The Engineering Management Program at Washington State University: Distance Education Industry Partnership Success Stories

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Abstract
The Engineering Management Program at Washington State University has an innovative university/industry partnership for training tomorrow's technical leaders. The Engineering Management graduate degree is designed to meet the educational needs of working engineers with a thrust towards project management, manufacturing management, quality engineering, systems engineering, design for manufacturing and theory of constraints. Students can choose from electives to customize this study of world-class management of technology. The Washington Higher Education Telecommunication System (WHETS), web-based instruction, and satellite allow the delivery of Engineering Management courses throughout the State and nationwide. Participants come from a multitude of industries and companies.

This paper concentrates on the relationship with one company, The Boeing Company, with corporate offices in Seattle, Washington, with students and facilities across the country. Students of the Engineering Management Program complete class projects as a normal part of every course and as a final end-of-program project. These projects address issues that apply within their organizations. This paper explores the value The Boeing Company has received from the student projects. A recent survey of 55 students reported 109 projects valued at $39.1 million for an average of $710,000 per student for those reporting. This paper summarizes ten representative projects.

Educational Value

There is general acceptance that a college education is valuable. Having a college degree conveys a message that the student has a general understanding of governments and politics, history and culture, biology and science, languages and physiology, communications and writing, reasoning and critical thinking. It is difficult to put a value on the benefit of having this broad knowledge and general skills. You can't put a price tag on attitude, approach, self-esteem, individual growth and the development of personal responsibility. But, it is easy to imagine the costs of not having them. The outcome of uninformed decisions, misunderstandings, and confusion could be monumental. It is easy to see why many employers require a college degree as a prerequisite for employment in decision-making positions.

Most studies of the value of education focus on the value to the individual. In this situation, the value of the specific skill can be determined by measuring the difference between the personal incomes of the different graduates. Comparing the starting salary of a computer science graduate with that of a liberal arts graduate can identify the relative additional value of specialized skills to the marketplace. However, this is a very short-sided view that bases educational value only on the value to the individual and not to the employer. Such comparisons do not portray the whole picture. An additional important dimension is what the students accomplish of value for their employers.

Washington State University's Engineering Management Program focuses on working professionals. Consequently, the students have the opportunity to actually apply their new knowledge as they learn. Each course requires students to write a paper or complete a project that applies the tools and techniques of that course in their working environment. The Program also includes a final, end-of-program project that requires students to integrate the many topics studied as part of their graduate work and at the same time focus with some specific tools into the technical management concerns of their employment.

The class projects encourages students to go beyond superficial understanding and try to integrate the realities of their world with the theory and practice of technical management. The class project brings relevancy to the course material and engages students in the learning process. The final end-of-program project often produces a significant contribution toward the improvement of technical management. Both the employer and students have a better appreciation for the course material when they can see its application. And, as a side benefit, the short-term value of the education can be directly estimated.

Determining the Value

There are almost as many different ways to compute value as there are cost accountants. Sadly, too many of the computations use the transfer of costs from one column to another as an artificial savings but of no overall value to the firm. To overcome this limitation, we encourage students to determine value based upon real, validated savings or true cost avoidance. Here are the guidelines we use:

