# Working Smart is Not Enough!

**Peter J. Shull and Jessica M. Crandall**

**Pennsylvania State University**

**pjs18@psu.edu**

## Abstract

In the age of constant increase in efficiency, working smart is not enough; engineers need to work smarter in the right areas. This sense of working on the right elements is common-place in industry, with such concepts as "just-in-time", lean manufacturing, and the 80% rule—where the focus is on what needs to be done and where distractions can be reduced. Even with this knowledge and clarity of importance, industry still has difficulty working on what is truly important for the company health. In response to this need, most engineering programs contain some form of efficiency training, usually imbedded in a course such as quality control or a required business course. An alternative to this traditional pedagogy is to recognize that students have an acute need not only to understand the concept of "working smarter in the right areas" but to be able to implement this concept. In keeping with the sense of creating pedagogy that is grounded in need-based, interdisciplinary, and real-world learning, this work proposes a method to integrate these concepts into students' daily life. This integration gives both value and purpose for the students to learn the material and practice it. This initial study asks the fundamental question: Do students understand that there may be a difference between what they believe is quality work and what the customer (the instructor) wants? The methodology used is to code student engineering reflections on a project that purposefully creates a conflict between the beliefs surrounding the meaning of "always strive to do a job 100%" and the reality of doing a good quality job. The results will show that students' perceptions as to what elements of their work are important are often in conflict with what is required.

## Introduction

Much of engineering education is driven by the needs of industry. Engineering programs respond to these changing needs by implementing topics that are deemed to have the most potential to meet the diversity of industrial needs—teamwork, communication, and leadership being just a few. While these topics, in addition to traditional "hard" topics, are widely accepted by engineering educators, exemplified by their proliferation in the literature and in engineering programs, there are topics that have not received appropriate attention. One such topic is customer satisfaction. Customer satisfaction could be considered a contender for the number one goal of any industry.[1,2,3] The basics of being customer-centered are encapsulated in engineering management concepts such as lean manufacturing where the focus is in elimination of all non-value added activities.[4] Ries, et.al. (2000) states that quality is not conformance to a narrow product focus but rather quality is the total conformance to customer requirements.[5]

While not entirely ignored in engineering education, customer-centered concepts are at most taught as a subset of topics in courses such as quality control or a management course. More importantly, concepts are not integrated into the fabric of the students' education but taught as a separate and distinct topic, if taught at all. Yet, to be effective, quality management based on customer satisfaction requires all parties to be invested and involved in the process.[4,5]

This work describes an initial effort to introduce students to customer-centered concepts. The pedagogical format will link students as the manufacturer and the instructor as the customer. This industry-customer relationship will apply to how the students perform assignments typical of any academic environment.

## Context

The sample in this study was made up of first-year engineering students in seven sections of a first-year seminar at a branch campus of a major university in the east coast of the United States. The school functions as a small liberal arts college with an engineering school. The engineering program is the largest program within the college. The course is a first year engineering design seminar that meets six hours per week in two hour blocks. The primary course goals include: engineering and communication computer tools, engineering design and design process, written and oral communication, engineering in a global economy, and ethics. The primary educational vehicle to achieve these goals is design projects. In addition to the primary goals, the course covers professional skills with a focus on personal responsibility and awareness.

Typically, ten sections of the course are taught in the fall semester of each year. The majority of the students were white males (~80 to 85%) with ~15 to 20% women and ~0 to 10% other ethnicities. All of them were engineering or 4-year engineering technology students ranging in age from 17 to 21 with a few adult students (>24 years of age).

## Methods

The specific exercise was designed to teach both a stated goal and unstated goal. The stated or overt goal was to help students develop the ability to visualize how a 3-D object might be unfolded into a 2-D object. Apart from an important general skill for engineering students, this is a commonly used manufacturing process for products made from sheet metal. The covert or intended collateral goal was to help students understand alignment or misalignment of students' beliefs of what constitutes quality work and what the costumer (the instructor) wants. The exercise covers one class period plus 20 minutes of the subsequent class period.

