

**THE WIREMOLD COMPANY:
LISTENING TO THE VOICE OF THE CUSTOMER**

TEACHING NOTE

This teaching note was prepared by Martha C. Fransson and Peter J. LaPlaca of Rensselaer Polytechnic Institute and Steven M. Maynard of The Wiremold Company. Presented to and accepted by the *Business Case Journal*.

CASE OVERVIEW

Steve Maynard, vice president for engineering at The Wiremold Company, a leading manufacturer of wire management solutions for new construction and retrofit of existing buildings, was reviewing two recent product development projects Raceway 4000 and Raceway 5500. Using Quality Function Deployment (QFD) and Voice of the Customer (VOC) methods for product development, these two products had been successfully launched in an extremely competitive marketplace and had fared well. Art Byrne, CEO of the company had asked Maynard to prepare a high level presentation to the CEO and senior executives of a Fortune 500 company about how Wiremold[®], a practitioner of Lean business principles and QFD, implemented the Voice of the Customer (VOC) market research in QFD. At the time of the case, Wiremold was a large privately owned company.

The case study presents a detailed description of the market research and preliminary design phases for two new products that were developed using QFD in a Lean business environment. One product (4000 Raceway) was a derivative product and the other (5000 Raceway) was a breakthrough product. For both projects, the KJ Affinity Method was used to interpret Voice of the Customer data for the construction of a First House of Quality. The description of each project concludes with information on the final stages of the product's development up to and including manufacturing and launch. The case contains an actual First House of Quality. Students are asked to analyze case data to evaluate the effectiveness of the company's VOC methods and its use of QFD.

The case study is intended primarily for graduate level courses in Hi-Tech Marketing and New Product Development with additional applications in undergraduate New Product Development and Business-to-Business marketing courses.

The Reference section to this teaching note contains a bibliography of articles and books about QFD, product development, Lean, and marketing research. The Additional Pedagogical Materials section contains three Appendices that may be photocopied and distributed to students. Appendix A provides a brief introduction to Lean manufacturing. Appendix B provides a brief summary of focus group methodology for comparison to the Voice of the Customer methodology that Wiremold used. Appendix C provides the materials for an exercise that may be performed in class using the KJ Affinity method described in the case. The Epilogue (which may

be read in class) provides a summary of Maynard's remarks to a class when he served as a guest speaker and answered student questions.

RESEARCH BASIS

In 1999 The Wiremold Company received the Shingo Prize² for Excellence in Manufacturing. At the inception of the research process, it was anticipated that there would be a book prepared for the corporate audience and that cases would be prepared for educational use. The research team was co-led by Professor Mario Emiliani (for the book) and Associate Professor Martha C. Fransson (for the cases). Team members conducted in-depth interviews with 13 members of Wiremold's management team. The completed transcripts of over 60 hours of taped interviews totaled approximately 900 pages. The research led to the preparation of a book (Emiliani, Bob et al, 2003) and to three case studies of which this case is one. None of the authors of this case are authors of or contributing authors to the book.

After the end of the initial research process, a company officer agreed to co-author a case about the product development process. The authors conducted additional interviews, obtained additional quantitative data, and obtained original QFD documents to prepare this case study. It is therefore a completely independent original work based on primary field research data.

Because the company believes that its product development process is a key strategic asset, the case authors have omitted all dates and disguised certain numeric data relating to projects described in the case. Some exhibits provide partial data only to prevent a precise linking between them. Case Figure 2 is from a project similar to those described in the case.

At the time of the case, it was Wiremold's policy that all decisions were made by teams, and this policy was an important component of company culture. For this reason, personal background information on employees was omitted except for Case footnote 2. It was Wiremold's policy not to release financial information.

SUGGESTED ASSIGNMENTS

Because this case is primarily intended for graduate level courses that are typically electives, students may come to the case with varying levels of prior preparation in Lean business, marketing research, and QFD. We have found that the case works best if students have had a reading in each of these areas to establish a common base level of preparation.

Depending on the level and mix of students, one of the following articles may be assigned to provide an introduction to Lean manufacturing (which uses small lot sizes and short changeover times compared to the large lot sizes and significantly longer changeover times of large scale manufacturing, traditionally known as "mass production").

Arnheiter, Edward D., "A Brief History of Lean Production", Appendix A to this Teaching Note.

Emiliani, M. L., "Cracking the Code of Business," *Management Decision*, Vol. 38, No. 2, 2000, pp. 60-79

Womack, James P. and Daniel T. Jones, "Beyond Toyota: How to Root Out Waste and Pursue Perfection," *Harvard Business Review*, September 1996

For an overview of QFD, the following may be assigned.

Hauser, John R. and Don Clausing, "The House of Quality," *Harvard Business Review*, May-June, 1988

O'Neal, Charles R. and William C. LaFief, "Marketing's Lead Role in Total Quality", *Industrial Marketing Management*, Vol. 21, 133-143 (1992)

For an introduction to qualitative marketing research, the following may be assigned.

