VALUE TRAINING AT THE ROCHESTER INSTITUTE OF TECHNOLOGY

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ABSTRACT

This paper describes the evolution of value training at the Rochester Institute of Technology (RIT), a private college located in Rochester, New York. It details the format and content of a graduate course on value measurement and management that was taught at RIT in 1992. The course utilized a new textbook that can be used to upgrade undergraduate or graduate VE Management courses around the world. Several innovative new VA/VE methodologies used in this course are included.

Rochester Institute of Technology

RIT is a private, non-sectarian, co-educational university, located in a suburban setting in Rochester New York. Established in 1863, RIT is listed among the top 15 universities in the Northeastern US.[1] Internationally recognized for its photographic and imaging science curricula, the university offers outstanding technical training in engineering, science and mathematics and in related liberal arts curricula.

RIT students are accepted on a competitive basis and the university selects students from the top 10 to 20 percent of those in the country. Entering students have a grade point average between 3.25 and 3.5 and the university maintains a student faculty ratio that ranges between 10 to 20 depending on curricula.

RIT VA/VE Course History

RIT has offered courses on VA, VE and value management (VM) to undergraduate and graduate students for over 20 years. Through the years these courses have evolved and now represent a significant innovation in value education and training. Research on the nature of value and on value measurement, design and management techniques has produced a number of new and innovative methodologies which are taught in these courses.

A four credit course on VA has been offered as an elective to RIT engineering graduate students since 1972. This course originated following a 1971 review of VA/VE training at Eastman Kodak by Dr. Richard Reeve, associate dean of Engineering. At that time Dr. Reeve was head of RIT's Department of Industrial Engineering and I was directing Kodak's VA/VE program. After his visit to Kodak, Dr. Reeve asked me to design and teach an evening course on VA/VE to industrial engineering graduate students at RIT. In the Fall of 1972 I taught a ten week pilot VA/VE course at RIT. The course was successful and RIT added VA/VE to the Industrial Engineering graduate school curricula as an elective in 1973. I have taught the VA/VE course from 1972 to 1992, alternating it with a course on technology forecasting (TF) that I teach to graduate engineers at RIT.

Hardware oriented VA/VE projects

Originally the VA/VE course centered on using VA to reduce the cost and improve the per-formance of hardware items. Students joined VA teams and analyzed hardware items using function analysis and the Miles job plan. Projects studied included small kitchen appliances, pressure gages, instrument guides, toys, igniters, paper punches, flashlights, etc. Although many worthwhile cost reduction and performance improvements were achieved, the students would often remark that VA/VE was simply an organized approach to "common sense".

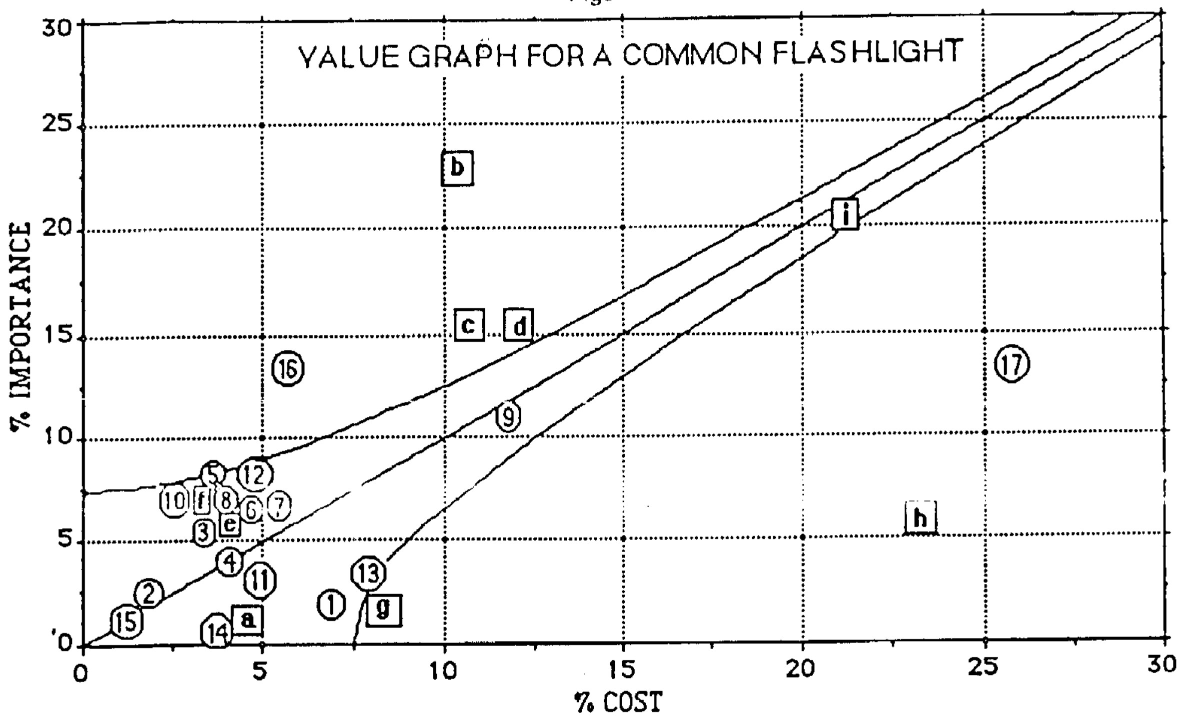
Bright engineering students learning advanced mathematics, physics, mechanics, thermodynamics, and the latest developments in computer science, microelectronics and simulation modeling, felt that VA/VE was not as intellectually challenging as programming a computer or designing a plastic part for injection molding. They found working in teams frustrating and they likened the job plan to study methods they had learned in grammar and high school.

