



Using Transparent Factory Design Project to Enhance Engineering Management Teaching

Dr. S. Gary Teng, University of North Carolina, Charlotte

Dr. S. Gary Teng is Professor of Systems Engineering & Engineering Management and Director of Center for Lean Logistics and Engineered Systems at the University of North Carolina at Charlotte. He holds a P.E. license in the State of Wisconsin. His research interests are in engineering system design, analysis and management, supply chain management, lean systems, and risk management. Dr. Teng received the Bernard R. Sarchet Award in the Engineering Management Division of ASEE in June 2012 for his accomplishment in engineering management education.

Using Transparent Factory Design Project to Enhance Engineering Management Teaching

Abstract

The objective of this paper is to discuss the effect of using a transparent factory design project as a term project to enhance the teaching of engineering management principles and practices that can enrich students' understanding of the current issues in engineering management and project management. This paper aims at showing an effective way to cover a broader business value related to local economic issues in engineering management education by using a term project, a transparent factory design project, in an engineering management course. The discussion also points toward the experience in offering this design project to enhance engineering management education to obtain an adequate level of experience to cope with a wide-ranging engineering management concerns in today's global business environment.

Introduction

In today's global business environment, engineering managers need to handle projects and engineering tasks which involve multiple collaborating parties and broader engineering and business issues. These issues consist of not only technical related engineering and management issues, but also much broader concerns, such as branding and marketing of the work, prospective value creation by the work, and potential economic issues connecting to local and regional communities.

It is critical for engineering management professionals and students to understand the significance of these broader concerns in their work. To show an effective way to cover these broader issues in engineering management education, this paper uses a transparent factory design and development project in an engineering management course to demonstrate the consideration of broader issues in project management as well as factory design and implementation.

In assigning students the transparent factory design project, the instructor provides students a transparent factory example first which is the Volkswagen Phaeton plant located in Dresden, Germany. Students use this Phaeton plant as a model for their own transparent factory design.

There is a difference between working on a non-transparent factory design case (a common type of factory design case for most engineering students to work on) and a transparent factory design case. In the design of non-transparent factory case, the design team often concentrates on the design of manufacturing systems and production processes to make the factory flow smooth and the factory operations efficient. However, for the design of transparent factory case, the design team needs to consider the visual appearance of the production processes and factory flow to the visitors in addition to the consideration of smooth materials flow and production efficiency. It also needs to consider the branding/marketing perspective of the factory operations. Therefore, more business related concerns are embedded into a transparent factory design case.

With the current global business environment, engineers and managers often need to deal with multiple suppliers/vendors and customers at different global locations and to attract potential customers' interest in ordering their company products. Therefore, it is necessary for engineering managers to cope with multiple aspects of business issues in engineering projects in addition to the technical related matters. The offering of transparent factory design case can provide students the opportunity to work on the additional business related concerns, and broaden their view in factory design.

The intention here is to show how the student project on launching a transparent factory in a local area covers the experience on broader issues, and to reveal how the change in the project required emphasis alters the approach of students' project work from traditional non-transparent factory design for the efficient production processes and factory flow to the factory design that includes the consideration of production processes and factory flow, the visual appearance of the production processes to the visitors, and the enhancement of company branding/marketing and business development through the visual attraction of the transparent factory operations.

Research Objectives

The objectives of this research are (1) to enhance engineering management students' understanding of engineering management principles and practices through the use of a transparent factory design project as a term project to cover broader concerns of engineering operations, and (2) to investigate the effect of using this project to enrich students' understanding of the current issues in engineering management and project management.

Due to the growing trend of global business competition, the management of engineering operations has to involve issues in branding, marketing, and business operations. Engineering management students need to learn to put these considerations into the design, management, and implementation of engineering operations. The benefits of using this transparent factory design project are to embrace these considerations into students' work and to achieve the objectives stated above.

The Transparent Factory Example

The transparent factory example used in the engineering management courses is the Volkswagen transparent factory located in the center of Dresden, Germany. This factory's walls are mainly made of glass, and its main activity is the assembly of Volkswagen's Phaeton which is a full size luxury sedan and is described by Volkswagen as their *premium class* vehicle^{1,2,3}.

The Phaeton has been in production since 2002, and is marketed worldwide. The facility where customers can watch their Phaeton being built is a state of the art operation, and is working towards integrating with local environment/ecology. This Volkswagen Dresden transparent facility is not only a luxury car final assembly plant, but also a customer service center⁴. In addition, it is a site for Volkswagen to enhance its brand name and to attract tourists⁵.

