Experiential-based learning in engineering project management within a global economy

by

Evan S. Miles

A THESIS

submitted to

Oregon State University

in partial fulfillment of the requirements for
the degrees of

Honors Bachelor of Arts in International Studies in Mechanical Engineering
Honors Bachelor of Science in Mechanical Engineering

Presented June 3, 2008
Commencement June 2008

AN **ABSTRACT** OF THE THESIS OF

Evan S. Miles for the degree of Honors Bachelor of Arts in International Studies in Mechanical Engineering presented on June 3, 2008. Title: Experiential-based learning in engineering project management within a global economy.

Abstract approved: ____

Dr. Ping Ge

Introduction

Over the past century, great technological advances have enabled high-speed communication and transportation across the globe. This technology trend combined with the needs of continuous expansion of market place has motivated major corporations not to restrict their business activities to within a single principality. Engineering design activities can take place across the globe, while projects themselves tend heavily towards larger and international scope, affecting greater numbers of diverse populations within numerous principalities. The social, cultural, political, and economical differences have inevitably raised tremendous challenges for coordinating widely spread, yet inter-connected collaboration project activities among the various stakeholders.

This establishes the need for effective project management to ensure that the stakeholders, all with diverse backgrounds, cooperate to effectively progress to the project's completion for the corporate sector, governmental organizations, and non-profit groups. Though extensive project management literature exists, little has been done on addressing the challenges faced by new managers in a global economy. In addition, in the current engineering curriculum, scant attention has ever been put on teaching such knowledge. This has left those inexperienced young engineers with frustration when beginning a prominent project management position. It is therefore crucial to develop innovative ways of acquiring such knowledge, and this thesis will address some of the major project management challenges in a global economy and share case studies on experiential-based learning.

Thesis Statement

This thesis seeks to discuss international engineering project management as a broad practice, and will include the author's learnings in the specific areas of the project life cycle, stakeholder interactions, budget management, and team coordination.

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I understand that my thesis will become part of the collection of Oregon State University. My signature below authorizes release of my thesis to any reader upon request. I also affirm that the work represented in this thesis is my own work.

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Evan S. Miles, Author

Acknowledgements:

First and foremost I would like to thank my father for the exposure to Mechanical Engineering with which I was raised, followed by my mother and sister for the complementary experience-based lessons that they lovingly effected in me throughout my life. Certainly I am an expression of the challenges our family has faced and the ways that we have come through as a team.

I would very much like to express gratitude to the Honors College staff and the International Degree staff. In particular, LeeAnn Baker and Renee Stowell continually encouraged me on to greatness and have been willing to support me as I noted opportunity after opportunity.

I would also like to thank the Mechanical Engineering (now MIME) Faculty and Staff which allowed me to choose my own pursuits over these past several years. The flexibility that was extended me has allowed me to better contextualize my own engineering knowledge, and to pursue my less technical interests.

Certainly without the experiences of MECOP and Engineers Without Borders this thesis would not have been possible. I extend a grateful salute to my teams at Intel and Oregon Iron Works, which were willing to rapidly incorporate me into their project management tasks and to share responsibility with me.

To the Engineers Without Borders students and advisors, I have greatly enjoyed our challenging and frustrating pursuit of a better world, and look forward to continuing that pursuit. Our work together has inspired me in great ways.

Finally, to my friends that have put up with me through the trials of senior project and the thesis. I would have gone crazy long ago without you.

Last, to God for the many blessings he has bestowed upon me, not least of which is my finishing these undergraduate studies.

Table of Contents

1. Motivation, Background, and Objective

Humans are creating more connections across the globe than ever before in the planet's history (Sklair 1999; Rowntree, Lewis, Price, and Wickoff 2006, 1). National boundaries are crossed by communication, infrastructure, and commerce at unprecedented rates (Zhang, Gregory, and Shi 2007; Rowntree, et al 2006, 1). Industries once controlled by a particular geographical region have now integrated production in distant regions (Machine Design 2007). It is undeniable that market interactions in one area or one culture can have far-reaching impacts for the entire globe. Many trade barriers that historically limited the movement of goods have been lifted and allow rapid transportation from specialized production regions to mass consumers in their own locales.

1.1. Globalization

Contemporary life is filled with the products of globalization and its effects to the point that they are invisible to most people living in modern Western society – they are hardly even noticed in daily life (Ellwood 2006; McMichael 1996). Yet it is important to understand that while trade has been far-reaching since the inception of civilization, a globalized Western economy such as is experienced in modern times is new (McMichael 1996; Rowntree, et al 2006, 2). This section seeks to understand some of the most basic aspects of this trend toward global economic interconnectedness (Rowntree, et al 2006, 2). There are many perspectives with distinct assessments of the implications of globalization and the net impact it has had on the world (Sklair 1999). The different outlooks on globalization will not be addressed in this essay, but modern engineering projects occur in the context of globalization and so it is necessary to understand the trend's major motives and impacts (Rowntree, et al 2006, 1).

1.1.1.Communication Lines

Communication is a primary contributor to and example of globalization (Ellwood 2006, 9). Globally-dispersed processes require by nature an effective means of communication in order to coordinate nodes of processing, production, and distribution, as well as those of needs-assessment. In fact, communication has historically been a major limiter of the extent of corporate expansion. Having Detroit automobile parts manufactured in Mexico would not have been possible in the early 19^{th} century unless the design for parts were unchanging. The parts could have been manufactured, but relaying instructions across the national and language barriers would have been inefficient with regards to both time and money.

When one thinks of trade empires, the British East India Company comes to mind as a monument of global linkage. Yet the British Raj focused its efforts in present-day India and Bangladesh on raw material extraction rather than materials processing, presumably also due to communication barriers and related economic incentives (Heitzman and Worden, 1989, 7; Lappe et al, 1998, 88). Communication about which fashions were in style in Europe would take months to get to India, and when the finished goods returned to Britain, clothing tastes would no doubt have changed. Communication has historically been a major barrier to corporate expansion and globalization.

The 20^{th} century saw radical progress in communications technology and infrastructure (Dankbaar 2007). The development and introduction of electrical and electronic communication forms, progressing from the telephone to wireless forms and eventually to the internet, has greatly reduced the inconvenient burden of communication delay (Machine Design 2007). In addition, technical data storage mechanisms such as computer-aided design and material standards allow conceptual data transfer via virtual networks. Global infrastructure now exists that allows transfer of specific technical information across continents and cultures in seconds or minutes, rather than months (Dankbaar 2007).

This rapid communication exchange enables business decisions to be made remotely, and entire projects can be coordinated from a desk in a completely different time zone. For instance, producers such as Infosys in India now communicate instantaneously with American and European counterparts in order to carry out their production requests, thanks to communication achievements (Friedman 2005).

1.1.2. Transportation of Goods

Transportation has historically been another difficulty for business operations with large geographical spheres of operation. Whether transporting products or resources, long shipping times and the difficulty of product preservation were often impassable barriers for early manufacturers. The food industry is one of the best examples, as many foods rapidly degrade in quality and as a result were not historically shipped to faraway markets, unlike textile products. Instead, food management over the vast majority of human history has taken the form of bioregional self-sufficiency, with some cross-regional exchange of nonperishable items.

As early as the 19th century and throughout the 20th century, this status quo began to change as transportation speed increased and preservation methods improved. Imperialistic governance by European nations over their distant colonies since the 16th century had emphasized production of cash crops to be processed and consumed in the homelands. In exchange, factory-produced goods were sent to colonies for consumption. By the 20th century many former colonies had stretched their agricultural bases and few had maintained agricultural self-sufficiency. They instead relied on supplemental imported foods, but had developed their own industrial bases. This development is paralleled by the earlier urbanization processes driven by the Western industrial revolution – fewer and fewer people were focused on sustenance agriculture, but instead depended on food produced outside of their immediate area.

None of these population or production shifts would have occurred had shipping technologies not revolutionized. Preservation of goods was crucial, even in its pre-refrigeration forms such as salting or canning. At the same time, though, the transportation methods progressed significantly. The net result has been fresher goods transported from further away, in less time. Indeed, shipping costs have decreased significantly and continue to decrease for the present-day transport of goods (Ellwood 2006, 19).

The historical development of shipping has led to very expeditious transport of goods in modern times. Modern cargoes can cross the Pacific Ocean in a matter of hours by cargo airplane when necessary, or larger shipments can take place by a cargo container on an oceanic super-transport ship. Regardless of the method of shipping quantity, speed, and security of shipment have been immensely improved moving into modern times.