1. Direct Throughput Value
   -Did your project produce any more product? If you produced one more at negligible increase in resources, the value is the sales price less truly variable costs (gross profit margin).
   -Did your project protect any sales? (Prevented lateness, Retained customers, Maintained relationships). The value of retained sales is the gross profit margin value of the product times the number of products per your influence time (say your influence extended for three months and you saved three per month then multiply the gross margin by 9).
2. Inventory Value
   -Did your project reduce any inventory (physical items or queued paperwork)? Inventory is valued at its raw material purchase price. Reducing variability 10% on a system can reduce the need for inventory significantly. Inventory holding costs can be 10 to 30% of raw material price.
3. Speed
   -Did your project speed up any process? Speeding any process is the same effect as adding additional capacity without additional resources. Reducing flow time 10% increases production capability 10% times the total productive capacity of the function. The function can accept more work per unit time. Reducing time also reduces the time inventory is held.
4. Cost Reduction
   -Did your project reduce actual money paid to perform a task? (Transferring people from one area to another can only be counted if you eliminate a new hire in the other area.) Material reduction, process simplification, process understanding all reduce waste, speed up delivery and increase output.
   -Did your project defer any costs (cost avoidance)? Often cost savings are not actual dollars in your pocket but money you didn't have to pay as a result of your work. Prevented penalty. Eliminated need for consultant work.
5. Estimating Value of Intangibles
   -Often a project is of extreme value for the following reasons: The solution resolves problems, provides answers, eliminates conflict, provides a plan, reduces stress, satisfies concerns, etc. The value of such a project depends upon the scope of the problem, the level in the organization and the breadth of its nature. The best model to choose to estimate the value is the "equivalent consultant cost". How much would it have cost if a consultant had provided the answer?
   -Here is an example determination. For a simple project, a consultant charges $1000 per day minimum and takes three days to find out what is going on. An outside consultant usually takes longer to solve a problem than an inside person. For this determination, assume the consultant solves the problem in about the same number of days over which you solved the problem (assuming you worked on the problem full-time). The consultant then takes three to prepare the solution in some presentable form. If you spend four full-time days doing a project, that's worth $3,000 + $4,000 + $3,000 or $10,000 in simple terms. For far reaching projects, multiply the estimate by a factor of 2 for each layer of supervision and for each additional outside organization involved. If you spend 20 days solving a problem that spans three layers of management supervision in the organization and it includes another outside organization, a rough estimate in consultant value would be ($3000 plus $20,000 plus $3000)*2*2*2=$208,000. Adjust your numbers in a conservative fashion.
   -Some projects are reports, analyses or summaries. Again, The value of the report (while not tangible) can be determined using the consultant model. How much would it have cost for a consultant to provide the same material?
6. Recurring Values
   -Often an improvement of a repetitive process provides value with each subsequent repetition. When estimating value, limit your scope to the number of repetitions expected in the first year (even though there may be long term ramifications of the improvement).

For a complex company such as Boeing, it is difficult to validate the value of any single initiative; it is seldom that any intervention is accomplished in a controlled fashion. Resources are often diverted to other processes in mid-stream, projects are cancelled or delayed, and priorities change frequently. A basic accounting principle holds that any decision should ideally be evaluated by the incremental effect on costs and revenues; however, this simple rule is difficult to apply when activities are so intertwined. Therefore, the self-reported values of projects according to the six basic methods listed above have not been formally validated. Nevertheless, they provide an initial estimate of the direct value of these interventions. It is certainly possible to quibble about the accuracy of the estimates, but we are convinced that the order of magnitude is correct.

Student Project Summaries

A student survey in the spring of 1999 accumulated the report of 101 projects from 49 students (a 40% response rate). The students were asked to report their estimated values of their projects over the course of their Engineering Management Program. Sometimes they reported significant improvements to their processes but no dollar value could be placed on the changed attitude of the people. Most often, the students reported some estimated valuation.

The reported projects were categorized by course. Different students found different courses and topics of specific value for them. Some courses were required fundamentals and others were specifically focused on improvement in specific areas. Table 1 groups the courses by the following general categories:

Analytical (Operations Research, Simulation, Decision Sciences, Design of Experiments)

Managerial (Management of Organizations, Financial Management, Project Management, Performance Measurements, Strategy)

Manufacturing (Manufacturing Operations, Manufacturing Science, Constraint Applications, Design for Manufacturing)

Quality (Statistics, Quality Management, Quality Control, Constraints Management)

Final Project (End-of-Program Projects)

Table 1 Self-Reported Student Project Values

	Analytical	Managerial	Manufacturing	Quality	Final Project
Number of Projects	10	34	13	37	15
Reported Value	$210,000	$940,000	$2,534,000	$2,436,000	$33,025,000

The aggregated projects present impressive reported value in all categories. The value of the end-of-program projects (those that require demonstration of both depth and breadth of the engineering management tools) is the most significant contributor of value to companies. However, that does not guarantee any particular student would gain similar benefit from any specific class or final project. Much depends upon the system value and influence students have over its operation. It is interesting to look at some specific projects to discover why these projects have such value.

Ten Case Studies

The following ten projects were end-of-program projects for students working full-time at The Boeing Company. Each project is accompanied with a general statement of the areas that attributed value without disclosing any company sensitive material.

1. Project: Applied Design for Manufacturing
   Self-Reported Savings: $250,000
   Design for Manufacturing techniques simplified manufacturing, reduced requirement for additional employees, improved initial designs, reduced redesign effort and avoided cost of redesign, rework and overtime.