The operations of this facility demonstrate the ability of a manufacturing facility to attract potential customers' attention to visit this site, to buy its product, and to tell their friends about

this site and this product. This attraction provides great customer experience as well as an excellent value in branding and marketing for the company.

The Approach

The approach here is to use a transparent factory design project as a term project for student teams to work on for an entire semester. Each student team needs to determine what type of product and what type of factory that they want to design with the requirement of transparent operations. Students need to view the Volkswagen transparent factory video clips, recruit their teammates, and search for a product and its associated production operations that are suitable for transparent operations.

For this project, all student teams need to provide three reports---a proposal, a progress report, and a final report. In addition to the three written reports, each team needs to do an oral presentation for each report. The emphasis on this project includes not only the design of engineering operations, but also the branding and marketing of the product, the site, and the company.

This project assignment has been given to engineering management/systems engineering students in the past three years. The project requirements have gone through a minor revision to shift the attention of students from the traditional manufacturing system design concerns to the design concerns including broader business and engineering strategy issues. The following statements show the objective of the project given to the engineering management students.

“The objective of this project is to let students be familiar with project handling, management, and implementation, and their related problems in a project with project team members located at multiple locations. You will learn and understand the concerns of time, cost, people, culture, technology, feasibility analysis, economic/business development, teamwork, and problem solving by working on this term project. The purpose is to give you the overall understanding of problem solving, teamwork, and project handling and management in a simulated development project environment.”

As mentioned above, there is a minor revision of the project emphasis during the past three years. The revision includes more discussion on the branding and marketing issues in the selection of the product being manufactured in the transparent factory and the site’s potential attractiveness in enticing prospective and current customers.

The reason for this minor revision is to broaden students’ view from a manufacturing/engineering system design perspective to a higher level of business/marketing/branding perspective for engineering operations. The following statements show the basic requirements for this transparent factory design project.

“Adopt project management principles to this term project that involves in the planning and development of a plan for building a transparent plant in the area for a type of product(s) by each team’s own selection. Some video clips of showing

Volkswagen's transparent factory in Dresden, Germany are good information sources for the similar work. This project work should include the consideration of project management activities in integrating various system elements and/or sub-system elements for future efficient plant operations in the Charlotte region. The emphasis can be from different perspectives of the design, such as from the perspective of the support of local region's supplier network, the perspective of local government's plan in improving local infrastructure to support the plant's operations, or the perspective of the activities in designing the factory in the Charlotte area.

The project results will be evaluated based on technical and management effort shown in the final report and the contribution on the selected factors, problems and/or research issues for managing a project in building a transparent factory in the Charlotte area. The design of the integrated Charlotte area transparent plant involves in the integration of activities in marketing, branding, manufacturing system, logistics system, transportation system, service system, economic development planning, and various organizations in the region.”

To reinforce the importance of a broader perspective for the project work, the instructor has made a minor revision of the evaluation forms for students' presentations. All students are required to evaluate other teams' presentations. The instructor has revised the presentation evaluation categories for final presentations from six categories to five categories with the emphasis on the bolded category, “Attractive results shown”. The following lists show the six presentation evaluation categories and the five categories for final project presentations.

Original presentation evaluation category list:

1. Smoothness of the presentation
2. Effective use of technical terms and concepts
3. Effective slides and/or visual materials
4. Adequate technical result(s) shown
5. Clearly shown contributions
6. Clear and effective summary/conclusion

Revised presentation evaluation category list:

1. Smoothness of the presentation
2. Effective slides and/or visual materials
- 3. Attractive results shown**
4. Clearly shown contributions
5. Clear and effective summary/conclusion

The reason to remove “the technical terms and concepts category” is that students always evaluate project work through technical perspective first. Removing this category would not eliminate their evaluation of technical contents. Instead, it will lead students to have better attention on other categories to have a more balanced evaluation of technical and non-technical

presentation contents. With this revision and the emphasis on the result attractiveness, students are guided to seriously contemplate the branding and marketing related issues into their factory design.

For presentation evaluations, the instructor uses three different evaluation forms for the evaluation of proposal, progress report, and final oral presentations. There is a brief discussion of the presentation evaluation form one to two weeks before each presentation to give students a better idea about how the presentations will be evaluated.

There is one interesting observation about the emphasis on attractiveness. With attractiveness of the project in mind, students have obtained more interest in other teams' project work. It results in more intensive discussions during the question and answer session after each team's presentation. These discussions are mostly concentrated on how the team would integrate its production operations with its business strategy and customer service approach to attract more people's attention and how the visual appearance of the factory and the product itself would raise people's attention on the product. The heavy discussion provides all teams a great help in refining their project work, or for some teams, in revising their approach/direction in some part of their design.

