTURING ENGINEERING IN THE ELECTRONICS INDUSTRY, Hewlett-Packard, Palo Alto, California. C. L. Anderson, R. L. Peters, University of California Davis, June 1973.

CYANIDE CORROSION EXPERIENCE IN PETROLEUM REFINING, Exxon Refinery, Benicia, California. W. H. Kimball, R. T. Sato, J. P. Stephens, University of Californ Davis, June 1973.

(a portion of)

AN ENGINEERING CASE STUDY

THE ISOTHERMAL CUP

Ryan Enterprises
Los Angeles, California

George A. Sousa II

Thomas W. Tesche

Written under the supervision of Professor J. M. Henderson and Professor R. F. Steidel.

University of California
Berkeley, California

June 1971

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and looks, Mr. Ryan settled upon $.70 as a reasonable price for the ceramic cup. He felt that a modest ceramic cup would sell better than the higher priced version. Combining the $.70 for the exterior, $.397 for raw materials and manufacturing and a 10% contingency cost to cover unexpected expenses, a price of $1.21 for the ceramic cup was determined. The plastic model was set at $.54 which included the same 10% contingency allowance.

Having established a minimum cost level for the cup, Mr. Ryan next considered the question of what the selling price should be.

Based on accepted marketing procedures, Mr. Ryan concluded that the cup would be sold for between $2.99 and $3.99. This price would leave sufficient margin for profit after the manufacturer's overhead, retailer's markup, advertising costs, and the material costs were met.

4.7 <u>Presentation of the Isothermal Cup</u>

In early 1960, Ryan Enterprises initiated a patent search to determine the patentability of a part or all of the latest cup design. One result of an earlier search was the discovery of a patent by H. G. Zimmerman. Concerned that this patent might in some way conflict with one of the variations of construction which they might use, Ryan Enterprises bought the patent outright. In March 1969 they applied to the United States Patent Office for a patent on the cup, under the title Thermodynamic Container. The patent has been issued and is included as an Appendix. Ryan Enterprises now felt that they had the Thermo-cup sufficiently well designed to present to possible manufacturers.

Mr. Gilbert Thomas, for the last several years has been a Vice President of Ryan Enterprises. After receiving his Bachelor's degree in Psychology and MBA from Long Beach State College, he became involved in the business and marketing aspects of numerous products.

Mr. Thomas was in charge of the marketing phase of the Thermo-cup project. In the spring of 1969 he contacted 10 major houseware manufacturers both in the United States and in Europe in hopes of presenting and selling the Thermo-cup idea. Exhibit 1 is a typical example of the introductory letter sent by Mr. Thomas to a prospective company. In presenting the invention he relates the outstanding features of the cup, and includes Figure 11.

One of the first major companies approached was Rubbermaid Corporation. On April 2, 1969, Mr. Thomas met with the New Sales Development manager of Rubbermaid, Mr. Moyer Smith. The Thermo-cup idea was so well received after his presentation that it was given top priority on Rubbermaid's New Products list. However, in the middle of April, during Rubbermaid's New Products Conference, it was decided to forego the cup at that time. The motivation for the decision was not entirely clear but it was felt that potential manufacturing difficulties were a factor and that the cup was outside their usual price range. The majority of Rubbermaid's product line sold for between 50 cents and a dollar.

The Thermos Company was the next manufacturer Mr. Thomas contacted. While the Regional Sales Manager was personally sold on the idea it was later turned down. The letter of April 24, 1969 from Thermos to Ryan Enterprises seen in Exhibit 2 implies that they were leary of being able to develop a sufficiently large profit margin to make the project worthwhile. Mr. Thomas commented later that Thermos, although a quite

GILBERT A. THOMAS
MANAGEMENT CONSULTANT
Specializing in the Management of Creative People

14711 Mimosa Lane
TUSTIN, CALIF. 92680 (714) 544-5362

June 6, 1969

Nibot Corporation
3600 West Pratt Avenue
Chicago, Illinois 60645

Attn: G. Gigstad:

Dear Mrs. Gigstad:

I enclose two signed copies of your disclosure agreement. This agreement has been signed by John W. Ryan the owner and inventor of the coffee cup.