"A Brief Introduction to Focus Groups", Appendix B to this Teaching Note, Excerpted from Fransson, O'Connor, Lynn, and Ziamou (1997)

Sandberg, Kirsten D., "Focus on the Benefits: Focus groups are rarely used effectively, but their smart use can provide big payoffs", *Harvard Management Communication Letter*, Harvard Business School Publishing, Boston, MA, April, 2002

LEARNING OBJECTIVES

1. To examine how a Lean business company obtained the Voice of the Customer (VOC) input to the First House of Quality (First House) in a Quality Function Deployment (QFD) process for product development.
2. To compare the methods used for obtaining VOC input for a Derivative product with those for a Breakthrough product.
3. To compare having the entire cross-functional team design and perform the VOC market research with traditional market research methods.
4. To evaluate the effectiveness of a cross-functional team for product development and Wiremold's commitment to co-location of team members.
5. To evaluate how closely Wiremold adhered to formal QFD processes.

QUESTIONS

1. What were the distinguishing features of Wiremold's Listening to the Voice of the Customer approach?
2. What were the differences between the market research processes for derivative and breakthrough products? And, were these important?
3. What are some typical problems with market research?
4. How successful was Wiremold in improving the market research process?
5. Did it help or hinder to have a multi-functional team?

6. Did the requirement for full-team approval likely lengthen or shorten the total process time?
7. How well does Wiremold's QFD process as described in the case adhere to formal QFD processes?
8. How does Wiremold's product development approach compare to the internally-focused "Build It and They Will Come" approach and the external-consultant "Hire a Market Researcher to Take the Blame" approach?

ANSWERS TO QUESTIONS

1. What were the distinguishing features of Wiremold's Listening to the Voice of the Customer approach?

There were three distinguishing features of Wiremold's approach to Listening to the Voice of the Customer. First, the company defined as "customers" all those members of the decision-making unit (DMU) who had a say about what wire management system was purchased and about what components would be used in any specific building project. The company sold to distributors who in turn sold the company's products to contractors. Normally, the distributors would be considered the customers and the contractors as the customers of the distributors, or end-users. Within Lean, there is a strong emphasis on the "value stream", defined as all activities that create value for the customer who buys the product. (Womack and Jones, 1996a) Therefore, in accordance with Lean practices, the team had an obligation to determine what influencers had a say in the buying decision and what value they added to the decision. The team decided that the contractors and members of other groups, architects, interior designers, building engineers, building owners, and building tenants, all had a say in the selection of a wire management system for a specific building. Therefore, the team realized that understanding the needs and preference of these groups was as important as distributors' opinions to ensure that the final product met their needs as contributors to the value stream. The team decided to refer to all of the groups of influencers and the distributors collectively as "customers" and to obtain their opinions and preferences.

Students may not be familiar with the concept of a "buying center" (Bonoma) or the roles of various members of a decision-making unit (DMU). For reasons of focus, the authors chose not to include more information about these groups (and the company was reluctant to share its perceptions in detail). However, instructors may wish to encourage students to speculate about the members of these various groups and their roles in the DMU. Table TN-1 contains a synopsis of how these groups typically influence the wire management selection process, and may be used by instructors as additional pedagogical material for illustrative purposes.

Second, the team did the marketing research themselves instead of hiring a professional marketing researcher for the task. Given the composition of the cross-functional teams (one person from marketing/sales, two people from product engineering/tool design, and one person from manufacturing engineering), Wiremold was not only doing the marketing research in-house, it was being done by people who would normally not be considered to be qualified for the task. However, given that modern

forms of Lean originated in Japan, Wiremold's practice is consistent with the Japanese practice of requiring engineering personnel (and managers) to assess customer needs first hand. (Johansson and Nonaka, 1987)

Third, the product development team was making its own decisions, and appears from the case data to have been bereft of direction from the company's marketing and sales personnel as well as input from senior executives. Within Lean practice, it is a requirement that teams make their own decisions and that they consider the needs and requirements of all parts of the company that will be affected by the decision. Kaizen teams cannot function effectively without this requirement. (Imai, 1986) This is also a requirement of best practice in QFD. (Hauser and Clausing, 1988)

2. What were the differences between the market research processes for derivative and breakthrough products? And, were these important?

The Derivative product Raceway 4000 was a re-design of a well-established older product that was becoming outdated due to competition from more attractive new versions being introduced by competitors. It was anticipated that the new version to be produced by the company would be based on existing technology and use existing Lean manufacturing methods (a pull system using manufacturing cells). (See Arnheiter 2002.)

The Breakthrough product Raceway 5500 was to meet a new customer problem that was fast becoming apparent in the marketplace: wire management for both communications and electrical power. Further, it was to employ new plastics technology to meet customer demands for improved aesthetics. The customers would have to learn how to install and use this new product which entailed new ways of managing what had heretofore been two very different wiring systems, and the company would have to learn how to make the product using new-technology plastics to avoid the traditional fire hazard of combining plastic and electrical power. Raceway 5500 was properly classified as a breakthrough product based on this combination of new technology and new customer learning. (See Wheelright, 1992b.)