This progress, as in communication, has facilitated globalization and global market connections. Without the ability to transport manufactured goods with such ease, large corporations would have to use remotely managed nodes of production and distribution for local markets, with only slight inter-region exchange (Chiesa 2000). Instead, vast intercontinental material extraction, processing, and production processes are coordinated to produce products to be sold in comparably dispersed locales. Thus the progress of goods-transportation processes and infrastructure has played a very important role in the formation of a globalized economy.

1.1.3.Expansion of Markets

Partially due to the global incorporating factors listed above, contemporary history has experienced an immense expansion of Western markets (Merchant 2005, 31). This perceived expansion process has allowed incorporation into Western markets via elimination of trade barriers (Merchant 2005, 33). New markets have been incorporated into a global market-based economy from the subsistence or local economies within which they have historically been participants. Similarly, entire nation-states within the former Soviet bloc have been reincorporated into the capitalist global economy of goods as trade and political barriers have dropped (Friedman 2005; Rowntree, et al 2006, 5). Figure 1 demonstrates the worldwide import tariff drops that have occurred since the 1980's.

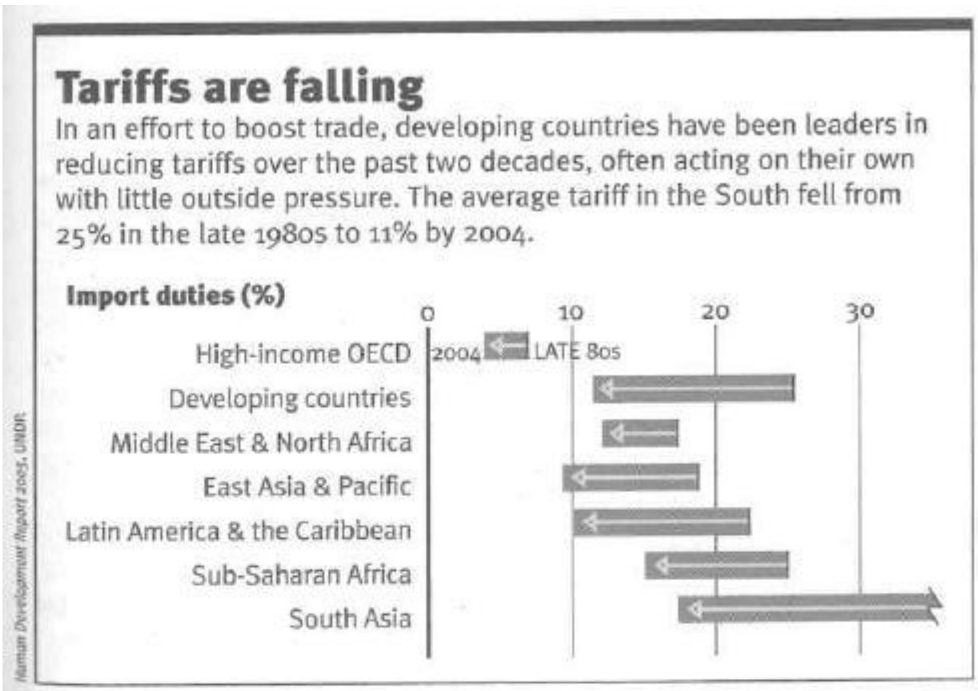


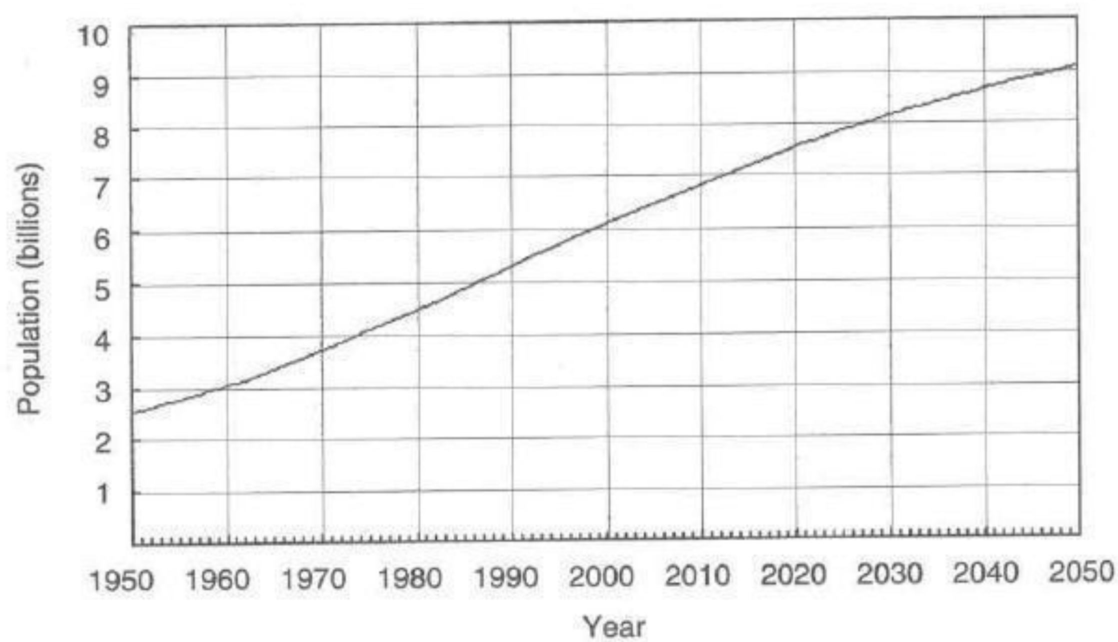
Figure 1: Decreasing trade barriers (Ellwood 2006, 35).

For both of these types of market expansion, it is important to realize that the new market participants likely had their needs more or less met by the previous economic form in which they were participating. For instance, in a subsistence agricultural system, participants sustainably share a sort of commons from which their needs for food, shelter, and textiles have been historically met (Merchant 2005, 44). As this economic community becomes integrated into the global system, outside economic forces are given the opportunity to participate in fulfilling local needs. Artificial needs may be introduced, such as cell phones and internet, which require external participation since they are based on external infrastructure and technology. For the most part, though, the Western global market seeks to meet needs that were already met by the previous system, such as food, and needs that did not exist prior to incorporation.

In some cases, such as the former Soviet republics, there were already complex localized systems developed to provide food. However, currency (the dollar) is supposed to determine suppliers in a global economy, and food is no exception. As a direct result, local agricultural production may be replaced by outside global producers, while local products are instead turned to exports. This process of production replacement can have two significant effects. On one hand, former food-producers may focus on production of an export crop with more substantial financial returns. On the other hand, this potential for export crop production comes at the sacrifice of the local community's ability to be self-sufficient for food. Many social changes have been associated with this transition to a Western economic model following the drop of trade barriers (Ellwood 2006).

The process of replacement is relevant because engineering or business-focused firms and groups seek to meet the needs of some market with their product or solution (Aucoin 2002). However, in many cases these new market participants have had a functioning system that met their needs for those items (McMichael 1996). That statement is not meant to imply that engineering solutions to improve production or efficiency are always negative introductions for new market participants. Nonetheless it must be noted that some local system of production must shift when an external producer is allowed to meet that local market's needs. This is true for all international projects, and must be considered carefully before integration is assumed: any external forcing causes a change internally. (Rowntree, et al 2006, 1-45)

That being said, the past 100 years have seen unprecedented levels of international exchange of goods and money. Production of raw materials and processing has been shifted on a broad scale from local and regional centers to international and global arenas (Gunhan and Arditi 2005). The potential market size for virtually any item has multiplied several times over as population has increased (see Figure 2) and barriers have dropped. Any item designed and produced in the modern era has greater likelihood for mass production and consumption than ever before. Indeed, there are more people on participating in the market than ever before (Friedman 2005) although not all of these people have access to the same resources.



Source: U.S. Census Bureau, International Data Base, April 2004 version. (Available online: http://www.census.gov/ipc/img/worldpop.gif)

Figure 2: World population and projected growth. Simultaneous expansion of Western capitalism means that there are more potential consumers for western products than ever before. Adapted from Lappe, et al (2006).

Of course, it also implies that there are many more potential competitors, and the local and global competition has caused the emergence of global production giants for staple foods and basic widgets. Private American agricultural firms raise huge portions of the global trade in wheat, and United States food aid subsidizes their excess production to aid areas that often do not traditionally eat wheat

(Lappe, Collins, and Rosset 1998, 134). The point is that with the exception of emerging industries, most contemporary economic activity involves both local (domestic) and external (international) forms of competition. Furthermore, due to the development of an interconnected global economy, far-reaching impacts can be possible from even small-scale local economic activities.