Mr Ryans invention, for which a patent application has been filed, utilizes the property of certain materials to absorb or give up many calories of heat when they change states, ie, undergo a phase change. Certain safe, low cost materials have been selected and constructed into a cup which has the following distinctive features as compared to an ordinary coffee cup and a thermo-cup, ie, an insulated cup.

	Ordinary Cup	Thermo Cup	Ryan Cup
Original temperature of coffee, tea, etc.	190°	190°	190°
Temperature after 3 minutes	170°	185°	140°
Temperature after 7 minutes	140°	165°	137°
Temperature after 12 minutes	124°	150°	134°
Temperature after 19 minutes	less than 100°	140°	130°

EXHIBIT 1

	Ordinary Cup	Thermo Cup	Ryan Cup
Temperature after 30 minutes	Ambiant	129°	124°
Temperature after 35 minutes	Ambiant	124°	120°

Our studies have indicated that the average individual can enjoy hot beverages in the 140° to the 124° range. The regular coffee cup requires one to wait seven minutes while the liquid cools to a drinkable temperature then one must consume it in five minutes or it is too cool to drink.

Hot liquid poured in a thermo cup takes nineteen minutes to cool down to drinkable temperatures then remains in the comfortable range for 16 minutes. The Ryan cup lowers the temperature of liquid poured into it to the drinkable range in three minutes and keeps the liquid in that range for 30 minutes.

This cup can be produced in either a plastic or ceramic version. With the proper promotion we feel that a significant volume of Ryan cups can be sold both in gift and houseware departments across the country. We are looking for a progressive company who can handle this item on an exclusive basis and do a proper job of marketing and promotion.

I plan to be back East in the latter half of June and would like to arrange a meeting with the proper persons in your company to show actual models of the cup and answer any detailed questions that may arise.