Students should bear in mind that the Raceway 5500 product was developed a year after the Raceway 4000 product, which meant that at least Maynard as functional head of the product development organization had the benefit of learning from the prior project. Also, Raceway 4000 was the first official QFD project undertaken. Although the case is silent as to whether any of the Raceway 5500 team members had participated in the earlier project, only the marketing-sales team member for Raceway 5500 was new to product development.

A comparison of the process used for the two projects should show two kinds of differences: those due to learning and those related to inherent differences between derivative and breakthrough products. The four process differences were: first, the ability to design survey instruments and gather and interpret data; second, the importance of job site visits and the number required for the project; third, the importance of gathering and analyzing data by customer segment; and fourth, the need for prototyping and confirmatory research especially for breakthrough products. Table TN-2 provides a summary of the market research processes for both products and may be developed in class by the students, used as an overhead, or distributed as a handout.

The first difference between the two projects was that the team working on Raceway 4000 apparently had difficulty understanding what market information they needed to gather. This is shown by the three different research instruments used during the first phase VOC research. The first 100 mail surveys were followed by a second mail survey to obtain rank order preferences (quantitative) data, and this was followed by follow-up telephone calls to obtain more information about the measurables (the quantitative measurement issues) data needed for the First House. In their contemporaneous notes, the Raceway 4000 team described this as “clarifying earlier responses”. The use of mail surveys to gather qualitative data is generally not recommended. In this case, however, the data was used for exploratory purposes only, and later confirmed and refined with data gathered through other methods.

However, the Raceway 4000 team was apparently very surprised by the number of surveys that came pouring in. They had more responses than they expected; the responses were top-of-mind, and they were overwhelmingly negative. Responses such as: “no visible seams; no rough edges; perpendicular cuts; available in many colors; lower installation costs” (Case) were negative. Delivered in person, these statements might even become hostile. In a hypothetical focus group, people might have said things like: the installed product has a lot of rough edges showing; there are gaps where there ought to be seams; the gaps are crooked and saw-toothed; the product is expensive to install and higher priced than other alternatives; and even when we do buy it, we have to paint it because the only color is gray. These negative messages were difficult for the team to accept, and they attempted to discard this data because the company was not responsible for these problems. (Case) (An all-to-common reaction to bad news from market research.) Only after the team realized that their mission was to design a product that would be problem-free in installation, did the team accept the negative statements as legitimate data.

In contrast, the Raceway 5500 team gathered all of this data in the first 100 telephone interviews. The switch to telephone interviews from mailed surveys is significant. The telephone interview format permitted the interviewer (a team member) to probe for clarity the first time around. The telephone interviews also included questions about rankings of desired features and benefits. This change meant that more complete data was gathered during the first phase, and that the same data set was obtained from all respondents. The case does not provide information on how long these interviews were. Some may have been close to an hour; others the more conventional twenty minutes.

The second significant difference was that the team working on Raceway 4000 visited only ten job sites while the later Raceway 5500 team visited nineteen. The first team watched installations and learned that the installers had significant unmet needs relating to tools and additional fittings and device plates. They also observed that the most prevalent of “many colors” was ivory, and that what the contractors were complaining about was having to paint the product that Wiremold was delivering on-the-job. In other words, the company was making the wrong color! They also collected data about how long it took to install the Raceway at various job sites, and found that installation time seemed to be a function of the number of linear feet installed and the number of devices tapping into it. From this data, we can see that the job site visits allow for follow-up questions and for probing a range of issues that were not included in the survey instrument – perhaps because it would have been too lengthy.

Although ten such visits may have been adequate for a derivative product, the Raceway 5500 team apparently believed that they needed significantly more for a breakthrough product. They arranged for nineteen job site visits, and expressed disappointment that they could not visit more institutions (particularly more hospitals). During these visits, the team learned that there was a new set of influencers in large institutions: employees who maintained the wiring systems and made routine installations and changes instead of outsourcing these to contractors.

The third difference was that while the Raceway 4000 team at some point in the process was able to identify the source of each questionnaire (all respondents were selected by company personnel), their ability to analyze the data by decision-influencing segment appears to have been limited, or there were no differences between segments. In contrast, the Raceway 5500 team decided to gather data from various sets of influencers at the start and to identify the data by segment: building-owners, architects, consulting engineers, and contractors. Again, all respondents were selected by company personnel, but for this project, the team was able to identify the source of each data point throughout the research process up until the point at which the responses were written onto sticky notes for analysis using the KJ Affinity method. Therefore, the KJ method was applied to each customer segment (really influencer segment) identified at the outset of the project. This change suggests that the understanding of the market research process had greatly improved by the time of the Raceway 5500 project and that the team made decisions at the outset to speed the gathering of research data and to improve their sophistication in analyzing it.

Both teams consistently used the KJ Affinity method to analyze the data that they collected using survey instruments. Most of this data was qualitative. Some of it was numerical; none of it was “projectable”. Accordingly, focus group methods could have been used to seek this data. For a comparison of the KJ Affinity method and focus groups, and the possible effect of this difference on project outcomes, please see the discussion following Question 4.