*Day 1, Part 1*

The exercise requires students to create five 3-D objects from sheets (2-D) of cardboard (file folders) given standard engineering drawings of the objects. There were three deliverables (see Figure 1):

1. Layout drawing of the object—this is a ¼ scale 2-D drawing of what will be drawn on the folder paper, cut out, and then folded into the 3-D object;
2. Actual 3-D object made from folder paper;
3. 3-D sketch of the 3-D object.

The instructions for the exercise were to do the following for each of the objects given in the engineering drawings (5 objects):

1. Layout the object (1:1 scale) on the folder using solid lines as cut lines and dashed as fold lines;
2. Cut out 2-D object and fold it to create the 3-D object—Tape it together;
3. Orient the 3-D object to maximize the detail of the object and then make a 3-D sketch.

*Rules*

1. All folds must be a line—sides cannot be connected by only a single point except on the 5$^{th}$ item.

The objects to be created were

1. a cubic box,
2. a ½ of a cubic box with all sides,
3. a four sided pyramid,
4. a four sided pyramid without a bottom (base open),
5. and a cubic box with a cylinder on top (the circular top is open like a candy jar).

The fifth object has a single-point connection where the cylinder meets the cubic box.

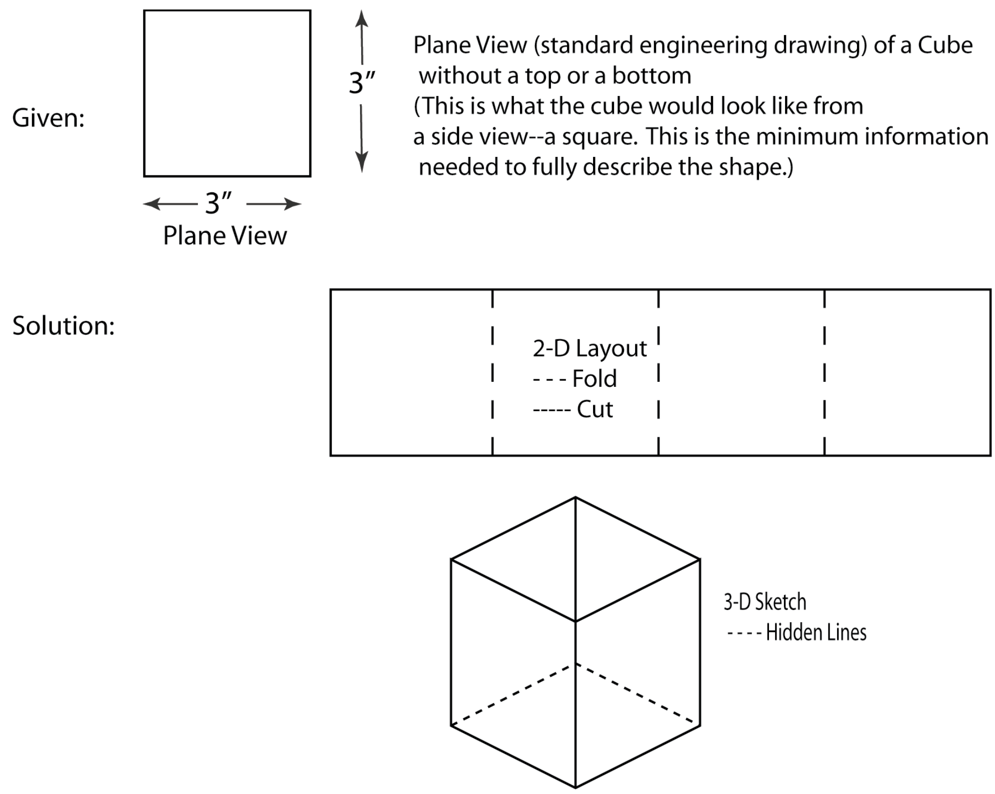


Figure 1  Shown is an example solution given a 3 inch cubic box without a top or bottom as the 3D geometric object.  The solution shows the 2D layout and a 3D sketch of the object.  Students must also make the physical object.