Looking back, the original course, essentially the same as SAVE's current Module 1 training, was short on content and would be unacceptable by today's standards of engineering education.

Research on Value Methodologies

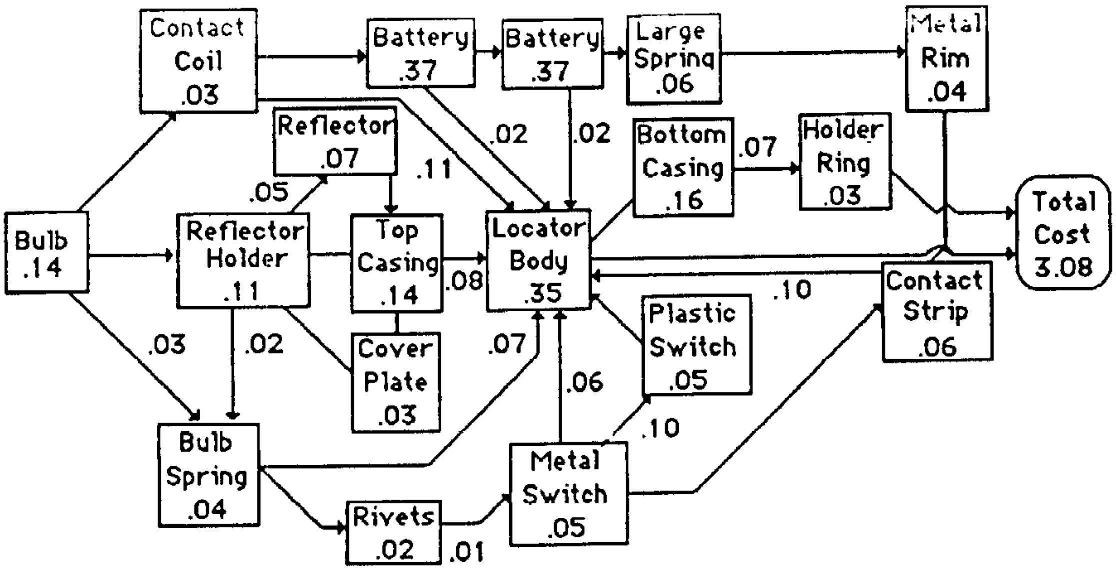
To overcome this deficiency, research was conducted on a number of new and improved value methodologies. This research led to the development and testing of several new value measurement techniques which were introduced into the VA course. The students were taught how to construct and use nominal, ordinal, interval and ratio scales to measure the value of components and functions in products and services. They learned how to express the value of components and functions in products and services in value indices, how to draw value graphs (see Figure 1), and how to calculate cost, importance and value improvement targets.