1.2. Capitalism and the Demand for Growth

This brings discussion to the form of the globalized economy: capitalism. The capitalistic mode of economy has two distinguishing features relative to other economic systems. First, the system is driven by the accumulation of private capital, meaning ever-increasing concentrations of wealth for those that begin with enough (Merchant 2005). Second, this private accumulation is made possible by an institutionally-enforced incessant demand for economic growth. That is, capitalism at its root seeks and rewards rapid financial improvement over all other business characteristics. The result of this motive is rapid creative progress and technological development because financial assets flow to the areas with greatest potential for returns. Thus, coupled with capitalism's drive for growth is the accumulation of private capital. Those with money invest it for the greatest returns and thus increase their portion of capital, while the rest of society hopes to be one of the few beneficiaries.

1.2.1.Relevance: Requires Improved Efficiency

This reality has several implications for engineering projects. First, it is clear that any sort of engineering endeavor requires financial resources, and thus project managers and business managers must find a method to make their activities attractive to investors. Since capitalism is driven by the financial bottom line, many businesses and projects focus on improving their cost – benefit balance: increase revenues or reduce costs. In the end, this comes down to an improvement in efficiency: revenues may increase more than costs for some period but eventually the market will require an improvement in the revenue-per-unit-cost efficiency in order to increase the profit margin. Thus efficiency of the project process and of management (overhead costs) becomes a primary goal for many industries (Girard, Legardeur, and Merlo 2007; Clarke and McKeag 1989).

1.2.2. Relevance: Outsourcing of Engineering Jobs

The second implication for engineering tasks places capitalism's demand for improved efficiency within a global context. The current state of marketing and production within most major industries in developed countries is highly international (Gunhan and Arditi 2005). The developed country serves as the intellectual development center, determining a market and designing a product to meet the market's need. Meanwhile, production needs are exported to less costly locales to reduce costs for labor-intensive portions of the production process.

The engineering community has seen an outsourcing of materials processing and more recently basic component production. Some industries have moved entire manufacturing and assembly processes from the place of the industry's origin to distant countries in order to lower production costs. However, until recently, this labor export primarily occurred for manual production work. Outsourcing was of production activities only. With a rise in education, especially advanced levels with development of specialized knowledge, the larger companies are beginning to draw upon qualified intellectual labor pools abroad (Cross and Sivaloganathan 2007). In short, the engineer may go the way of the welder and the assembly line technician – elsewhere (Friedman 2005; Machine Design 2007). All markets, including that of labor, are vulnerable to foreign competition (Gunhan and Arditi 2005).

To understand this outsourcing trend, one must examine the drive for business efficiency placed in a globalized context. Not only has access to new markets been granted by globalization, but in a similar manner access to new labor pools has been granted. Thus, on one hand there are more competitors fighting to have a share of the global market for goods. On the other hand, there are that many more laborers that may be employed. Recall also that on the business side, improved efficiency is necessary to survive. As a direct result, contemporary economics suggests that the lowest cost producer will win the largest market share, and that the lowest cost producer is the most efficient at producing its widget. One of the best methods to improve this efficiency is to draw on the lowest cost labor pool that can successfully complete the required tasks. Thus, from a business standpoint outsourcing all labor to the least expensive places with sufficient education is an excellent strategy, although it may take significant time and resources to accomplish (Zhang, Gregory, and Shi 2007). (Dankbaar 2007)

This context of employment is important for contemporary engineers and engineering managers to understand. In order to retain employment in the intellectual sector of a capitalist economy, engineers and engineers managers need to outweigh the cost savings of outsourcing with their more efficient activity. This requires that effective and timely communication occurs to coordinate successful design activities in ways that external potential intellectual centers are unable to do (Dankbaar 2007). Engineers must either be better at engineering or better at managing their engineering tasks than their counterparts (Zhang, Gregory, and Shi 2007). This paper's intent is to make young engineers better at becoming managers to facilitate their preservation of placement in the intellectual center of production, and to accomplish this task with basic education about globalization's relationship with engineering project management.

1.3. International Project Scope

The paper has shown that engineering tasks need to be carried out in an efficient manner in order to increase the likelihood of a project's successful investment. It is important to characterize the scope of contemporary engineering projects to understand why this desired efficiency is hard to attain. Certainly engineering tasks can be complicated, but the basic product development cycle and normal stakeholder relations can be heavily obscured by the setting of globalization. In essence, international engineering projects are very sensitive to a number of world events, technical factors, and cultural settings (Gunhan and Arditi 2005).

1.3.1. Larger, More Technical Projects

Not all modern engineering projects are enormous technical undertakings, by any means. Not all modern engineering projects have an international scope, either. However, many fit into one of these categories, and in general engineering projects have become more complicated, more dynamic, and larger in scope since the 1950's (Zhang, Gregory, and Shi 2007). The more complex a project becomes, the more participation is required both internally within the project team and externally with outside agents, and the more challenges a manager will face (Cates and Mallaghasemi 2007).

Examining the transportation industry, there are many examples from which to choose. The automobile has undergone a significant transformation, first in the name of safety and later due to the introduction of computer-controlled electrical systems. The various safety standards among different countries have caused differentiation of vehicle designs nearly as much as have market-determined features (Ge, Lu, and Bukkapatnam 2005). The introduction of seatbelts, airbags, and crash testing, for example, has required significant engineering design activities to meet United States standards, whereas the same requirements for other countries are more or less difficult to meet. Thus, by attempting to appeal to a globalized market, the makers of modern automobiles must spend significant engineering resources to meet the needs of the national entities encompassed within their target market.

Meanwhile, the field of aviation has grown tremendously during the past 50 years experiencing a similar process of market expansion and national regulation. While the first airplanes could be built in a garage or back yard, modern airliners require thousands of engineers cooperating across continents simply to complete the design for a single unit. The production process then requires semi-unique parts produced all over the world, intricately timed with delivery to create a product to be used to cross multiple principalities and meet their individual restrictions with coordinated maintenance. Other traditional engineering fields exhibit a similar trend towards global participation and impact. Therefore while engineering activities may be focused about a particular set of discrete tasks, they take place as part of a larger process that typically has global implications or global participation. For most of the world, the days are gone when local work only had local effects.

1.3.2. Effect on More Diverse and Larger Populations

Indeed, modern engineering tasks often have widely dispersed effects on increasingly diverse populations (Sklair 1999). The traditional analysis of affected persons discusses the relevant stakeholders as consumers, customers, employees, and investors. However, modern production practices have made it clear that there are other stakeholding individuals that have been left out. Communities near material extraction, material processing, and production facilities are affected by potential environmental degradation, byproduct waste, and politics that can be associated with the presence of these facilities. (Chang 2005)

A brief overview of the relevance of globalization on traditional stakeholders will prove useful. Beginning from the top down, globalization affects investors by opening new opportunities and causing increased efficiency via competition. As a result, integration into a global market economy means improved opportunity for gains for investors. Globalization affects employees with a combination of complex interactions. Downsizing and layoffs are countered with increased employment in new ventures, while mechanization and outsourcing of labor stipulate an increase in worker effort in order to remain employed.

For customers, globalization brings an increasing variety of potential products to your doorstep. Items from distant regions can be purchased and delivered both expeditiously and economically. Customers' options for product selection increase from the simple locally or regionally produced goods to a whole slew of international options. Yet for the consumer, this variety increase is paired with the reduction of product quality, perceived or real, as producers strive ever more for increased efficiency in their design and production processes. Items are often mass-produced to compensate for shipping costs in competition with local products, and the mechanistic worldview of the production process may not emphasize the attributes a consumer truly values. The net result for the consumer is more choices between similar items that are heavily processed. (McMichael 1996)

1.4. Summary

The progress of globalization to contemporary integration adds significant complexity to what is conceptually just a simple market economy. As a result, the tasks of engineering and project management have expanded in scope and difficulty. There are three primary challenges that should be drawn from the sections above, as illustrated in Figure 4.