The students are told that the goal is to finish the project before the end of class—an hour and fifty minutes.  Periodically, the students are reminded of this goal.  At the ½ hour mark, I stop all work and ask the students to evaluate their progress—"Given that approximately ¼ of the time has elapsed, evaluate the amount of work you have done.  If you are still on the first box, what do you need to do differently to accomplish the task on time?"  Then I explain the concept of increasing their production rate at a sacrifice of some product quality.   This does not mean that you do a poor job, but simply lower the quality enough that you meet the time constraint.  Or stated differently, you maximize quality while meeting the hard constraint of time.  I call this using the 80% (quality) rule.  In this case, slightly reduced quality might mean not making cuts perfect, taped edges might be slightly misaligned, or drawings are sketched rather than detailed as mechanical drawings.

*Day 1, Part 2*

The concomitant out-of-class assignment to the in-class work was to respond to the engineering journal prompt

> "Write about your experience using the 80% rule for the 2-D to 3-D project."

This was to be done as soon as possible but at the latest within 12 hours of the end of class. The time constraint on the out-of-class journal assignment was to capture the experience while it was still a fresh experience.

*Day 2, Part 1*

At the beginning of the next class, students are asked to volunteer their experiences. These responses are written on the board. From this conversation, I present the idea that the consumer sets the standard of quality and not the manufacturer of the product. And, in this instance, the standard was “less than perfect” for the gain of having the product delivered on time.

*Day 2, Part 2*

Following this discussion, students write an engineering reflection on their beliefs regarding the 80% rule.

> “Now that you have heard the discussion on the 80% rule and its potential applications, reflect on the 2-D to 3-D project.”

**Data Source and Analysis**

The data sources were two journal entries and student discussion from seven sections of the Introduction to Engineering Design course. These sections covered a three-year period from Fall 2007 to Fall 2009. A subsection of the total journals were selected to be used to develop the data set. The subsection was random—first five journals off the stack for each section reviewed. The only specific rejection criterion was incomplete journal entries. No effort was made to separate data based on demographics such as adult students, gender, or rural or urban background.

The journal entries were student responses to the in-class exercise—the 80% rule. Students were given two journal prompts.

Prompt #1. Write about your experience using the 80% rule for the 2-D to 3-D project.

Prompt #2. Now that you have heard the discussion on the 80% rule and its potential applications, reflect on the 2-D to 3-D project.

Prompt # 1 was assigned immediately following the end of the 80% rule exercise and was to be completed within 12 hours. This prompt was purposefully designed to be broad in scope, as not to lead students towards any specific thoughts or beliefs. Given that this was a reaction journal assignment, student entries were to be completed as soon as possible but no more than 12 hours after completion of the exercise.

Prompt # 2 was assigned following a presentation of student responses to Prompt #1, a brief lecture on the purpose and application of the 80% rule, and a subsequent discussion. Student response to the second prompt was reflective in nature and as such the assignment was due 3 days later at the beginning of the next class.

The two journal entries were coded separately to probe students' responses regarding beliefs about doing less than a "perfect job" and emotional responses to the exercise. Table 1 details the specific coding.

Table 1 Coding scheme for data sources.

| |
|---|
| *Coding scheme for responses to Prompt #1* |
| 1) Emotional responses to the exercise: e.g., excitement, anger, frustration, etc. |
| 2) Beliefs indicating students' perception of what constitutes a quality job. |
| *Coding scheme for responses to Prompt #2* |
| 1) Change in students' perception of what constitutes a quality job. |

**Results**

A total of thirty-five journals were coded and analysed—5 from 7 different sections of the class. The results of the coding according to the scheme in Table 1 are presented in Table 2. Each of the coding elements is broken down further. This subdividing was used to clarify competing thoughts, actions, or beliefs that emerged from the responses. In each category, two sub-categories were developed.