The fourth difference was that the Raceway 5500 team conducted confirmatory research on their first phase conceptual and physical designs. The confirmatory research was accomplished with the aid of physical prototypes and interviews between team members and customer groups during a second round of site visits.

The first difference, the ability to design survey instruments and gather and interpret data, probably reflects learning within the product development function. The second, the importance of job site visits and the number required for the project, probably reflects an inherent difference between a derivative and a breakthrough product. With a derivative product, there should be less variation between customers (because the product category is familiar to a broad range of customers) and therefore fewer job site visits ought to suffice. The third difference, the importance of gathering and analyzing data by customer segment, probably reflects both learning and the inherent differences between the two projects. In the Raceway 4000 project, the team was clearly inexperienced in understanding qualitative market research data, but it is also possible that segmentation was unimportant. In the Raceway 5500 project, the team had the foresight to realize that there probably were different segments with different buying criteria and to set up their research program to be able to uncover and analyze the differences. Finally, the fourth difference, the need for prototyping and confirmatory research, probably relates primarily

to the inherent product differences. Since customers often have difficulty verbalizing what they want when they have never seen the product, confirmatory research is essential for breakthrough products, and less-so for derivative products.

3. What are some typical problems with market research?

This question and question 4 that follows it presume that at least some of the students in the class have some knowledge about the basic market research process. If this is not the situation, it will be necessary for the instructor to provide some basic information. Assigning Appendix B to this teaching note and/or the article “Focus on the Benefits: Focus groups are rarely used effectively” (Sandberg 2002) will provide students new to qualitative marketing research with a preliminary understanding of focus groups as a primary tool in this arena. We have prepared the answer to this question to supply an instructor with the basics for a short lecture on the subject if needed.

Sample size, the number of people contacted, is always a critical issue. For quantitative data to be used to make projections, it is customary to obtain sample sizes of at least 300 respondents for statistical validity. However, in the early exploratory stage of market research, much smaller sample sizes are often used to gather qualitative insights that will be used to design products, promotions, and communications campaigns. For exploratory research, what counts is not the number of people that were contacted but the number of insights that they generated. For Wiremold’s product development teams, projecting market share was not the primary issue; understanding the customers’ wants and needs was essential to the product design and development process.

Focus group methodology has a long history (back into the 1950’s at least) and remains the predominant method of conducting exploratory market research that is qualitative in nature. It is excellent for gathering insights into customers’ and prospective customers’ top-of-mind thoughts. However, it is expensive, time-consuming, does not permit in-depth probing, and is subject to bandleader effects. A frequent problem is that the company hiring the research firm is dependent on who is assigned to moderate the focus groups, and the adequacy of that person’s knowledge of and comfort with the specialized issues to be dealt with in the focus group sessions. Despite these potential (and sometimes often actual shortcomings), focus groups have been the primary device in the qualitative researcher’s toolkit for over half a century.

For focus groups, it is customary for the market research company to recruit and select the participants, although the company may of course submit names of specific desired participants. Usually, a typical focus group will include a number of buyers and users who are unfamiliar with the company’s products. The name of the company may or may not be revealed to participants. Company personnel often watch the group interview process from behind a one-way mirror, and/or read the transcripts, listen to audio-tapes, or view the video tapes of the group interview. Usually the moderator extracts from the transcripts specific statements that seem important and uses these to support specific findings and recommendations in the final report.

However, beginning with the introduction of QFD methods in new product development in the late 1980’s, Japanese-style methods were sometimes used to obtain customer insights. Company personnel sought face-to-face contact with customers and end-users to eliminate the barriers to understanding that often arose from market research

mediated through the third-party research personnel. Meetings with individual customers eliminated the bandleader effect in focus groups, misunderstandings by moderators who did not understand the appropriate terminology (industry lingo), and improved the speed of the research process at lower cost. Keeping records of the insights gained from these meetings was important, and often resulted in transcripts that had to be analyzed. The meeting transcripts had to be analyzed using an affinity methodology. In Japan, the affinity methodology of choice was the KJ method; in the U.S. the analysis was usually accomplished by using a statistical package operating on electronic text documents.

More recently, there has been another wave of change, this time led by academics seeking to devise alternatives to focus groups for exploratory research that would provide provably equivalent results, be more efficient, and less expensive. (Sandberg, 2002) Griffin and Hauser have found that twenty one-hour depth interviews (one-on-one) generate the same number of insights and new ideas as ten two-hour focus groups. (Sandberg, 2002) A focus group typically has eight to twelve people. Ten groups with an average of ten people would mean that approximately one hundred people discussing five to ten topics would give each person about two minutes on each topic. (Sandberg, 2002) The depth interview clearly would provide more time to explore each person's thoughts on the five to ten topics, or alternatively, to explore more topics. Further, with specialized focus groups requiring fees to be paid to individual participants for two hours of their time, a methodology that required fewer participants for shorter periods of time would clearly save on participant fees (one hundred people for two hours versus twenty people for one hour) and could be accomplished in the same amount of interviewer time (twenty hours). Assuming that participant fees were as high as \$100 per hour, ten focus groups would cost \$20,000 versus \$2,000 for twenty depth interviews.