Sincerely,

Gilbert A. Thomas

Gilbert A. Thomas

GAT/pt

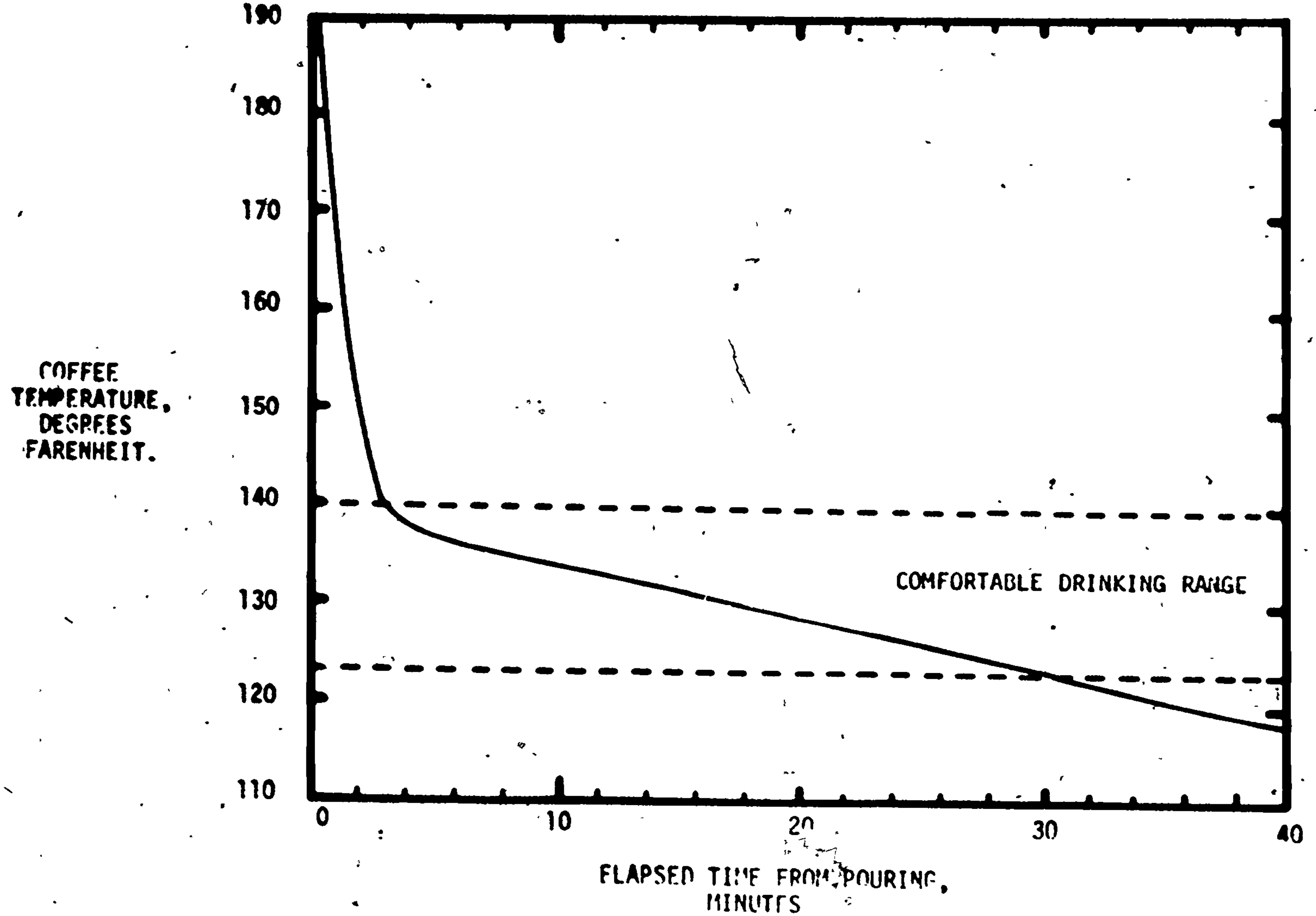

Figure 11 Temperature History of Coffee in the Isothermal Cup

(a portion of)

An Engineering Case Study

DESIGN OF AN IMPROVED AIRCRAFT SEAT

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California

R. Stephen Ball
William B. Goodman
William J. Kennish

Written under the supervision of Professor J. M. Henderson

University of California
Davis, California

June 1972

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problems, the vertical portion of the test was considered a failure. The horizontal testing, however, had surpassed the 21 g level and thus was considered a success.

Immediately following the testing at Oklahoma, Mr. Kubokawa presented the results to the Government Agency Seating Systems Conference. The panel seemed interested, and encouraged further development. There was even some mention of installing a few operational models in the Presidential helicopter.

3.5 Second Redesign

Following the tests, two modifications were made. First, the U. S. Air Force dummy, called Dynamic Dan, was obtained for subsequent testing. Dan is water filled and more closely approximates the dynamics of a human. Second, the slider block was modified in an effort to prevent its gouging problem. It was felt that the slider block was digging into the guide rails rather than sliding. If this were the case, the high peak accelerations could easily be accounted for. To solve the problem, the corners and edges of the block were rounded.

3.6 Third Testing

By 22 March 1972, all modifications had been made and again the seats were ready for testing. Rather than spend the time and money to retest the seats in the horizontal direction, it was assumed that they had qualified in that direction from the first test at Oklahoma. Attention was thus focused on vertical testing.

Charles Kubokawa and Dennis Matsuhiro attended the testing. Once again their purpose was to supervise the testing, refurbish the seats, and interpret the data.

On the first run of the testing, a failure occurred (see Exhibit 3.2). Immediate inspection showed that the wrong size bolts had been used to attach

NASA-Ames LTI:239-3
Moffett Field, California
April 5, 1972

Exhibit 3.2

MEMORANDUM for Director

From: C. C. Kubokawa, Research Scientist, Man-Machine Integration Branch

Subject: Report of trip to FAA, CAMI, Oklahoma City, March 22-24, 1972

The subject trip was made by the writer and Dennis Matsuhiro to conduct a series of vertical dynamic impact tests on the NASA, Ames aircraft passenger seats.