For prompt #1, the two codes were each broken down into *Promoting* or *Inhibiting*. Promoting refers to responses that would help the student achieve the task such as "no matter what job you have, you will have deadlines so you just have to do the best you can". Inhibiting responses are belief or actions that tend to sabotage students efforts, e.g., "Here is my biggest hate for this whole idea: <u>I don't like signing my NAME to work that is slop.</u>"

Of the thirty-five students, eight (23%) responded with emotionally promoting responses, e.g., "When the project was assigned I was really excited." Seventeen students expressed inhibiting emotional responses. These ranged from mild discontent with the use of the 80% rule to strong dislike. Strong emotions defined by the use of words such as rage and furious were used nineteen times by nine different students. Six (17%) students had responses in both categories.

The belief code garnered inhibiting responses from nineteen (54%) students. The majority of these were related to the need to do perfect work or give 100% to the task. A typical sentiment was "I do not care to just do something half ass [*sic*]. If you are going to put effort into your work might as well give it your all." Fourteen students expressed promoting beliefs such as "I think this [time constraints] will definitely happen in the workplace." Eight (23%) of these students listed both inhibiting and promoting beliefs.

The coding elements for Prompt #2 were also subdivided. The element of *change in student perception* was divided into *real change*—change from their initial response to the exercise and their reflection after clarification of the purpose/application of the 80% rule —and *initial understanding* where students had some understanding of the rule from the beginning or at least learned it during the execution of the assignment. All students that exhibited real change indicated an "aha" recognition of the purpose of the 80% rule from an initial aversion to it. Seventeen (49%) students fell into this category. An additional five (14%) students indicated initial understanding of varying levels. Two (6%) of these students had entries in both coding categories.

Table 2. Summary of coded student responses to the two engineering journal prompts.

| | |
|---|---|
| *Coding scheme for responses to Prompt #1* | |
| 1) Emotional responses to the exercises. | |
| a. *Promoting* | 8 (n=35) |
| *b. Inhibiting* | 17 (n=35) |
| 2) Beliefs indicating students' perception of what constitutes a quality job. | |
| a. *Promoting* | 14 (n=35) |
| *b. Inhibiting* | 19 (n=35) |
| *Coding scheme for responses to Prompt #2* | |
| 1) Change in students' perception of what constitutes a quality job. | |
| a. *Real Change (Change from the beginning to the end of the exercise.)* | 17 (n=35) |
| *b. Initial understanding (Student had some initial understanding of being customer-centered.)* | 5 (n=35) |

**Discussion**

College students bring with them a lifetime of academic experiences. From Kindergarten through 12$^{th}$ grade, these students have been turning in papers, taking tests, and doing projects that are graded and returned. One would think that over such an extensive period students would have developed a keen sense of what the customer (instructor) wants and would focus on delivering a targeted quality product for the particular assignment and the particular instructor. In other words, they are able to read (or at least find out) exactly what is expected. This is the basic concept of lean manufacturing—"Know the customer and make what *they* want."[4] Despite this extensive experience of at least twelve years of constantly changing customers (instructors) and the concomitant variation of expectations, students seem to hold fast to preconceived notions of what is a quality product as if *it* is an absolute.

In this work, students' expressions of quality were overwhelmingly divorced from the instructor's explicit instructions. Expressions of preconceived notions of quality dominated:

"In doing only 80% of the quality I felt as though I was doing a disservice to the consumers of the product I was producing."
"I kept going back to fix those mistakes causing me to use more time and try to make up for that time on a later one."
"I feel as though I have failed if I do less quality."

These student comments do not show a maturation of customer sensitivity, but a hardening of beliefs that parallel common clichés such as

"Nothing less than perfect will do."
"Give it 100% or nothing."
"If it is worth doing it is worth doing right."