4. How successful was Wiremold in improving the market research process?

The opportunities for improving the market research process (as discussed in response to question 3) centered around: speed, cost, avoiding "filtering" of information through a moderator, removing the bandleader effect, ensuring that an adequate volume of customer insights was obtained, and ensuring that an appropriate method of affinity analysis was used to analyze the customer insights. All of these are discussed below. For the convenience of the instructor, we have added four sub-questions:

- a. Was an adequate volume of customer insights obtained?
- b. Was an appropriate method of affinity analysis used to analyze the customer insights?
- c. Was it appropriate to use the same analytical method for both the Raceway 4000 mail survey and the Raceway 5500 telephone survey?
- d. Did the job site visits help or hinder the market research process?

The Wiremold product development teams decided to conduct their own market research. The primary effect of this decision was to remove any potential "filtering" effect of a third-party moderator. It also provided the team with an opportunity at each stage of the VOC process to make a go/no go decision. This meant that the team was in control of the speed at which the VOC process would proceed and the cost of each activity. Delays and cost overruns would be the sole responsibility of the team. This was consistent with Lean and with company policy. (Case, Table 3) Because the team decided

not to commission focus groups, or group interviews of any kind, they removed the bandleader effect. Thus, the decision not to use focus groups clearly removed two sources of potential error in the results (moderator filtering and bandleader effects) and provided opportunities for closer control of the dimensions of speed and expenses. This leaves two criteria for additional consideration: Was an adequate volume of customer insights obtained? Was an appropriate method of affinity analysis used to analyze the customer insights?

- a. Was an adequate volume of customer insights obtained? In the context of two minutes per topic with one hundred people, a mail survey questionnaire with open-ended questions might be a reasonable alternative to focus groups for exploratory research with a known group of customers, provided that enough surveys were mailed and returned to generate enough insights and that the affinity method for analyzing the insights obtained was solid. We turn next to analyzing the mail survey for Raceway 4000.

The Mail Survey for Raceway 4000 The composition of the cross-functional team would be sufficient to consider all dimensions of the customers' wants and to determine whether the product could be produced using existing technology. The team would therefore be less likely than a group of outside market researchers to ask questions implying a possible product requiring a technology not yet available. Having the team develop the questionnaire reduced the risk of raising expectations in the marketplace that the company would be very unlikely to meet and assured that *all* necessary aspects of the product were considered. Product engineering could ask for information about alternative ways of meeting the customer's wants/needs/requirements. Marketing/sales could ask about pricing, typical usage, features and benefits that are required but not available from products in the market. Tooling and manufacturing team members could ask questions related to producing the new product while keeping manufacturing cost low. Trade-offs between "nice to have" and "costly to make" would surface early in the process.

There were some theoretically poor outcomes that might have resulted from the team's decision to prepare their own mail survey. The questions might be biased or otherwise difficult to answer. The team members might not consider their questions as carefully as a professional, and therefore the survey development process, while fast, might be flawed. The requirement for consensus might lead to interpersonal conflict. The instrument might be too long (because it included everyone's questions), or it might omit vital questions that would be obvious to an outsider.

The case data for the Raceway 4000 mailed questionnaire indicates that the team limited the scope of the questions to customer desires for features and benefits and their buying practices. All team members realized that it was important to them individually to get their questions into the survey. The marketing/sales team member "took it upon himself" to "probe the wording of each question". (Case) The marketing/sales team member's questions related mostly to buying practices, pricing, use, and product differentiation (critical market segmentation criteria). The case data indicates that marketing/sales member also developed a list of customers to receive the questionnaire. (Case) The case also indicates that the questions were open-ended and required customers to write their opinions in their own words. A total of more than 100 surveys were mailed and approximately ninety persons responded (a very high rate of return).

From this data, we see that the primary differences between this survey instrument and a typical mail questionnaire are three in number. First, this questionnaire was intended to provide qualitative data. Mail surveys are typically used to obtain quantitative data for use in making projections. Second, the recipients included as customers could include the full panoply of actual members of the decision-making unit (DMU): distributors, contractors, architects, building engineers, building owners, tenants, etc. Thus, the data might not be comparable for all sub-groups in the sample. Third, all of the selected recipients were known to company personnel as purchasers and users of company products and valued for their opinions. Customarily, the survey would be blind, that is, individual respondents would not be identifiable.

The way the team processed the responses points to their intention of gathering qualitative data. After receiving responses, the team had ninety responses to at least six topics (using Case Table 4 as a proxy for the questions on the Raceway 4000 project). This gives the potential for 540 insights, assuming that all responses to all questions are different. However, we would expect that there would be considerable duplication of insights. The case states that the team read all of the survey responses and prepared a sticky note for every statement that seemed important and that this process resulted in more than 100 phrases (written on sticky notes) that were subsequently analyzed using an affinity methodology. (Case) Ten insights per person from 20 depth interviews would give 200 insights, and some of those insights would probably be duplicates. Thus we can conclude that the mail survey appears to have generated an adequate number of insights.

b. Was an appropriate method of affinity analysis used to analyze the customer insights?