Figure 1



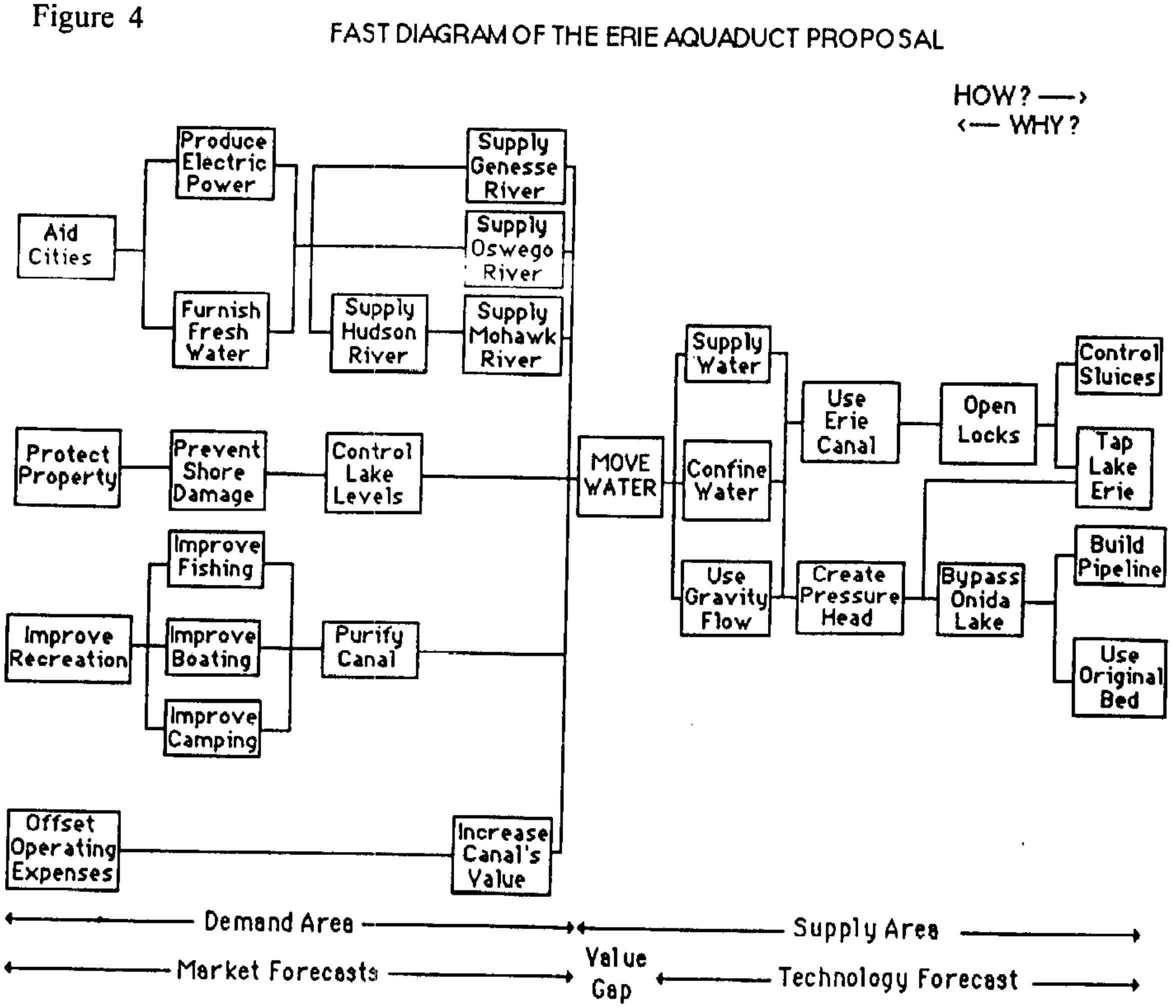
Code	Function	Code	Component	Code	Component
a	= reflect light	1	= top casing	10	= metal switch
b	= emit light	2	= top cover plate	11	= plastic switch
c	= conduct current	3	= reflector	12	= large spring
d	= complete circuit	4	= reflector housing	13	= bottom casing
e	= access switch	5	= bulb spring	14	= holder ring
f	= permit hand grasp	6	= metal coil	15	= rivets
g	= protect components	7	= metal strip	16	= bulb
h	= house components	8	= metal rim	17	= batteries
i	= supply power	9	= plastic body		

Figure 2
ADJACENCY DIAGRAM FOR A COMMON FLASHLIGHT



The students learned how to create and use different types of FAST diagrams (see Figure 4) and function matrices to target future product improvements. Research on function analysis led to the development of dysfunction analysis and adjacency diagrams (see Figure 2) which students then used to analyze products. Research on value led to the concept of a value force which changes with time and to the construction of system dynamic models to simulate these changes. Further research showed that it was possible to combine elements of VE with technology forecasting and to develop a value planning process for creating a series ofcustomer oriented future products[2]. All of these new methodologies together with other value oriented methods such as QFD, design for assembly, and customer oriented product concepting have been incorporated in the RIT course which has been renamed Value Measurement, Engineering and Management.