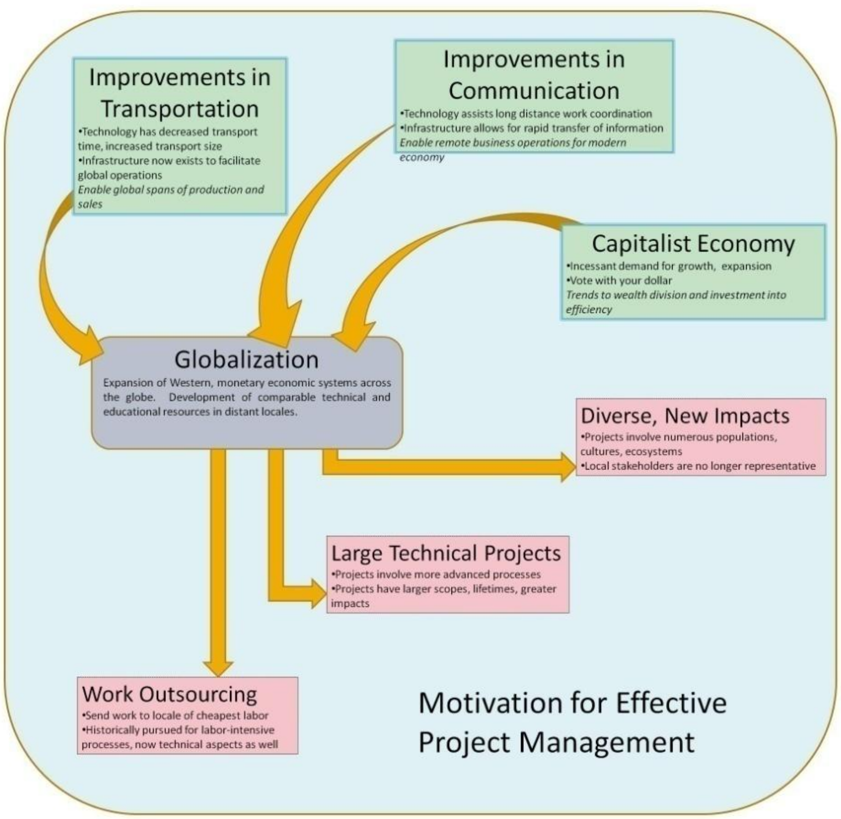


Figure 4: Shows primary causes and effects of globalization as relevant to international engineering project management.

1.4.1. Diverse Stakeholders

While a simpler market economy accommodates the same broad stakeholder categories, it does not account for the global diversity that is present within each grouping. It is unlikely that a Japanese investor would look to place his money in the same manner as a South African former entrepreneur. Neither do automotive consumers in Brazil and California expect to use their cars for the same purpose or even maintain them the same way. Communities, traditionally ignored as a stakeholder because of their underrepresention in decision-making, are particularly diverse in their perspectives, interactions with producers, and even their responses to integration. In any case, there is no one-size-fits-all in a globalized economy. Engineers and managers need to be careful to contextualize their entrance into new markets in an appropriate manner (Ellwood 2006; McMichael 1996).

1.4.2. Need Effective Project Management

Within any capitalistic economic mode, efficiency is a factor of business survival. Ever-increasing efficiency is necessitated for whole economic groups in order to surpass or survive broad scale competition in a globalized economy. In order to maintain jobs, this increasing efficiency requirement must be heavily borne by effective management and limited overhead costs. There is little time for schedule buffers or adjustment to new strategies. Management procedures are required to be short and accurate with little error and brief project introductory periods, and traditional management methods do not meet the demands of an international context (Zhang, Gregory, and Shi 2007).

1.4.3. Little Preparation for Young Managers

Young engineers are not prepared to undertake managerial tasks in such a globally-integrated economy (Aucoin 2002). Insufficient managerial training is provided by educational institutions as management is often considered an experiential skill set . However, on-the-job training to compensate for this educational gap goes directly in the face of the drive of capitalism: it is time-consuming and imperfect; in essence it is inefficient. While it is true that management styles and practices must be developed through experience, this paper asserts that an increase in awareness of globalization and its relevance to project management will improve young engineers' ability to transition into managerial roles within the global economic structure.

2. Experiential-based Learning Context for Global Engineering Project Management

I myself am a very young engineer: I am about to graduate from my undergraduate studies in Mechanical Engineering and International Studies. However, I do believe that I have some small pieces of understanding that ought to be passed on to other engineering students or young engineers. Few young engineers are given an opportunity to participate in management activities early in their career. As an engineer's career progresses, however, he or she develops more and more technical expertise but often has a limited perspective of the global implications and interactions related to his or her work activities (Aucoin 2002). Thus I would like to pass on the few things that I have learned from my stints in management roles to other young engineers with aspirations to manage.

2.1. My own experience

My personal experiences in engineering-related management roles have been fairly brief and extremely diverse, but have given me exposure to many different aspects of the project and product life cycles. As a student, I participated in the Multiple Engineering Co-Operative Program (MECOP), and also took on various leadership roles in Oregon State University's chapter of an engineering humanitarian organization, Engineers Without Borders. As fortune would have it, the opportunities given to me all contained some international aspect, and it was due to these unique exposures that my perspective of engineering management developed. This brief section seeks to inform the reader of those experiences to assist in understanding the limited basis from which my understanding stems.

2.1.1. Intel Corporation

My first internship placement within MECOP was as an Operations Manager for one of Intel Corporation's chipset manufacturing plants. The internship was structured to increase managerial duties for the intern as he or she understood the processes, policies, and operations in the fabrication environment. As an Operations Manager, my duties included day-to-day manufacturing performance oversight to ensure that my assigned manufacturing unit was prioritizing their processing of chipsets appropriately to meet the production goals assigned to the whole plant. Each manufacturing unit specializes in a particular type of processing using dedicated machinery, but has to choose which product to process as it becomes available.

The entire manufacturing process is delicate and complex. A single fabrication plant produces many products in parallel, each with several hundred processing steps before a unit of product is completed. With a start-to-finish production time of months and an in-factory stock of tens of thousands of silicon wafers, the daily coordination of production was a significant undertaking.

A corporation such as Intel has facilities across the globe. My particular fabrication plant had sister plants in Ireland and Arizona, and our neighbors in Intel's complex communicated very frequently with employees in Israel to coordinate a distinct product development cycle. Yet even wider than Intel's corporate span is the distribution of its products and services around the globe. Electronics components designed and manufactured by Intel are found within computing and networking systems both large and small. The experience of working for a major global supplier was crucial to understand the corporate business side of globalization, as well as the competitive aspect. During my six month internship Intel's Oregon operations underwent their first layoffs in twenty years.

2.1.2. Oregon Iron Works

My second MECOP placement was within a smaller, Oregon-based metalworking company. Oregon Iron Works (OIW) has several business groups manufacturing for miscellaneous heavy-industry sectors, and I was placed into a Project Manager role in their new Streetcar Division. The streetcar industry was essentially a brand new market for American producers, and OIW's product was being developed to meet a transit need with domestically-produced vehicles for the first time since the 1940's. As a Project Manager on the small development team, my job involved less technical engineering than would be expected for a new product: OIW had partnered with an experienced streetcar manufacturer from Eastern Europe and was carrying out a technology transfer.

Thus, my responsibilities focused primarily around component selection and purchasing in order to meet United States requirements for domestically-produced transit vehicle, as well as coordinating the technology transfer from foreign processes and specifications. I was responsible for several component groups within the entire vehicle, and functioned as a communication link between the experienced European designers and the American replacement producers. This gave me excellent exposure to cultural and social differences in structure and in knowledge. Often, the Europeans had used a production method that would be impractical in the United States due to labor-intensive methods or material standards, and could not make sense of our inquisitiveness. Also, the difference between labor systems became readily apparent as our team transitioned the manufacturing technology and documentation to a form that we could in fact produce reliably and efficiently.

2.1.3. EWB-OSU

My third and entirely distinct engineering management experience has been via my involvement within the Oregon State University students' chapter of the non-profit Engineers Without Borders. This international humanitarian organization notes that many quality of life increases in Western history came about due to engineering improvements. Sanitation and drinking water are two primary examples, and EWB seeks to partner with communities in underdeveloped countries to determine a sustainable engineering solution acceptable to that community that can be easily implemented.

I first became involved with the OSU chapter during my 3rd year of undergraduate studies, and eventually had the opportunity to travel to El Salvador three times to assess and help implement a sustainable drinking water system for a rural village. In addition, I have held several elected and appointed positions within the chapter, but the relevant management activities involved the El Salvador project. For this project, I participated in selecting and preparing travel teams, assessing community needs, and developing potential design solutions. These experiences helped round out my international engineering experiences nicely: the villagers with whom we work are undergoing integration into a global economy. Furthermore, I experienced management on a different level: for some of these activities I had become the group's expert.

2.2. Topics to be covered

Now that the challenge and the author of this thesis is more readily understood, this section will lay out the approach. To rebuild the basic engineering knowledge or the process which globalization affects, the paper will summarize the project life cycle. The major project phases are the setting in which engineering tasks take place, so some overview will be given detailing each phase and what is to be expected from it.