The Raceway 4000 team intended to use the KJ Affinity Method of analyzing the customer insights. The case states that they had learned the procedures in the QFD seminars. However, their initial doubts centered around whether or not they were “a panel of experts”. After they decided that they were qualified as expert-enough to understand and evaluate what the customers were saying in response to their own questions, they proceeded to follow the KJ procedures. (Case) Appendix C contains an example of the KJ process that may be also used as an in-class exercise. For our purposes, however, the issue is whether or not use of the KJ Method represented an improvement over traditional affinity methods of analysis used to interpret focus group data. In the next section of the answer to this question, we provide a comparison of what the team did with what would have been done to analyze focus group results, and in the subsequent section, we provide a productivity comparison.

(i) *Comparison of Focus Group and KJ Affinity Methods of Interpreting Qualitative Data* Had the team used focus group methodology, specific statements would have been extracted from the transcripts of the structured group interviews. In customary focus group methodology, the moderator interprets the statements, and often refers to selected ones in the report. If KJ methodology were applied to focus group results, the specific statements would be extracted and written sticky notes for evaluation by a panel of experts. Theoretically, the experts could all come from the market research firm, or the raw data (statements extracted from the focus group interviews) could have been turned over to company employees for analysis using the KJ Affinity method.

There are some strong similarities and differences between a typical focus group process and the KJ Affinity method of analyzing questionnaire data. In contrast to the

focus group, which uses oral data from a structured group discussion, the KJ Affinity Method uses oral or written statements by respondents to a questionnaire to uncover user opinions. (The survey instrument should contain open-ended questions to solicit opinions.) Like a focus group, the KJ Method seeks to develop and analyze qualitative data. Like a focus group, it does not require that this qualitative data be converted to quantitative data for quantitative analysis.

Unlike a focus group, the employees analyze the data themselves, without relying on an outside trained evaluator. Instead of one person doing the analysis and drawing conclusions, a panel of people knowledgeable about the product and its uses perform the analysis and draw conclusions. Because the members of the panel can be expected collectively to understand product or industry-related jargon, they can be expected to interpret respondents' statements in industry context. Because the analytical process is silent and involves moving the sticky notes into related columns on a wall, no one member of the panel is able to exert a bandleader effect on the others. Dissenting interpreters simply make their copy of the words on the disputed sticky and put the duplicate sticky in their location for it. In this way, the KJ method provides the flexibility necessary for a piece of data to have more than one meaning (a "both and" construction instead of an "either or" construction.) Table TN-3 contains a comparison of the characteristics of focus group and KJ methodologies. It may be photocopied and distributed or used as an overhead slide.

(ii) *Comparison of Focus Group and KJ Methods on the Dimension of Productivity* Some focus group studies are more productive than others (Albrecht, Johnson and Walther 1993; Krueger 1994; Stewart and Shamdasani 1990). We developed (from the literature) a list of eight criteria to evaluate the validity and integrity of traditional focus group results that could also be applied to the KJ Affinity method described in the case. (See Table TN-4.)

The productivity of the KJ Affinity Method as described in the case should be consistent with what we would expect from a traditional focus group. The two significant exceptions (both in favor of the KJ Methodology) should be higher clarity and depth of data (a desirable effect) and the near-absence of bandleader effects (a desirable feature). Both of these should result from the context created by the KJ methodology. Silence, required during the analytical phase, allows all data to be considered (leading to greater depth and clarity) and precludes efforts by a moderator or a dominant participant to alter, steer, or influence the creation or interpretation of the qualitative data provided by the participants (in the focus group) or the respondents (to the survey.) See Table TN-4 for the complete productivity comparison. It may be photocopied and handed out or used as an overhead slide.

Thus we can conclude that an appropriate method of affinity analysis, the KJ Method, was used to analyze the customer insights for the Raceway 400 project.

- c. Was it appropriate to use the same analytical method for both the Raceway 4000 mail survey and the Raceway 5500 telephone survey? We have established the KJ Affinity Method as an appropriate method for analyzing qualitative insights gained from exploratory market research. Accordingly, the use of that method in the Raceway 5500 project is appropriate. We have established the preparation of survey instruments by company employees as appropriate. We have established speed and costs savings as

appropriate, but under the control of the Wiremold product development team. We have established the removal of moderator “filtering” and the bandleader effect as desirable. We have established a benchmark of “more than 100” insights as an adequate number.³ The issue to be examined for Raceway 5500 is whether the 100 telephone interviews produced an adequate number of customer insights.

There were three significant differences between the mail and telephone surveys. With telephone interviews, the team members had an opportunity to probe and to ensure that each they obtained an answer to each question. Second, they were able to ensure that they had responses from 100 customers. Third, they had decided to gather data by four decision-influencing segments: building-owners, architects, consulting engineers, and contractors.

The team needed an adequate number of insights from each segment. The telephone interviews gave them the control they needed to ensure that they would gather enough data. Case Table 4 gives a selection of six open-ended questions for these interviews. With 100 interviews, this should generate 600 insights, perhaps more if some interviewees had a lot to say. Assuming that the interviews were evenly divided among the segments, that gives a possible total of 150 insights per segment. Even allowing for some duplication, this quantity of data appears to be adequate compared to the benchmark of “more than 100”.