Figure 4



VA/VE service projects

Not all of the RIT value courses have been concerned with hardware. Since industrial engineering (IE) students are trained to analyze procedures and systems it is appropriate to focus their efforts on team projects where they can use their IE skills to study the functions of organizations and services. On occasion I select an interesting government service or private business project that I feel will intrigue the students. I contact managers in this business to see if they are willing to have RIT students conduct a VA/VE study of their operation. Managers must agree to furnish the students with relevant information and to sit in on and review the RIT team VA/VE presentations.

Projects selected and studied included the operation of a local marina, the operation of the New York State Barge Canal, the operation of the US Coast Guard International Ice Patrol (Newfoundland), and a study of off shore oil drilling operations in Arctic areas.

In these studies students are assigned to five person VA/VE teams based on major functional areas of the subject under study. A FAST diagram is created and the value of functions and components in the "business" is measured. Individual students are assigned different functions on the FAST diagram. Term project reports are required from teams as well as individuals. Students motivated by these projects often produce significant cost reduction and performance improvement proposals.

Endorsement and expansion of VA/VE training.

In 1983 Colby Chandler, then president and CEO of Eastman Kodak, was the keynote speaker at an international conference on engineering education held at RIT. In his address Chandler described the relationship he felt should exist between academia and business. Intrigued by the cooperation between De Marle and Reeves at Kodak and RIT, he described our efforts to develop programs that would upgrade academic training and improve thevalue of products and services. Chandler used our cooperation as a role model for other companies and universities to emulate.[3] Chandlers talk to over 600 engineering educators exposed them to VA/VE. It also led to an expansion of RIT's VA/VE training to undergraduates.

In 1980 Dr. V. Raju, Head of RIT's Department of Manufacturing Engineering, had taken my course as part of his graduate program. After graduating with a masters degree Raju spent several years in industry before returning to RIT to study for a doctorate. At RIT he joined the faculty of the manufacturing engineering department where he organized and taught an undergraduate course on VA/VE in 1984.

This VA/VE course was patterned on the graduate course and is now taught to undergraduate mechanical and manufacturing engineers by Lou Gennaro, a member of the full time Manufacturing Engineering faculty. Unlike the graduate course, the undergraduate course has VA/VE student teams work on topics from companies where the undergraduates co-op.

Many RIT undergraduates are part of a work study co-op program where students work in industry for one quarter of the school year before studying at RIT for two quarters. This arrangement lends itself to studies of industrial products and services in the VA/VE course.

Textbook

One of the problems encountered in teaching college VA/VE courses has been the lack of an adequate textbook. Until recently, VA/VE books dealt only with variations on the original Miles job plan, were highly specialized, old and out of date. Through the years RIT used a variety of different books as texts, including books by Larry Miles, Carlos Fallon, and Art Mudge, and supplemented them with handouts of recent articles on techniques and or applications. While they sufficed at the time, these books are out of date and do not cover the techniques I described in the paragraph on research above.

To overcome this problem, Larry Shillito and I co-authored *Value, its Measurement, Design and Management* which was published in 1992, by John Wiley Interscience[4]. The book is a college text-book and is specifically targeted for university VA/VE courses, engineering design courses and engineering economics courses.

At RIT the book was used to teach two Value Measurement, Engineering and Management graduate courses in 1992. It received excellent reviews from students who rated it better than texts used in other courses throughout the college. The chapters in the book are grouped in sections that expand upon the book's title and correspond to the modules of the RIT graduate course. Each chapter contains examples, drawings and a large number of references. The table of contents of the book is printed below.

Table of Contents

RIT's Value Measurement, Engineering and Management Course

Topics covered in this four credit graduate engineering course follow the same order as those covered in the book. The course lasts ten weeks and consists of four different modules:

1. The Nature of Value. (one week)
2. The Measurement of Value. (Three weeks)
3. The Design of Value. (Three weeks)
4. The Management of Value. (Three weeks)

The first section of the course provides a theoretical framework and orientation to the subject of value. Value is the primary force that governs market behavior. A "value force" exists and its magnitude can be measured numerically. The value of goods or services is directly related to their importance and inversely related to their cost. Importance derives from our perception of the ability of an item to satisfy our wants and needs. The value force controls the production of all goods and services in a market economy and value is the cornerstone of a healthy economy.

Value is the measure of Charles Darwin's fitness and the basis of evolution, especially the evolution of products and services to fill human needs. Maslow's theory of human motivation and personal growth is directly related to the operation of the value force and the concept of value energy is discussed.