The Project Work by Engineering Management Students

The following project lists contain the transparent factory design project work done by students in Year 2014. Instead of working on the design of factory operational flows and on the logistics considerations for the transparent factory, these projects done in Year 2014 have a significant increase in the consideration of business and branding strategy in all teams' design process.

Spring 2014 project list:

- High End Division for Mid Range Furniture Manufacturing Company
- Glasshouse of Whiskey Brewing and Manufacturing Company
- Volkswagen "Sonnenkraft"
- Lean Solar Panel Manufacturing

Fall 2014 project list:

- Design and Development of the Transparent Warsteiner American Relocation Project
- Carolina Custom Clothing, CCC
- Bringing Tesla to Charlotte: Electrifying the Future Transparently
- Design and Development of the Transparent Chocolate Factory – Cadbury World
- Design and Development of the Transparent Factory through the Relocation of BMW Motor Cycle Plant from Berlin Germany to Spartanburg, South Carolina
- Design and Development of the Transparent Factory of Motor Cycles from Harley Davidson Motor Company

These projects are completed in an undergraduate class in Spring semester, and in a graduate class in Fall semester. To provide some perspective of these projects, a project named Carolina

Custom Clothing (CCC) will be used as an example for discussion. A portion of the executive summary of the project is shown below⁶.

“This project started with the idea of creating a transparent clothing manufacturing and shopping company. As the project advanced and as we saw from survey that the customers are not totally satisfied by the standard sizes of the current clothing companies, we decided to develop the concept of a company that produce custom fitting clothes to their customer with the opportunity to see and interact with the designer and line operators during the process of manufacturing.”

This team’s project objective is to develop a concept to prove that a company that enables customers to design and create their own custom fit designs of clothes within a fun and amusing interactive production environment is revolutionary but also feasible.

Initially, this team concentrated on the manufacturing part of the operations including the evaluation of the CNC cutters and their economic evaluation, customer profile input, and the selection of raw materials. Questions were raised during the team’s first two presentations and their subsequent discussions, and pointed toward the issues on customer interface and waiting time while clothes are being produced and the ways for the company to attract more new customers into the store/factory with a satisfactory experience. In the end, this team refined its point-of-sale application design to enhance customer experience, and developed marketing and advertising strategies that include a preferred customer plan, CCC sponsorship, CCC donations, and shopping wall display.

Transparent Factory Project Survey

A simple project survey form is used to investigate the effect of doing the transparent factory design project with an emphasis on both factory design and business issues. In 2014, 33 students have filled out and returned the survey form (shown in Figure 1) at the end of semester after they completed the course. The purpose of the survey is to see their perception about the difference between working on a traditional factory design project and a transparent factory design project.

Table 1 shows the survey result of “perspectives” for both transparent factory and traditional factory design projects from 33 responses. The top five perspectives for students to work on a transparent factory design project include branding, marketing factory visual appearance, project management, and customer service operations. However, the top five perspectives for traditional factory design project include production/manufacturing processes, financial feasibility, project management, logistics operations, and manufacturing management.

Transparent Factory Project Survey

While you are working on your transparent factory project, you and your team's perspectives in working on the project are pointing toward (select the critical ones):

- | | | |
|---|--|---|
| <input type="checkbox"/> Branding | <input type="checkbox"/> Marketing | <input type="checkbox"/> Production/Manufacturing Processes |
| <input type="checkbox"/> Logistics Operations | <input type="checkbox"/> Factory Layout Design | <input type="checkbox"/> Local Economic Development |
| <input type="checkbox"/> Factory Visual Appearance | <input type="checkbox"/> Financial Feasibility | <input type="checkbox"/> Customer Service Operations |
| <input type="checkbox"/> Global Supply Chain Issues | <input type="checkbox"/> Project Management | <input type="checkbox"/> Business Development /Management |
| <input type="checkbox"/> Manufacturing Management | <input type="checkbox"/> Product Design | <input type="checkbox"/> Factory Value Creation |
| <input type="checkbox"/> Support Operations | <input type="checkbox"/> Transportation Issues | <input type="checkbox"/> Global Business Issues |

If this project is a traditional factory (with no transparent display) design project, you and your team's perspectives in working on the project would be pointing toward (select the critical ones):