Additionally, the project manager role needs to be examined. Although the exact responsibilities will vary depending on the company, some carryover is inevitable. Young engineers aspiring to manage must be aware of all that such a position entails. Aside from the everyday coordination tasks and important memos, the manager's job can involve lower profile chores that are just as significant.

Throughout, some highlight will be given to some of the major challenges of engineering management, which every manager has faced to some extent. I seek to offer various perspectives on the basics of management, including my own. These sections bring my short experiences out of the woodworks to answer the simple questions that escape the attention of the engineering student during schooling (Aucoin 2002). In my opinion these are the nuggets of information that young engineers need to make an effective transition to management.

2.3. Reflection and Discussion

To this point, we have effectively motivated this paper: globalization requires effective management processes including an efficient transition from engineering to management for aspiring young engineers. Contemporary trends related to globalization have presented many challenges for engineering projects, which have impacts with a longer reach and more widespread impacts than ever before.

Although I may not have extensive background from which to draw, my positions in engineering management have shown me that school does not prepare you for a managerial role. There are many aspects to successful management that young engineers need to learn, and I hope to bring some of those to light. One of the most important things to understand, however, is the foundation: the project process.

3. Project Life Cycle

The project life cycle is probably the single most important preparatory set of knowledge for engineering students to successfully perform engineering or managerial duties. It is the roadmap that determines where a project will end up, and while it may not openly give directions, it allows a big-picture understanding of where you are in the project. Milestones are given and tasks are highlighted to ensure that a project goes where it is directed. Certainly engineering tasks will happen with or without an in-depth understanding of the project life cycle, but they may not occur with motivation or in a timely manner, either. Understanding the project process gives relevance to engineering or managerial tasks, and even lends a sense of urgency in some cases.

As an engineer, one could get by without knowing more than immediate deadlines. As a manager, understanding what is ahead and around is crucial. For the purposes of this paper, only the most basic of project life cycles will be discussed. Various models exist for different types of engineering tasks, such as product development, technology research, and project implementation, but almost all share significant aspects with the outline presented below in Figure 5 (Girard, Legardeur, and Merlo 2007; Eschenbach at al 2007). Nonetheless, it is absolutely necessary to investigate and understand the specifics of the process for your branch of engineering and your work (Chiesa 2000).

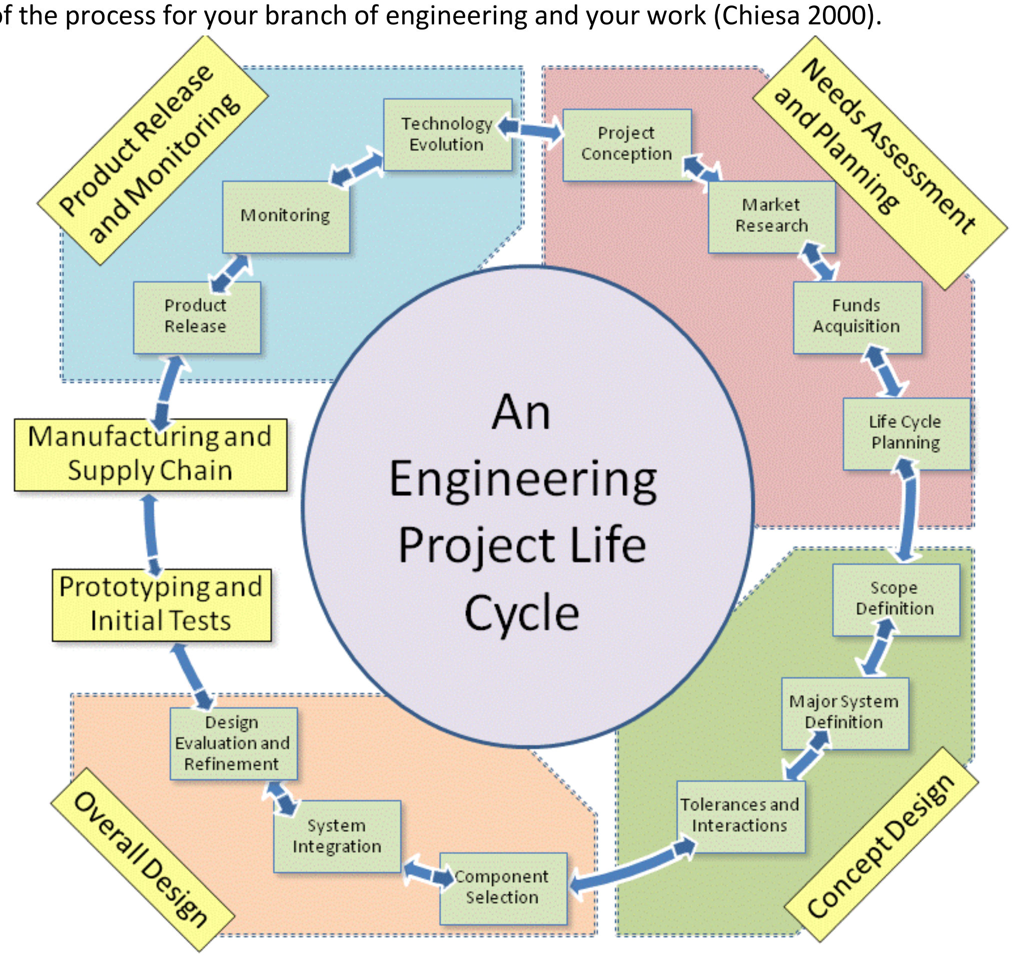


Figure 5: Shows general project life cycle as discussed in this thesis.

3.1. Needs Assessment and Planning

The project process for modern engineering projects and contemporary products begins well before the scope is even marginally defined. It begins with an idea in the case of products, or a perspective on some need in the case of projects. Someone notes an improvement to be made, or on the large scale someone discovers an opportunity for beneficial change. After this initial observation, the needs assessment and planning activities of the project process (or product development process) begins. The most important question during this stage is 'Should we pursue this project?' There are several different analyses that typically occur during needs assessment and planning; four approaches are covered below.

3.1.1.Project Conception

Project conception is the initial attempt to determine the project's potential for success. This approach looks at available technologies to enact the desired changes or effect the noted improvement. Is it even possible for a widget to do whatever desired task? If it is theoretically possible, could we produce one? Do we have the workforce we would need? What is the purpose of the project and does it make sense? All of these questions are examined in project conception. This is before an organization or group has committed significant financial resources on the project. Thus the goal is to ensure that investing into the project will not be a waste of capital and to establish the project's value.

3.1.2.Market Research

Market research takes a people approach to determining the project's efficacy. Is this project something that is desirable to people? Are there enough people interested in our potential work that it makes sense to do it? For products, is there enough potential that we could make a profit? Engineering firms seek to make improvements that assist the populace in some way, and market research's purpose is to ensure that some population will indeed benefit from a particular project and then to identify that population. More fundamentally, “engineering looks after matters relating to technical feasibility, and marketing has responsibility for their commercial viability” (Clarke and McKeag 1989).

Once the market research indeed determines that the project has a plausible beneficiary, the next step is to develop an understanding of that beneficiary. Market research then focuses on understanding the project attributes that will make it accepted by its stakeholders. For a product, these may include a target cost, physical size, function, or feature that makes the product desirable over its predecessor. For a project, stakeholders may desire that a particular process is followed or that follow up procedures are put in place, possibly negating some negative characteristic of the process. Thus, accurate market research is absolutely necessary for a project to be accepted or for a product to sell.

3.1.3.Funds Acquisition

Funds acquisition is another critical step at the beginning of the project process. The project will not progress beyond needs assessment until it is financed. How to pay the high initial costs is normally related to the type of project, but there is usually still some difficulty in actually acquiring sufficient funding. For example, construction projects such as bridges would typically be financed by the beneficial principality, but the principality may not immediately budget sufficient financial resources to pay for the whole project’s cost. A new product, on the other hand, is typically funded by either a bank loan for new businesses or by investments or profits for mature businesses. Of course nonprofit projects are entirely different, relying on fundraising such as grant-writing. Regardless, the project’s financials have to be in order and a tentative budget created before entering the design phase (Mizell and Malone 2007).

3.1.4. Life Cycle Planning

Life cycle planning is slightly distinct from the other analyses in this section, in that it is not make-or-break and does not investigate a single business aspect. This is the planning section, after all three of the other preliminary checks are passed. During life cycle planning, a timeline is assigned to the rest of the project process, and macro-scale planning occurs. What will the project life cycle look like? What sorts of follow up will be necessary? What are the major design or implementation tasks and when will additional support labor be necessary? What potential future does the project hold?