The second section of the course moves from theory to application. Students learn how to measure the value of components in different systems. They study nominal, ordinal, interval and ratio numerical measurement techniques and use them to measure the relative importance and cost of different items. Students quantify importance using numerical rating techniques. They assign numbers to the importance of components in products and services and prepare value graphs and indices that relate importance to cost. These indices and graphs uncover areas where improvements are needed and target areas for value improvement. Students study the transience of value, and learn how to build mathematical models to simulate value changes that occur with time.

The third section of the course deals with design. It concentrates on function analysis and innovation. Patterned on the adage that form follows function, this part of the course teaches students how to create goods or services of improved value. A total value concept based on satisfying customer, retailer and producer needs is taught. FAST diagrams and indentured function matrices are used to portray "how?", "why?", and at "what cost?", user needs are met in any design. Function design matrix systems such as Customer Oriented Product Concepting (COPC), Quality Function Deployment (QFD) and Technology Road Maps (TR), are used to improve the value ofproducts and services. Value Measurement techniques are used to quantify the value of new system designs.

The final section of the course deals with the management of value. Valuism, an evolving world wide system for value improvement is described. Valuism includes many methodologies for improving the value of goods and services. VA, VE and VM, methodologies are central to valuism, and are described in detail. Value planning (VP), a powerful new methodology based on functional planning, is described. The organizational and behavioral aspects of VA, VE, VM and VP are discussed in the course. Students learn how a wide variety of other valuism techniques such as quality function deployment (QFD), design for assembly (DFA), total quality management (TQM), just in time (JIT), concurrent engineering (CE) etc. can be used with VA/VE to improve the value of products.

As in traditional VA/VE workshops, students learn to apply value techniques to actual problems. Student value teams are formed in the first session and work together to improve the value of specific products or services. At the conclusion of the course these teams are required to turn in term reports. The course has 40 hours of formal class work. About half of the time is spent in lecture and half in teamwork. A course outline showing the lecture topics and class exercises is shown below. Class exercises are underlined. Students spend an additional six to eight hours a week on homework assignments. In the fall the class was conducted once a week from 5 PM to 8:45 PM and the lectures and class exercises were integrated as shown. In the spring when the course was conducted twice a week from 5 to 6:45 PM, the lectures and class exercises occurred on different days.

Course Outline.

RIT - EIEI 601 - Fall Quarter 1992 - Course Outline
Text: Value: its Measurement, Design & Management

Session # Topics

9/8/92

1. Orientation, Class objectives & format, Textbook overview, The nature of value. The value force, Value, Growth and Evolution. History & evolution of various products & services. The Value Disciplines, VA /VE/VM,The VA/VE job plan.
Team formation, Team building exercise. Team Project assignments.
(Read Chapter 1 -) The Value Force. & Chapter 2- Value, Growth & Evolution

9/15/92

2 Value Measurement Process & Techniques. Level 1(customer level) systems & components. Estimating importance. Pareto exercise What would you buy? Level 2 (design level) systems & components. How important is it?- Q-Sort exercise.
Teams meet to discuss possible projects and missions
Read Chapter 3 - Value Measurement & Chapter 4- Value Measurement Techniques

9/22/92

3. Value Measurement Techniques. Ranking,Direct Magnitude Estimation, Successive Comparisons, Pair, Comparison Methods.
Value Index, Value Graphs, Tanaka & Sun optimum value zones. Calculating Importance, Cost & Value Targets.
Teams select study topics and missions types -i.e., Flashlight-Value Analysis, Cork Remover -Value Engineering, Microwave Popcorn - Value Planning.
Read Chapter 5 - Modeling Value & Chapter 6 - Value and Decision Making

9/29/92

4. Scoring Models,Value control graphs, Value & Decision Making. Paradigm Testing. Value Standards. System Dynamic Modeling of the dynamics of value, Life cycle Cost Models. Demonstrate Stella modeling on a Macintosh computer.
Teams analyze their product & its market. Prepare value graphs and improvement targets for their projects.
Read Chapter 6 - Chapter 7 - Function Analysis

10/5/92

5. Function analysis, Two word functives, Basic & secondary functions, Function maps & matrices. FAST Diagrams, Dys-function analysis. Dysfunction Diagrams, Function and dysfunction costs. Adjacency diagrams.

Midterm examination.
Read Chapter 8 - Quality Function Deployment & Chapter 9 - Technology Road Map Individuals prepare FAST/Dysfunction diagramsfor their projects.