- | | | |
|---|--|---|
| <input type="checkbox"/> Branding | <input type="checkbox"/> Marketing | <input type="checkbox"/> Production/Manufacturing Processes |
| <input type="checkbox"/> Logistics Operations | <input type="checkbox"/> Factory Layout Design | <input type="checkbox"/> Local Economic Development |
| <input type="checkbox"/> Factory Visual Appearance | <input type="checkbox"/> Financial Feasibility | <input type="checkbox"/> Customer Service Operations |
| <input type="checkbox"/> Global Supply Chain Issues | <input type="checkbox"/> Project Management | <input type="checkbox"/> Business Development/Management |
| <input type="checkbox"/> Manufacturing Management | <input type="checkbox"/> Product Design | <input type="checkbox"/> Factory Value Creation |
| <input type="checkbox"/> Support Operations | <input type="checkbox"/> Transportation Issues | <input type="checkbox"/> Global Business Issues |

In your opinion, is there any difference in approach for you to work on a traditional factory (with no transparent display) design project and a transparent factory design project?

- Yes No

If there is a difference in approach, what is/are the difference(s)?

Which type of project, a traditional factory (with no transparent display) design project or a transparent factory design project, provides you broader perspectives in factory design, technical concerns, and business and management issues?

- Traditional Factory Project Transparent Factory Project None

Name: _____

Figure 1. Transparent Factory Design Project Survey Form

Perspective/Factory Type	Transparent	Traditional
Branding	29	17
Marketing	24	15
Production/Manufacturing Processes	18	24
Logistics Operations	17	21
Factory Layout Design	18	16
Local Economic Development	13	11
Factory Visual Appearance	24	2
Financial Feasibility	14	22
Customer Service Operations	19	14
Global Supply Chain Issues	11	16
Project Management	23	22
Business Development /Management	12	17
Manufacturing Management	8	21
Product Design	6	15
Factory Value Creation	17	15
Support Operations	4	17
Transportation Issues	14	16
Global Business Issues	10	13

Table 1. Perspectives for Transparent Factory and Traditional Factory Projects

In answering the difference in approach question, 26 students checked “yes” to the question. For the last question (the broader perspective question), there are 7 check marks for the “Traditional Factory Project”, 26 for the “Transparent Factory Project”, and 3 for “None”.

From the survey results, we can conclude that students are more aware of the branding and marketing issues in the transparent factory design process. On the contrary, more students consider manufacturing operation issues while they work on a traditional factory design project.

There is one interesting observation about the responses to the financial feasibility perspective. Only 14 out of 33 responses checked the “financial feasibility” for the transparent factory design project whereas 22 responses considered financial feasibility for traditional factory design project. One possible interpretation is that students are willing to take a higher financial risk for transparent factory project to pursue a much broader value for the company. Or it could be the students have not got the point of the essence of the “financial feasibility”.

Conclusion

With global business competition intensified, engineering managers have to deal with much broader business concerns while performing their engineering and management functions. The discussions in this paper intend to show an effective way, using a transparent factory design project, to cover these broader issues in engineering management education.

In launching a transparent plant in the local area, engineering management students need to consider manufacturing and production related design issues just like what they do in the design of a traditional manufacturing plant. In addition to these design work, students also add business concerns into their design for a better design that covering marketing, branding, and business development activities. Based on the transparent factory survey result, the majority of students agree that this transparent factory design project provides them broader perspectives in factory design, technical concerns, and business and management issues.

The experience gained in offering this transparent factory design project to engineering management students shows that it is very effective for students to obtain understanding on integrating business, management, and engineering design activities into one design project activity and to learn the importance of putting branding, marketing and business values into factory design.

References

1. Volkswagen International, "The Phaeton," <http://en.volkswagen.com/en/models/phaeton/highlights.html>.
2. Volkswagen, "The Transparent Factory - A Glass Factory Creating Transparent Excellence," *Volkswagen UK*, <http://www.volkswagen.co.uk/about-us/company/factories/glass-factory>.
3. Volkswagen, "Transparent Factory Website," <http://www.glaesernemanufaktur.de/en/>.
4. "Excellence in Customer Experience: The Transparent Factory," *Beyond Philosophy*, December 19, 2011, <http://beyondphilosophy.com/excellence-customer-experience-transparent-factory/>.
5. Basem Wasef, "21 Cool Facts about the Transparent Volkswagen Factory," *Popular Mechanics*, <http://www.popularmechanics.com/cars/news/industry/21-cool-facts-about-the-transparent-volkswagen-factory>.
6. Z. Alkadi, A. Pathak, J. Shah, J. Adkins, R. Fox, and Z. Montreuil, "Carolina Custom Clothing, CCC," EMGT 6901 Class Project Final Report, December 2014.