Accordingly, we can say that Wiremold was indeed successful in improving the market research process for both of the projects described in the case on the dimensions of: speed, cost, avoiding “filtering” of information through a moderator, removing the bandleader effect, ensuring that an adequate volume of customer insights was obtained, and ensuring that an appropriate method of affinity analysis was used to analyze the customer insights.

- d. Did the job site visits help or hinder the market research process? The Raceway 400 team visited ten job sites after they had developed their first phase First House. The purpose of these visits was to verify their understanding of the exploratory data. They discovered important new needs for better tools and new products (base covers and fittings), and they measured installation times in the field. They also had opportunities to ask follow-up questions relating to their interpretations of the mailed questionnaires (*play catchball*). “They returned reinvigorated with new ideas. They had seen the unspoken needs first hand. Now they understood the questionnaire data better – and they had lots more to boot.” (Case) As a result of the job site visits, the team obtained many new insights and revised their First House. They also developed new First Houses for two new complementary product lines: installer tools and additional devices. (See Table TN-2)

The Raceway 5500 team visited 19 job sites after analyzing their telephone interview data but before preparing their First House. They obtained more data and analyzed it using the KJ Method and then proceeded to construct the First House. They then returned to the same job sites with conceptual and physical models of Phase One designs.

Taking engineering personnel to customer site visits is an essential component of Japanese-style market research and of QFD. The primary reason is that engineers can interpret problems that they see (dragging around a portable power saw and a one hundred foot long extension cord and moving a temporary power outlet) as possibilities for new ways to accomplish the basic task: cutting raceway. They can conceptualize on

the spot how they might design and make products to meet those needs. (Johansson and Nonaka, 1987) Further, taking teams of employees to customer sites is increasingly practiced in new product development. The team can observe phenomena that would not be top-of-mind in a typical focus group setting, and would not therefore come to the surface as important information. Even in consumer product research, site visits play an increasingly important role as companies seek to learn what is really going on in customer's minds.⁴ (Sandberg, 2002)

The next issue is sample size: whether or not the teams visited enough job sites. The Raceway 4000 project with only ten job site visits may or may not have included enough of them. On the other hand, this team was learning how to make decisions about how much research they needed and how deeply they needed to probe to obtain an adequate understanding of customer attributes needed for the First House. They obtained insights from seeing installers at work that they would not have obtained so easily any other way.

The Raceway 5500 team visited nineteen job sites twice. They would have liked to visit more institutions, but were unsuccessful in obtaining access to more than the seven that they visited. They discovered a hitherto unknown set of influencers. (Case) They too obtained information that probably could not have been obtained any other way.

Thus, the Raceway 5500 team benefited from the learning experiences of Raceway 4000 with respect to job sites visits. The job site visits became a standard part of the market research process at Wiremold as they produced information that was more easily observed than described. This was a significant improvement in the market research process.

5. Did it help or hinder to have a multi-functional team?

Multi-functional teams can experience difficulties due to internal politics (managers don't like losing a person, and the person may fear being away from his/her "home" department) and due to perceived frustrations in communicating with people from different functional backgrounds. These two influences (internal politics and perceived frustration) exert strong influences in most organizations to inhibit the naming of and performance of multi-functional teams.

QFD, however, *requires* a strong means of coordinating all of the skill sets within the organization that will be required to design, develop, manufacture, and launch a product. Typically, these disciplines include marketing and sales, product engineering, tool design, and manufacturing engineering. If a technology is to be used that will be new to the company, it would be required under QFD to include a person with expertise in the new technology. (Hauser, 1988) The QFD team for Raceway 4000 properly included the prescribed minimum four disciplines: marketing/sales, product design engineering, tool making, and manufacturing engineering as it would not address new customer needs immediately. The Raceway 5500 team properly included a plastics expert in addition to the four basic disciplines (marketing/sales, design engineering, tool making, and manufacturing engineering) because the company would be using new technology in its design.

Wiremold provided formal training to its employees through the American Supplier Institute to ensure that a formal QFD process would be used. Further, the company trained new employees in QFD in advance of assigning them to a team. This practice

ensured consistency of expectations among the employees when they began to work together and that all team members could immediately participate in the necessary tasks to complete the product development project. The company provided training in supplementary techniques (see Case Table 2). The company kept the teams small (four to five persons), which is essential when total member involvement and consensus is required. (Valle and Avelle, 2003) In this way, the company overcame objections to multi-functional teams based on expectations of communication difficulties.

The company also applied Lean management practices to QFD. By requiring the team members to work on just one project at a time, the company virtually eliminated start-up times between phases of the project. By grouping the members' desks around a conference table, the company virtually eliminated waiting times when the project was on hold while the members tried to schedule a conference to solve a problem. Both of these practices contributed to shortening the total elapsed time required for the project. Both of these practices eliminated Type II *muda* (steps that create no value and are immediately avoidable) in the form of wasted time due to unnecessary delays. (Arnheiter, 2003) The exceptions to the full-time participation rule were the manufacturing engineers, and, as can be seen at the end of the case, the inattention of a particular individual began to cause unnecessary delays in the Raceway 5500 project. Maynard asked for, and received a replacement, a series of events that was consistent with the company's Lean culture.