6. 10/12/927.
FAST Diagrams, Quality Function Deployment (QFD), Technology Road Map) (TR).Teams review homework assignment and prepare FAST & Dysfunction Diagrams for projects. Teams determine function & dysfunction costs, prepare a function cost matrix and a value graph of functions.
Read Chapater 10 - Customer Oriented Product Concepting. Prepare a TR and a QFD House of Quality matrix.

10/19/92

7. Functional innovations, Creative thinking & creative techniques.
Brainstorming low value areas of projects. Phase II value measurement of ideas, Q sort or other screening of TR, COPC or QFD ideas, Examination of trade-offs, Selection of best functional ideas for inclusion on TR or COPC matrices.
Teams prepare and weight a TR, COPC or QFD matrix.
Read Chapter 11 - Valuism & Chapter 12 Value Management.

10/26/92

8. Valuism. VA & VE, VM Corporate Value Management Programs & Councils. Japanese Value Programs.
Teams measure the value of their best morphologies. Run Economic Analysis. Construct Stella models, Prepare new value graphs, begin to prepare proposals.
Read Chapter 13 - VM- Behavioral and Organizational Aspects & Chapter 14 - Value Planning.

11/2/92

9. Value Planning, Proposal preparation, Implementation planning (milestones, project management), Course review.
Teams work out project implementation schedules. Finalize Stella Models, Prepare final team reports and presentations .
Read Chapter 15 - Valuism, VM and the Future

11/9/92

10. Team presentations, Team and Individual reports due. Final Examination. Course evaluation.

Selecting Team Projects

A key element in VA/VE training and in the success of a value improvement course involves the subjects that the students work on. Subjects can be selected by the students themselves or preselected by the instructor and assigned to the students. Students get involved in topics which they find interesting. However they need guidance in selecting both topic and value methodologies (i.e., should they use VA, VE, or VP to improve the value of a product? In a 10 week course, students should be urged to select simple products with relatively few parts. Hands on improvement of a product that they have selected is much more motivating than examining a case history where someone else improved a product.

When a more complex machine or service is selected for study, the teacher needs to collect data and contact people before the class starts to accommodate a ten week study. Project planning is a must if the class is expected to work effectively on a large project. Mechanical and manufacturing engineering students tend to prefer simple "nuts and bolts" projects while industrial engineering graduates and business (MBA) majors tend to like the complexity of larger organizational or procedural projects.

VA, VE and Value Planning Team Projects.

In the fall 1992 value class graduate industrial engineering students selected microwave popcorn, cork removers and flashlights as topics for value improvement. Three teams were formed, one used value analysis to reduce the cost of a flashlight, one used VE to design a new cork remover, and one used value planning to develop a portfolio of new and improved microwave popcorn products. Each team followed a structured job plan and used functional analysis to identify areas for value improvement. Value Measurement techniques were used to create value graphs and to target trade offs and design improvement opportunities. Figure 1 is a value graph that shows the value of the flashlight components and functions.

All of the teams brainstormed and screened a large number of creative ideas before developing their final recommendations. The teams used modern VA/VE methodology and successfully integrated a number of related techniques into the VA/VE process. They used Quality Function Deployment (QFD) to benchmark their products andused system dynamic models to simulate the life cycle cost and cash flow of their recommendations. The flashlight team used adjacency diagrams and design for assembly and manufacturing models to study how to assemble and manufacture their new flashlight. Figure 2 shows an adjacency diagram that was used to combine and reduce parts. The flashlight team dramatically reduced the number of parts and improved performance and customer features.

The microwave popcorn team used VA/VE techniques as well as time and motion study to analyze the packaging, assembly, preparation and consumption of microwave popcorn. System dynamic models developed by this group modeled the effect of the timing of five separate product introductions on company sales and revenue. One packaging suggestion provides a user cash flow rate of return of 182% in three years and other suggestions introduced innovative consumer oriented features and functions.

The cork remover team conducted an extensive market research study to determine the relative value of several different cork removers. A questionnaire was developed and distributed to employees at 27 different wine cellars. Employees who open wine bottles during public wine tours were asked to rate various cork removers. This team integrated the results of this survey with a FAST diagram and then used functional morphology matrices (TR and COPC) to help design an improved cork remover.