The impact tests were conducted using both the Air Force anthropometric dummy, "Dynamic Dan" and the FAA Alderson dummy.

The one and only seat failure occurred on the very first test. The failure was attributed to a wrong size bolt, which was used to attach the roller guide blocks of the outer seat shell to the main seat structure. (3/16 inch diameter bolts were used instead of 1/4 inch bolts.)

The tests were resumed on the following day after minor modifications of the roller guide block attachment points on both test seats.

The following is a brief summary of the vertical test data:

Test #	Dummy Used	Seat Peak Loading	Seat Attenuation (1)	Comments
1	Dynamic Dan	25g	to 22.5g attenuated 2.5g	*
2	Dynamic Dan	34g	to 25g attenuated 9g	
3	Dynamic Dan	45g	to 25g attenuated 20g	@
4	Dynamic Dan	34g	to 25g attenuated 9g	
5	Dynamic Dan	33g	to 25g attenuated 8g	
6	Alderson	35g	to 25g attenuated 10g	
7	Alderson	34g	to 25g attenuated 9g	

(1) Occupant of seat experiences 4-5g less than seat g because of g attenuating cushion.

* Required repairs to roller guide blocks. Sheared off bolts of guide block. Wrong size bolts were used in initial assembly at ARC.

@ Hit 3/4 inch plywood on flooring. Almost limit of energy absorbing cable stretch length.

Exhibit 3.2 (Continued)

Significant data were gathered to help improve the seat design. The tests revealed that the seat structures were designed well enough to withstand and attenuate a 45g vertical drop. Seat impact g attenuation could be increased at the lower 33-35g levels if softer or smaller diameter energy absorbing cables are used.

It is felt that the tests were highly successful, and the seat program should be continued until an operational prototype seat with significantly improved crash protective properties (relative to current civil aircraft seats) is demonstrated.

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the roller guide block to the seat. The mistake was a result of fabrication and not design. The error resulted in the bolts being sheared off when subjected to the large load.

The tests were resumed the next day after the proper bolts had been installed. Further testing resulted in satisfactory data for g levels up to 45 g's in the vertical direction.

4. DEVELOPMENT OF PARALLEL SEAT

During this same period, Mr. Matsuhiro was working with his own design. Late in September, 1971, Mr. Matsuhiro finished a set of detailed drawings of his own seat concept. These drawings were given to the NASA Ames machine shop where an estimation of the cost for building a prototype was to be made. Mr. Matsuhiro anticipated design changes in the near future after the first test at Oklahoma, so he did not pursue the cost proposal during the month preceding the test.

After the second test results were known, Mr. Matsuhiro decided he should pursue the cost evaluation of his own seat design. Not having heard from the shop for the preceding month he confronted the shop personnel to find that they had misplaced the drawings. For the following two months the shop searched for the drawings. Once they had been located, Mr. Matsuhiro began to arrange to have the prototype made. Unfortunately, the $50,000 allocated for his program had been reallocated to another project because Mr. Matsuhiro was unable to get a cost estimate for the seat from the shop. It was therefore decided to focus attention upon successfully completing the Stencel seat.

5. FUTURE DEVELOPMENT

The final test completed Stencel's contract obligations. NASA officials decided not to renew the contract with Stencel, but rather to carry on further development "in house" (at Ames Research Center). The present seat design is shown in Figure 5.1.

The further development that is necessary involves modification of the recline actuator system, lightening of the seat as a whole and improving the attenuating characteristics at low g levels.

Once again, however, skepticism has arisen in NASA Headquarters. The question now becomes one of determining whether future development is justifiable. Apparently the lack of push from the benefactors involved (airlines, public, etc.) has been the cause of the hesitancy in Washington. As a result Mr. Kubokawa must now contact the airlines in an effort to gain support for his program. Two alternatives face him during this campaign. He may either arouse enough support from the airlines or he may convince the FAA that such a seat is necessary for safety in commercial airlines.

If Mr. Kubokawa's efforts fail to gain the financial backing for the coming year, the seat will die as a prototype. The only hope would then be that some company would pick up the NASA design and complete the development. According to Mr. Kubokawa, it may be that we are several catastrophic airline accidents away from a safer NASA seat.