Life cycle planning is more than planning, though. Having prepared answers to the preceding questions, it allows the management of the project to consider whether the project still makes sense. This type of decision needs to be repeated over and over throughout the project's life, and is often performed by a series of go/no-go checks (Clarke and McKeag 1989; Parsons 2006; Eschenbach et al 2007). Some projects or products have great potential but are simply not in the best interests of the businesses that discovered them. At this point a common decision is whether to pursue the project now or wait until later. Also, having a sense of the entire life cycle will allow a group to decide if the project or product is in line with their vision, mission, or goals for the relevant time period (Chiesa 2000).

3.2. Concept Design

Having completed the needs assessment and planning stage for a new project, the next major phase is concept design. Assume that budgeting has been completed and indeed there is a popular desire for the project. The assessment team indicated that a certain technology could be implemented to successfully meet the project's general goals. However, a preliminary technology assessment is very different from trying to actually make the system work. Concept design seeks to verify that technology can indeed be implemented to satisfy the project's most demanding technical details and meet the project goals.

3.2.1. Project Scope Definition

The first step in verifying the potential to meet project goals is to set up a metric for the project to be evaluated against. When is the project considered a success? What is the project's goal? Answering these questions is absolutely crucial for focusing the design tasks and coordinating them to actually complete the project (Chiesa 2000), and is usually done in collaboration with high-level decision makers such as executives. In essence the scope definition sets the boundaries for the project – which activities or design subjects are part of the project and which are excluded for any reason, but just as important is what is the project's goal and when is it considered complete?

3.2.2. Major system definition

Having defined the project's overall scope, it becomes necessary to break up required tasks into discretely categorized groups of related items. For the design of a new product, this is often the functional systems level of assembly. For other types of engineering projects, these may be concurrent task sets that require different skill sets, such as laying pipe and boring a well for a water distribution system. Distributing work to the local experts in this manner often allows for design solutions to be developed efficiently and sets up a management structure by which tasks are easily monitored. Breaking down the project into smaller, manageable tasks allows identification of trouble areas and ensures that each technical component of the project is addressed in terms of technological feasibility.

3.2.3. System Tolerances and Interactions

Of course, dividing a project into modular teams has its drawbacks. By focusing on distinct component or functional system sets, design teams tend to lose perspective on their system's interdependence with the rest of the project. Therefore, it is important to define interactions between systems before the design phase is reached. These tolerances are typically set after the initial conceptual design identifies the tightest technological constraints, whose restrictions must be accommodated by related systems.

This system-system interaction definition is a highly interactive process whereby all functional areas are examined for strict needs and then toleranced in order to meet each other's requirements. This type of definition, though, allows for design groups to focus on their functional area without the constant stress of interface issues. Certainly some communication across design groups is necessary to verify design plausibility, but without a functional group breakup and subsequent tolerance definition, the communication would be taxing and could slow down a project significantly.

3.3. Overall Design

Following conceptual design, the project's concept has been technically verified as possible, and the project group has financial and popular incentive to pursue it. The next stage is design, which is an iterative process aimed at making the conceptual design as near to reality as possible before production. The same approach that was applied within conceptual design is distributed through the various functional design groups to effectively disperse and monitor design tasks. Design is typically an endeavor of long duration and great importance. However, many of the details will be skipped over since this is the process in which engineers are most actively engaged. It is assumed that all engineers are familiar with some design process at least. The process described here places emphasis on using suitable major components to reduce design stress, then to integrate them into design.

3.3.1. Component Selection

Component selection in this instance refers not to the choices between fastener types or hose types. Many projects and products have the opportunity to incorporate a previously developed component designed by a specialist with experience in that particular field. These components could take up entire functional groups and require only accommodation and fastening design work. In many cases this type of component integration will produce a higher quality component than new, in-house design. However, centering a system's design on several off-the-shelf components may impose incompatible design constraints on the finished product. In addition, it is likely that more than one competing off-the-shelf component will meet the design requirements, so project managers may be required to choose between comparable products. Still, selecting an appropriate component can reduce the design burden significantly.

3.3.2.System Integration

With major components selected and the other individual functional areas designed fully, design integration of the parts becomes necessary. Engineering projects experience a similar challenge in coordinating logistics for the final implementation or construction. At the design stage of system integration it is very important to coordinate the design and logistics with precision and often include a buffer to remain conservative. It is extremely rare for a project or design to progress unimpeded. Furthermore, while allotting excess time for even a simple set of tasks appears to go against efficiency, the consequences associated with missed deadlines validate use of some margin of error.

3.3.3.Design Evaluation and Refinement

It is well known that design is an iterative process. Some method of evaluation must be carried out to ensure that the design will perform as intended, or well enough to be satisfactory. Even in the cases when all systems appear to be integrated successfully and seem as though they will function as intended, there is typically other potential for design refinement. Could a less expensive material be substituted anywhere? Is there a way to reduce the number of fasteners? Can single-part complexity be lowered to drop production costs? Would a change in supplier of some component ease production? Many of these questions will come up in discussions with higher levels of management, so lower-level managers should consider them all along the design process. One of the best abilities to have as a manager is big-picture thinking. Does it make sense to do this in the big picture, or is there a better solution?

3.4. Prototyping and Initial Tests

Prototyping a new design is probably one of the most useful methods to discover design flaws and make improvements. Prototyping tests the design first with a manufacturing trial run, which brings up any discrepancies within design documentation. This can lead to significant stress for the design team, as they are effectively on standby to fix mistakes as they appear. Delays here are typically real, affecting the final completion date, so the process is typically a top priority.

In addition, though, prototyping provides a very valuable check on the project's progress. A prototype may be physically examined, allowing different stakeholders an improved understanding of the project. To this end it can be used very effectively as a public relations device. More significantly, though, it gives the design team and upper management a very good sense of whether or not the project can success in its design goals. The point of the prototype is that it will have at least a limited portion of the final product's functionality. If its parts move together as is intended, then it is likely that the finished product will also work. This check is crucial for the momentum of a project, and a successful prototype begins the transition from majority design-oriented work to majority production-oriented work.

Prototyping is not necessarily possible for all types of engineering projects. A full scale bridge will not be built and tested before the real bridge is built in place. Similarly, modern airliner series are prototyped when major flight characteristics are changed, but many hundreds of design changes are made between the manufacturing of any two airliners in the same series. It would be terribly impractical to prototype an entire airliner each time you wanted to build a new unit.

3.5. Project Implementation and Manufacturing

Following successful prototyping, although often with some overlap, comes the stage of manufacturing and production, essentially the project's implementation. The design has gone through several reviews and design iterations prior to the prototyping, and has been shown to be producible and functional by prototyping itself, thus passing another check. This stage has multiple useful aspects.

On one hand manufacturing is initially used to hone the build process so that efficiency is promoted. Also, some of the first manufactured units or implemented systems may be subjected to additional, rigorous internal testing and monitoring to ensure sustained, satisfactory function. Some businesses are required to issue product recalls because their prototype functioned properly for their monitoring cycle, but failed shortly thereafter. This implies the need to test products with loading in approximately the same manner that they will be loaded during normal use, called cycle testing.

On the other hand the purpose of manufacturing is to produce units of product for external use, and to complete the supply chain so that the project is complete. Continued supply chain coordination is extremely important for increasing a product's or project's efficiency, because increased coordination and planning of material or component delivery can drastically reduce manufacturing lags. Furthermore, though, effective supply chain coordination facilitates outbound completed product in its delivery to customers. This is an appealing change to corporations because it means that there is less time with money spent on a potential revenue source prior to the sale of the piece for profit.

3.6. Product Release and Monitoring

By the time manufacturing has begun and the supply chain is developed and in place, the product is released to its market. All other product development phases are preparatory, but after release the fruits of the endeavor become clear. Similarly, it is after a project's implementation that consumer use factors into valuations. Perhaps all the parts work properly, and perhaps the project's technical and aesthetic goals were met, but release determines the project's success.

Release, though, is not the end of the project cycle. Product may be manufactured for a very long duration following release, perhaps with significant redesign activities to optimize to the market's needs before the final decline. Projects, both construction and research, typically require some sort of long-term monitoring or maintenance to determine whether a change has occurred and whether additional efforts must be implemented to adjust the original project.

3.6.1.Technology Evolution

Engineering project and product design are inherently innovative processes; they apply new technology to an existing problem in search of a solution. Associated with this innovation come the discovery of other applications for the new technology and consideration of similar technologies that could prove useful in implementing the original project idea. Clarke and McKeag (1989) emphasize the benefit of investigating all potential related projects. During the project process, however, many of these supplemental ideas are removed from the design activities; only a few are incorporated into the project idea. Some discarded ideas are out of the project scope, while others may be ideal put place the finished project or product beyond the customer's purchasing price point.