Value Management study of the Erie Aqueduct

In selecting class projects for VM I use projects that deal with business, organizations or services. These projects stress forecasting, planning and implementation more than engineering. As a VM project, I had graduate industrial engineering students at RIT study the operation of the New York State Barge canal. They proposed converting the canal to an aqueduct to supply fresh water to New York City. For a number of years New York City has been operating with insufficient water for a prolonged drought. The U.S. Army Corps of Engineers has been involved in efforts to alleviate this serious problem since 1975 and the class reviewed reports they had written on the problem,[5,6] and on the multi-billion dollar Hudson River Project designed to meet New York Cities future water needs[7].

In 1986 students in my VA/VE class developeda value plan for the construction of an "Erie Aqueduct" that would use the New York State Barge Canal to supply water from Lake Erie to the Hudson River Project. Figure 3 is a map of the proposed Erie Aqueduct that would carry water from the Niagara River to New York City. The ERIE AQUEDUCT would increase the flow of water from the Niagara River and Lake Erie into the Erie Canal and would carry fresh water to areas throughout New York State. Increased water flow would:

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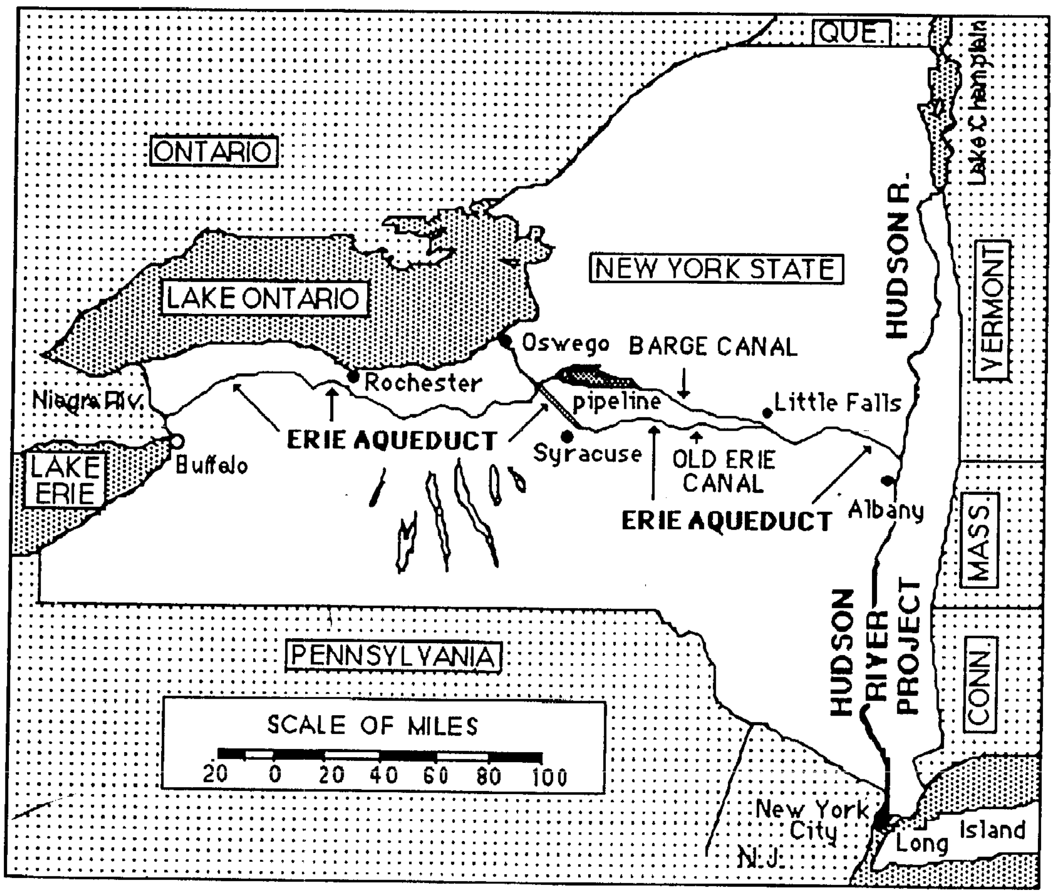
Figure 3 Route of the proposed Erie Aqueduct



1.) Control water levels and prevent property damage on Lake Erie and Ontario.

2.) Purify the canal and improve the environment.

3.) Provide fresh water to farms, towns, villages and cities along the canal.

4.) Improve recreational uses of the canal, i.e., fishing, boating, hiking, camping etc..

5.) Augment water supplied to New York City via the Hudson River Project.

6.) Produce hydroelectric power at dams and locks along the canal and its spill basin.