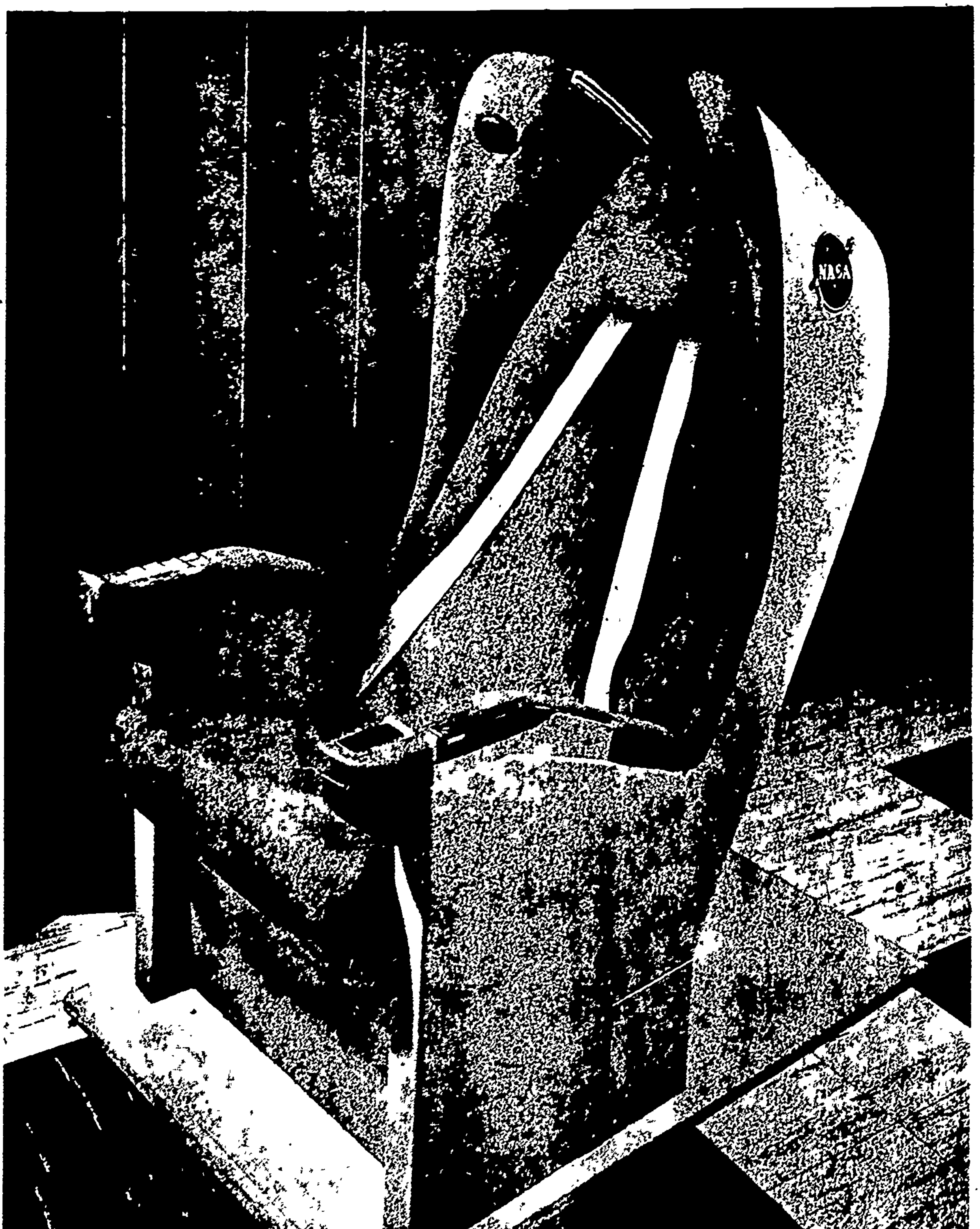

Figure 5.1 - The Final Design