When the initial project has been implemented, or the new product is entering full-scale manufacturing, it is important to recall these creative ideas. Often with only slight modification the project can be implemented for a different use or different customer. Product design can sometime be altered aesthetically to reach an entire new demographic with the same or similar function. On the more radical side, occasionally a technology is applied during conceptual design in such a way as to inspire innovation applying the technology to another field entirely. This process is referred to as technology evolution; one implementation of technology leads to further innovation and dispersion of the technology across additional fields.

3.7. Reflection and Discussion

This section covered a lot of material regarding the engineering project process, seeking to build on the basic knowledge that young engineers develop during their education. The model described is very basic but addresses key stages within product development cycles and project implementation cycles in order to further develop the awareness of setting while an engineer sets about his tasks. It is important to know what else may be occurring, and what is coming up next. It is just as important to recall the decisions that were made at the previous stage in order to be efficient about pursuing the project's idea.

The stages described above could be applied to nearly any engineering project, domestic or international. Time was not spent placing each phase of the process in the context of globalization, but that is the backdrop to which the engineering applications of technology occur. The next section will begin to discuss challenges that arise for managers and engineers alike when an engineering process such as the above is placed in a globalized economy, and particularly if the project is international in scope. Until now the theme has been generalization, but the paper now takes a turn to discuss specific experiential insights into the challenges that young and old engineers face when transitioning to management. These can be particularly trying for the less experienced young engineers and specific illustrations will help this demographic get their feet beneath themselves.

4. Obstacles and Strategies for Effective Management

Management is often called the soft side of engineering. Its tasks emphasize communication, team-building, and resource coordination rather than the scientific and technical certainties to which engineers have been trained and are accustomed (Aucoin 2002). It connects business strategies to engineering design activities (Clarke and McKeag 1989). The discussion below is by no means an exhaustive compilation of challenges facing engineering managers in a globalized economy. I selected the issues listed below because of their relevance to my experience with engineering management, and the implications that globalization held for my managerial tasks.

4.1. Stakeholder Interactions

One of the primary managerial responsibilities is communication. This includes interactions with the engineering team, but with the other stakeholders as well. The project manager represents his team and the design to upper levels of management and perhaps also to the public relations spokesperson, to project partners, to component suppliers, and to distributors. It is via the project manager's representation that the most prominent stakeholders are enabled to understand the project and determine the effect of their stake (Ge, Yu, and Bukkapatnam 2005). Thus, a great burden of external responsibility lies in the manager's communication and project representation to key stakeholders such as upper levels of management (Aucoin 2002).

Placed in the context of globalization, the burden of managers' responsibility for communication increases greatly. Effective communication relies upon the ability to express oneself in a manner that is intelligible to the listener. When a listener is located great distances away and the communication medium is limited to speech and excludes nonverbal aspects, misinterpretation becomes commonplace. This difficulty is exacerbated by differences in culture and or language between the dialogue participants, because expected tonality is lost as a communication medium.

During my employment at Oregon Iron Works, one of my tasks was to coordinate with OIW's eastern European partners to oversee the technology transfer. We would have weekly status meetings discussing what tasks needed to be done next, by when, and by whom. There were several difficulties that quickly mounted as a result of the differences between partners. The OIW team was frequently frustrated with the little progress that was made on what it viewed as pressing issues in missing documents. The partner continually insisted that all technology documentation had been transferred. Frustrations mounted and occasionally the partnership would be strained, requiring involvement from the upper levels of management.

Due to the global nature of the partnership, the morning meetings were destined for challenge in many ways from the beginning. The geographic proximity of ten time zones of difference meant that the weekly meeting took place outside of both groups' normal work hours, lending weariness to the conversation. In addition, while the eastern Europeans spoke English fluently, the use of a non-native language still strained their active dialogue participation. Finally, over time it became clear that there were major socio-cultural differences also at play. OIW expected that all manufacturing documentation would be maintained and utilized in written form. The partners, however, utilized manufacturing documents as guides and relied more often on their technicians' manufacturing expertise. In the end, the technology transition required more work than either partner had initially expected or intended.

The example above illustrates challenges straining a partnership, but the same factors – physical distance, language difference, and cultural difference - play a role in other stakeholder communications. Means of communication other than the telephone face similar difficulties. Face-to-face conversation is the ideal medium of communication, but is limited to infrequent trips impractical for task coordination. Electronic mail is even less personal than the telephone and has more likelihood for misinterpretation. Due to its discrete timeframe, miscommunications can have drastic consequences before they are noticed. In general a manager has to be very careful with the message delivered by communication, but this need is magnified greatly by globalized economic activity. Managers must be certain that their message has been received correctly as well.

This level of care with communication can be difficult for engineers. Engineers are stereotyped as less socially experienced and poor communicators in general, demanding that an emphasis be placed on very delicate communication especially as they move into managerial roles. I recall that during my internship at Intel I sent several erroneous messages lacking the correct attachments or even including misinformation even though I put much effort to forming my memos with care. Since manufacturing coordination was performed over phone, I also had several constructive conversations with my team leaders asking to clarify what I had meant by my instructions. We young engineers need to take these communication growth opportunities to heart and be explicitly careful in all communications. Slang and incorrect grammar may be acceptable for conversations with friends, but within a company anything but well-structured and complete sentences leads to trouble.

4.2. Budget Management

A second critical aspect to management that is new to engineers as they transition into the role is budget management. Engineers may be good at keeping track of their own finances, but as an engineer the budget has been decided for you. The costs have usually been fully assessed for your design or testing responsibilities to be incorporated in the business activities. If additional resources are necessary for a task, you either make do without them or request support from your manager.

Thus, as a manager you are receiving these requests for additional support, and must decide what to do with them (Chang 2005). If during budgeting a portion of money was set aside for this sort of contingency, you may elect to spend it, assuming that the decision is within your level of responsibility. Other options are to reject the expenditure or to request money from your own superiors. Making the judgment on which of these requests to approve and which to prioritize is not a simple decision for an engineer: someone thinks that each of these requests is necessary for the project's success, and the engineering perspective says to do the least tasks to ensure the project's success. Determining which financial requests are supplemental requires intuition and judgment, but engineers typically would rather stick to numerically-based decisions (Chang 2005).

My personal experience with engineering project budgeting comes primarily from Engineers Without Borders. Since our finances are based on fundraising activities that the chapter must carry out, the chapter has additional motive to conserve the limited resources at our disposal. Budgeting for international construction and development projects becomes challenging for an entirely different reason (Mizell and Malone 2007). Standard construction materials are frequently unavailable in other countries due to a different set of standards. Preferred designs may be unfeasible to implement due to component unavailability, forcing the utilization of less effective or more expensive systems.

While working with Engineers Without Borders – Oregon State University on a rainwater harvesting system in El Salvador, budgeting and materials acquisition was a substantial obstacle that I came up against. Although our chapter had sent teams to the project location during several assessment trips, the teams had been unable to accurately predict a system cost. When seeking approval from the EWB-OSU Executive Board, the design team was forced to give a best estimate of the implementation costs.

That December on the implementation trip, the team was forced to make several significant deviations from the original design due to elevated material costs and material unavailability. Having failed to plan a sufficient financial buffer, the team barely had enough money to pay for the system components and transportation costs. With limited ability to request the rapid release of additional funds, we ended up withdrawing personal funds to pay for some of the additional project costs, floating the project along with cash until we returned to the United States. Subsequent implementation trips have put forth coordinated efforts to better tabulate expected costs and resource availability.

4.3. Team Coordination

While engineering managers may spend large portions of time interacting with stakeholders or planning budgets, the activity that is most commonly associated with a managerial role is team coordination. Management's purpose is essentially "to ensure that all design work takes into account the views and requirements of all those involved in design activity" (Clarke and McKeag 1989). Of course this topic could be developed to exquisite detail, but only few select subtopics will be examined.

4.3.1.Scope Monitoring

Defining a project's scope must be carried out very early on in the project life cycle, but thereafter it is the manager's responsibility to monitor the project scope (Aucoin 2002). This includes interim project performance checks to ensure that the original project is still within reach (Chang 2005) and that the design team's activities have not shifted due to scope creep (Aucoin 2002). However, it is just as important that a manager understand the potential flexibility of scope. Reexamining and redefining the scope of a project is not an uncommon procedure, and is usually associated with regular project monitoring tasks (Aucoin 2002).