Students recommended that the project be conducted in two steps. The first stage will double the flow of water into the canal from its present rate of 1,237 cubic feet per second. The water will flow along the canal from Lake Erie to the Oswego River. The second stage of the project involves construction of an aqueduct around Syracuse that would allow water to flow by gravity from Lake Erie to the Hudson river. Here the Erie Aqueduct project will interface with New York City's Hudson river project. The Erie Aqueduct is described in a short video tape that was prepared at Syracuse University.

The proposal deserves serious consideration and is an excellent example of how a VA/VE study can lead to real innovation.

Students in the class developed an extensive FAST diagram for the project. The diagram has two branching sides, one showing the benefits and the other the technology needed to meet the market demand. The diagram was used to form VA/VE teams and to assign functions for individual students to research. Figure 4 shows this two sided diagram. Individual and team reports developed by thestudents indicated that the project would benefit millions of people in the Northeastern US and that the project could be accomplished at low cost. The amount of water removed from Lake Erie is very small and would have beneficial results if done during high water periods.

Expanding College and University Value Training.

Students in RIT's value courses are using the latest VA/VE methodologies together with other value improvement methods to improve the value of products and services. RIT's VE and management training courses are among the most advanced in the world. Students study the latest VA/VE methodologies and learn how to apply these techniques to their work. As new techniques are developed in related fields they are researched and integrated with the value methodologies into new and exciting procedures. RIT is not alone in this effort. Other universities such as The University of Wisconsin, Madison (Tom Snodgrass) and The University of North Carolina (Jerry Kaufman) offer excellent VA/VE training. Unfortunately the three universities together with a handful of others are all that do.

In 1989 Tom Snodgrass, CVS, FSAVE, director of the Center for Value Education at the University of Wisconsin in Madison, contacted 325 universities and colleges in the United States listed as having engineering schools and continuing education departments. At the 242 institutions that agreed to be interviewed, representatives from the engineering college or continuing education department answered questions about training in VA, VE or VM. One hundred and twenty five schools said they offered no training in VA/VE and eighty two could not be interviewed. Only 13 schools indicated that they offered credit courses to students in this area.[8] Twenty three colleges offered VE courses through a continuing education department and only eight of these schools offered a 40 hour course. One hundred and seventeen schools said they taught students about VA/VE in courses such as engineering economics, (42 schools) engineering design, (16 schools) manufacturing engineering, (13) industrial engineering (10), and engineering management.

The total time devoted to VA/VE/VM in these courses appears to be 25% or less. Although the number of hours devoted to VA/VE varied from course to course, the time devoted to value training averaged between 5% to 15% of total course time. However twenty eight schools reported that the amount of time they devoted to VA/VE was either small, or totaled between 1 to 4 hours of training. I am indebted to Tom Snodgrass for allowing me to include the results of his study in this paper.

Whence Value Education in Colleges and Universities?

It is obvious from the University of Wisconsin survey that VA/VE training is minimal in US colleges and universities at this time. Many colleges have never heard of it [9] and those that have may view it as an old and rather specialized technique. They hear much more about other techniques like Total Quality Management or Concurrent Engineering and are likely to opt for these courses instead of VA/VE in designing their curricula. SAVE and the Miles Value Foundation are interested in expanding VA/VE training at colleges and universities and are searching for a way to do this. In 1993 each SAVE chapter will be asked to promote a college credit course in VA/VE/VM at a college in their area.

RIT has structured a course on value which incorporates VA/VE and other value improvement techniques. The RIT course defines value and shows how VA/VE and other value improvement techniques can be used by value teams to analyze, measure, design, improve and create products and services of superior value. Engineering colleges are interested in value and the RIT courses I've described could become part of the core curricula of these colleges, augmenting current courses in Engineering Economics and Engineering Design.

In 1993 each SAVE chapter will be asked to promote a college credit course in VA/VE/VM at a college in their area.

Business colleges, especially those offering an MBA program, would profit by introducing courses on VM into their curricula. In these courses business teams would learn how to measure and improve the value of organizations and services. The book that Larry Shillito and I co-authored can be used as a text in either curricula. The course I've developed at RIT can be tailored to engineering or business students by selecting "nuts and bolts" type projects for engineers, and organizational or service projects for MBA students.

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6. "Northeastern United States Water Supply Study, Summary Report" North Atlantic Division, U.S. Army Corps of Engineers, 1977

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8. Of these schools, six offered undergraduates courses, and seven listed graduate courses.

9. One hundred fifteen colleges contacted by Tom Snodgrass expressed interest in learning more about VA/VE.