If we combine the responses of emotions and beliefs from Prompt # 1, we find that all but four students (89%) out of the thirty-five wrote at least one inhibiting emotion or belief regarding their experiences in performing the 80% rule exercise. Many of these expressions indicate that the students are very clear on what is quality and indicate that this assignment is contrary to their image or concept of quality.

"I am kind of a perfectionist in that I believe it should all get done, or not at all."
"I really don't like deadlines, especially outrageous ones because they force you into using this 80% rule."
"I still do not like the 80% rule. If the goal is get it done, I still like to have it perfect."

While it is not surprising that students have an understanding or notion of what might constitute quality or the bounds of quality, it is surprising how rigidly and narrowly they define quality.

Many students directly stated their strong emotional response to this exercise. It is clear in many of these instances that the level of inhibiting emotion could easily have interfered with the student ability to function efficiently and effectively.[6] Nineteen (54%) such responses from nine (26%) students were recorded. These responses where characterized by expressions such as

"I hate this project. At the end of class when everything was graded I was furious and wanted to yell!!"

The word hate was used seven different times.

The second part of this exercise offered students an alternative viewpoint that is explicitly customer driven. In this alternative perspective, specific quality of the product is overshadowed by the customer's absolute need to have the product delivered on time. In reflection of the exercise and in light of this new perspective, students showed a clear shift from quality as a fixed and absolute property to recognition that it might be malleable. In this reflective engineering journal entry, nineteen (54%) of the students showed either a change in thinking from their original fixed beliefs or showed some knowledge of the usefulness of the 80% rule. Of the thirty-five student in the study, five (14%) were not represented as a result of the specific coding. The remaining eleven (31%) students did not express any change that was detected through the specific coding.

**Conclusion**

This work was intended to focus students on their beliefs regarding the difference between industry-centered and customer-centered attitude. This was accomplished through a simple class assignment that had an overt goal of teaching basic engineering skills of visualizing 3-D objects and how they can be unfolded into 2-D objects. By superimposing a covert goal that conflicts with most students long held beliefs that you should make the objects perfect, the students reveal, to themselves, their bias that parallel industry-centered behavior, i.e., they refuse to do what the customer (the instructor) wants. Here product quality conflicts directly with time/delivery constraints.

Student self reporting via the first engineering journal response showed that nearly all students would sacrifice getting the product done on time to make a perfect product. The sacrifice they made to produce their vision of quality was the grade received on the project by not completing it on time. This level of sacrifice demonstrated students' commitment to their beliefs in being industry-centered.

The second portion of the exercise presented students with the opportunity to view the process from the viewpoint of the customer. For most of the students, this was an aha moment of learning. They reflected that they never thought of assignments as delivering a product to a customer that may want something different than what they would normally produce. The result was that nearly 61% of the students represented indicated that by making academic assignments customer centered they are producing quality products even though they would prefer to do a better job.

**Bibliography**

1. K. Matzler and H. H. Hinterhuber, "How to make product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment," *Technovation,* Vol. 18, Issue 1, pp.25-38, 1998.
2. M. Holweg, "The genealogy of lean production". *Journal of Operations Management* Vol. 25, No. 2, pp. 420–437, 2007.
3. D. Bailey, "Automitive News Calls Toyota World No. 1 Car Maker," *Reuters.com*. Reuters. http:/www.reuters.com/article/businessnews/idUSN2424076820080124. Retrieved 19 April 2008.
4. M. Adams, P. Componation, H. Czarnecki, and B. Schroer. "Simulation as a Tool for Continuous Process Improvement," *Proceedings of the 1999 Winter Simulation Conference,* pp. 766-773, 1999.

5. D. Reis and LPena. “Linking Customer Satisfaction, Quality, and Strategic Planning,” *Revista de Administracao de Empresas,* Vol. 40, No. 1, pp. 42-46, 2000.
6. M. E. Pritchard and G. S. Wilson. “Using Emotional and Social Factors to Predict Student Success,” *Journal of College Student Development,* Vol. 44, No. 1, pp. 18-28, 2003.