I have had the excellent opportunity to take part in a few scope reexaminations and project progress reviews, the most notable of which took part within Engineers Without Borders. In early 2007, EWB-OSU had sent multiple project assessment teams to the chapter's intended project site in western El Salvador, and each team had returned with somewhat discouraging information regarding the project's feasibility. The water distribution project faced unforeseen barriers within the community's physical geography, social structures, historical non-profit interactions, land use permissions, and available water quantities. As a project team, we were unsure of the project's potential for success, and even worse, the community knew that we were doubtful. They began to wane in commitment to the project. A simple-sounding task of directing water from springs to communal distribution points had turned into a monster of a challenge.

The project leadership decided to take a step back from the intricate design processes which seemed to keep running into dead ends. It was time to reevaluate the scope and reevaluate the project's priorities. Since we were not certain of the efficacy of a community-wide water delivery system, the team decided to focus in the short term on addressing the pressing water quality problems. A sustainable system of point-of-use filters designed by Potters For Peace was determined to be the best effort that the project team could implement with available resources. The team as a whole decided that improved community support was necessary for the project to progress any further. This account ends well: the community was inspired by EWB-OSU's successful filter implementation, and the project later included water distribution into its scope once again. The student organization has now implemented a rainwater catchment cistern for a local school, and has detailed implementation plans laid out for the next several school terms.

4.3.2.Human Resources

Another traditional managerial role is to coordinate with human resources, the corporate branch responsible for hiring and firing of employees. This coordination is the manager's opportunity to develop his or her project team into a cohesive unit. The manager has technical tasks to coordinate, but those tasks require interaction between team members. While many potential employees may have the desired level of technical specialist knowledge necessary for the work to be accomplished, the manager can take advantage of the opportunity to build his team with employees that complement the engineering network that already exists (Aucoin 2002). The converse, of course, is that the manager may also desire to reorganize or displace parts of his team that do not function as a unit.

During my internships at Oregon Iron Works and Intel, I did not directly participate in the hiring, firing, or review of employees. As an intern, a decidedly temporary post by nature, it would have been unethical for me to release someone from their permanent work in almost any circumstances. However, my employers did offer me some opportunity to see into these processes as they incorporated me into their managerial teams. For instance, I was allowed to observe an evaluation process by a mentor of one of the employees that I often supervised while at Intel Corporation. A better instance was at Oregon Iron Works, where my manager asked me to review applicants for positions on our team, to offer my opinions about the potential benefits to the team. Through both of these experiences I have been offered insight into human resources methods to better a project team's operations by utilizing employee selection and review.

4.3.3. Work Distribution, Breakdown

Work distribution is probably one of the more difficult manager tasks to learn to do well. Several work breakdown methods have been evident in my various places of work. A few are presented below, in an attempt to emphasize the consequences of various methods to distribute tasks.

Engineers tend to think concretely and employ scientific logic wherever possible (Chang 2005). The prescriptive work breakdown according to this thought process is to divide work into equivalent shares. Some will complete their work faster than others, and the team can then organize to tackle the remaining parts before moving on to the next set of tasks.

This approach is limited at best, and in essence encourages team members to work less efficiently because what they cannot accomplish will be taken up by the rest of the team. Another method is to allocate work according to skills and abilities that the team possesses. The most talented specialist tackles the most challenging problem within their specialty, and so on such that all tasks are accomplished. Although this ensures that each task is accomplished properly, it is hierarchical and individualistic. It may work effectively for some time but overloads the most talented individuals, and also encourages each specialist to work alone, thus undermining their potential management skills.

Better approaches exist, and their implementation typically needs subtlety (Chang 2005). One such method attempts to address each technical task properly while simultaneously encouraging collaboration by forming small groups with specialty-level diversity to tackle the various tasks. The tasks are allocated to each group based on the most talented specialist in the group, who then has the responsibility to delegate tasks to his or her group members.

One great advantage to a system like this is that it develops specialists' knowledge, as they have the opportunity to work on a task above their expertise with direct specialist oversight. This specialist knowledge development is important to the project's long-term success and can be regarded as an investment (Cross and Sivaloganathan 2007). Similarly, collaboration is required, so work becomes less individualistic (Aucoin 2002). Of course, there are drawbacks to this method, as well. Of the three methods mentioned, it is the least time-efficient in the short run. This immediate inefficiency may be overcome by the collaboration that is encouraged or the specialist knowledge that is developed (Cross and Sivaloganathan 2007). However, the method must be implemented delicately, as it is fundamentally based on a ranking of specialist talent (Cross and Sivaloganathan 2007).

4.4. Reflection and Discussion

Recall that the context of the managerial roles above is a globalized economy and global operations. Communication may be a challengingly influential and delicate responsibility within a single political, cultural, and linguistic set of boundaries. However, the difficulty is magnified as any of these borders are crossed (Cates and Mallaghasemi 2007). Misunderstanding, accidental connotations, and unspoken social constructs all have the ability to frustrate cooperation.

Managing a budget across political borders becomes a challenge due to localized markets. Package service expectations are commonplace in some countries, while in others every task is an additional cost no matter how minute. Planning a budget around these differences is challenging and requires significant flexibility. Often one is required to operate under less-than-ideal operations: with a lesser construction material, or without strong internet connectivity, or perhaps altogether without a particular commodity.

Team coordination takes on an entirely different set of challenges (Girart, Legardeur, and Merlo 2007). Ensuring that scope drift does not occur while managing remotely, as in a globalized context, is difficult. Similarly, projects are likely to progress more slowly than in a local context, so it is not easy to assess satisfactory project progress as an ongoing indicator of project feasibility. Managers instead must be very proactive in their monitoring and assessment of the project.

In the same way, managers need to carefully take advantage of their chance to build team solidarity through human resources tasks. This is the one opportunity to structurally improve the project's likelihood of success. Since the project team members will inevitably have different abilities to effectively operate in a globalized economy, the manager has another specialization set to take into account when breaking out work. All of the manager's tasks are thus more complicated by incorporation into a globalized economy relative to strictly domestic business (Cates and Mallaghasemi 2007).

5. Recapitulations

As the globalization of economic structures integrates the world's increasing population into Western capitalism, there are many opportunities for corporate growth. The lifting of trade barriers combined with improvements in transportation and communication infrastructure give engineering projects the freedom to operate across traditional borders of political and cultural entities. While this demands improved efficiency of production and development efforts, and offers excellent financial rewards, engineering groups must be careful to understand the full impact of their operations. These include replacement of subsistence economies, changes for vast and diverse populations, and the eventual outsourcing of technical specialist positions.

Challenges abound for project managers when functioning in such a globalized context. The core responsibilities of managers include communication with stakeholders, budget planning, and team coordination (Chang 2005); all of these roles are made more difficult by international operations. In essence, operating within a globalized context demands more talent from managers relative to strictly domestic projects. Developing the ability to perform these roles with reference to the project life cycle is fundamentally experiential (Engineering Management 2007), and the roles are social (Chang 2005). The development of young technical engineers typically emphasizes individual mechanistic work which exacerbates an eventual transition into the social and flexible work of management (Chang 2005). With globalization, another layer of understanding is necessary in order for a successful transition into management.

Thus, it takes significant time to become an effective manager, and that transition time should be addressed by education and corporate development. Young engineers require first an understanding of the globalized system to operate effectively. A solid grasp of the fundamental project cycle is also necessary. Finally, low-level skills in the core managerial roles can be developed through experience early on in engineers' careers. For all these areas, exposure early on in engineering education and technical positions could reduce the difficulties faced by young engineers transitioning into management.

This thesis does not intend to be a comprehensive review of international engineering project management knowledge. However, it has put forward the major relevant influences of globalization on engineering projects and their management. As a young engineer with some international project management experience, the management opportunities extended to me have highlighted the difficulty faced by young engineers transitioning into management.

Additional preparation could ease this transition, especially in the challenging context of globalized economy. First, enhanced educational emphasis on global context of engineering is necessary to motivate young engineers to understand their impact on the world. Second, intimate knowledge of the project process must be developed through whole-cycle or multi-cycle classroom exercises as well as real-world applications.

Finally, since management expertise is acquired through experience and practice, playing the manager in a real project is a necessary component of an engineer's education that does not appear to be adequately addressed. Having experienced the challenges of a managerial role may additionally encourage active team participation in young engineers due to the understanding of interdependence and responsibility that is associated. Indeed, engineering management activities need to be incorporated into young engineers' practices early in their career at the very latest, before isolated technical specialization reduces the interpersonal skills necessary for an inherently social management position.

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