2. Project: Quantitative Risk Analysis Using an Integrated Product Team
   Self-Reported Savings: $5,000,000

This project used a hybrid risk analysis process associated with military products on two specific applications to reduce the uncertainty during the early portion of the product development process to improve decision making, accelerate design processes and reduce redesign efforts.

3. Project: Implementing an Engineering Parametric Estimating Methodology
   Self-Reported Savings: $5,400,000
   This paper developed and instituted a statistically based parametric cost estimating system that simplified, accelerated and minimized the risk in creating estimates for new military systems. The approach was clear and understandable raising customer confidence in the estimate. This project included significant cultural changes needed to implement switch to the using the new technique.

4. Project: Developing an Engineer for Product Development
   Self-Reported Savings: $1,000,000
   This paper accelerated the development of knowledge and capabilities of product engineers by improving their access to product development knowledge in a more effective fashion. As a result, younger engineers could tackle more complex designs earlier in their career effectively accelerating the creation of engineering expertise. This allowed faster and better designs, fewer delays, less redesign, and earlier deliver of new products.

5. Project: Reductions in Receiving Inspection Testing Based on Closed Loop Testing Processes
   Self-Reported Savings: $2,000,000
   Boeing receives millions of parts from vendors daily. This project improved the inspection/acceptance process to accelerate the delivery of component parts from receipt to the point of manufacture. It significantly reduced holding costs, eliminated many manufacturing delays and reduced manpower needed for inventory receiving processes.

6. Project: The Contribution of Virtual Manufacturing Simulation to Agile Manufacturing in a Digital Design Product Development Environment
   Self-Reported Savings: $3,000,000
   This project links the use of virtual manufacturing simulation software tools to the manufacturing process providing quicker response to manufacturing requirements. Designs can be tested for manufacturability in advance eliminating many redesigns, rework and production problems. There is an added confident component designs will combine correctly. Product improvements move more quickly into production.

7. Project: Implementing Critical Chain Project Management on the Space Shuttle Stowage Locker Project
   Self-Reported Savings: $9,400,000
   This project used an aggressive scheduling technique with selective protective time buffers and buffer management to accelerate the schedule for critical component assemblies. This pilot project completed far ahead of schedule much improving cash flows and at the same time minimizing quality concerns. The tools developed in this pilot will now be used in major projects the whole center.

8. Project: Continuous Improvement in a Captive Shop Environment
   Self-Reported Savings: $3,500,000
   The project creates an approach to continuous improvement in an organization that cannot determine its market, its materials or the technical processes. The paper documents six cycles of systemic quantum improvement using the theory of constraints to exploit and then eliminate constraints resulting in dramatic improvement under the most confining conditions.

9. Project: Applying the Theory of Constraints to Design of Military Aircraft
   Self-Reported Savings: $3,000,000
   This paper demonstrated an aggressive approach to scheduling the design of complex systems at an accelerated rate to deliver in 18 to 24 months projects that had previously taken 3 to 4 years. The effective application of this process reduces costs of design, moves designs into production much

sooner and frees designers to work on other waiting work. It also improves the accuracy of project completion estimates.

10. Project: The Application of Design for Manufacturability Principles in a Multi-Chip Module Product Line
    Self-Reported Savings: $250,000
    An analysis of the production line discovered eleven specific recommendations and improvements that reduced the margin for error, simplified processing, improved first pass yield, created faster deliveries and increased the effective productive capacity of the system.

Conclusion

These ten cases point out may different areas where student engineers applied engineering management improvements to create significant value for their firms. The value reported is monetary. However, each improvement project also changes the culture and attitude of those involved in the change. They become more attune to additional improvements, confident in their abilities to succeed and desirous to be involved in an ongoing improvement process.

The education in the Engineering Management Program is very valuable to the students' employers. In some cases, the self-reported value of the projects may be overstated. In many cases, the full value of the projects is understated (when the student is not aware of positively effected processes outside their immediate span of control). The individual projects reported only document the projects completed during the Engineering Management Master Degree Program. We can expect that the graduates will continue to apply the technical management tools in the future to provide continuing value to their firms.

While any individual student or employer cannot be promised such significant returns, it is clear that the education of engineers in technical decision making positions and with influence over technical processes can provide significant benefit in the leadership and operation of their firms. As a whole, the value of education in such an environment overwhelms the cost.

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