At first glance, it appears that using teams of four full-time members dedicated to one project at a time, and all co-located would be very expensive. If the activity is evaluated on a total productivity basis, measured by the number of projects completed and the man-hours required to complete them, it turns out that the full-time co-located teams are far more productive. There are two keys to this analysis. The first is the elimination of unnecessary waiting time on the project (as discussed above). Assigning part-time members to the teams often dilutes their effort as they work on other things, (Wheelright and Clark, 1992a) and would be another source of Type II *muda* (Arnheiter, 2002). The converse policy, composing the teams of only full-time members typically results in shorter development cycles, improved speed to market, and improved market share as a result of earlier market entry. The second key is that the method described in the case requires management to make critical strategic decisions about what development projects should be undertaken and why. In so doing, management should prune the list of projects to a number consistent with the company's competitive strategy and resources. (Wheelright and Clark, 1992a)

The case states that among Art Byrne's first actions was to establish a new products committee that henceforth would approve all proposals for a new product development projects. Because the product development function was now strategically important, the committee's first act was to prune the number of products in development from over thirty to four. Byrne also articulated a commitment to having only four projects on-going at a time. Thus, the company's actions in establishing the four co-located teams of four members were consistent with best practices in QFD, Lean, and strategic product development management. The apparent "hidden cost" to the four departments of "losing" one employee each could be overcome by staffing those departments correctly (perhaps adding resources) and by the benefits (speed to market, better design, and better manufacturability) of best practices in product development management. The high level political problems of assigning people full-time to teams and then co-locating them had

to be overcome at the highest level of the organization (by Art Byrne the CEO in this case).

5. Did the requirement for full-team approval likely lengthen or shorten the total process time?

Traditional methods of product development (before QFD) called for either sequential development stages based on transfer of the project from one discipline to the next (the “throw-it-over-the wall” approach), or overlapping development stages as the team membership changed gradually depending on the stage of the project (the “rugby” approach) to move the product through the development process. (For a detailed description of these two approaches see Takeuchi and Nonaka, 1986.)

These traditional approaches entailed long lead times as projects went from one phase to another, often to people working in different areas who spoke different “lingos” within the company. Typically, a company would have many new products under development, and team members would be working part-time on their project, and often working part-time on several projects. This tended to mean that individuals would have start-up times as they rotated from one project to another. Further, as one team member sent or mailed information to another, the project would be on hold while team members waited for each other to reply or schedule meetings. Finally, executives might have shifting priorities for the workers, which resulted in projects moving between the “front burner” and the “back burner”. QFD, a process created to focus multidisciplinary attention to one product under development was created to minimize cross-disciplinary inquiry and to minimize the numbers of times that a decision had to be revisited (a source of individual start-up times and many waiting times). QFD specified what had to be done in each stage of the project and how to do it. (Hauser, 1988; O’Neal and LaFief) As a result, QFD in fact shortens total product development times as measured by the number of engineering changes and when they occur. (Hauser, 1988, Exhibit II) QFD also overcomes the “silo effect”. (O’Neal and LaFief)

6. How well does Wiremold’s QFD process as described in the case adhere to formal QFD processes?

As indicated by the list of articles and books in the QFD section of the Reference section to this teaching note, there is a voluminous literature on the subject of how to do QFD. Further, QFD has along and honorable history, having begun in Japan in the 1960’s and having attracted the attention of U.S. automakers in the 1980’s. More recently, observers have noted that despite Japan’s long recession of the 1990’s, the country retained its position as the second largest economy in the world.

Even a decade of zero and negative growth with interest rates hovering at 0 percent has not denied Japanese manufacturers the ability to make products that are the envy of the world in quality, reliability, customer satisfaction and value. ... Japanese management systems ... have kept the country at the forefront of global trade and productivity. Among the most visible of these management systems, because it pertains not to managing

their cultural idiosyncrasies but to the design of the physical products they sell world-wide is Quality Function Deployment. (Akao and Mazur, 2003) From this testimony we know that QFD is important, that it must be efficient (Japanese manufacturers couldn't afford to waste resources), and that it is effective. The question is, really, does the Wiremold case give students a good example or a poor one?

The authors believe that Raceway 4000 and Raceway 5500 were sufficiently complex to be more interesting than simple service company examples (e.g. pizza restaurants and health clubs). They were also, however, simpler to design than an automobile, the examples in the Hauser and O'Neal and LaFief articles. Wiremold performed all of the important phases described in the literature. (See Table TN-2.) Wiremold omitted detail steps included in the manuals for doing QFD (Terninko; Akao, 1990; Cohen; Yang and El-Haik) because the teams judged that they weren't needed for the projects that they were working on. Some current QFD research looks at how QFD may be accomplished in a global context using the Internet (Huang and Mak) as global competitors continue to use the process to design complex industrial products.

Therefore, it seems appropriate for us as authors teaching in the fields of marketing, product development, and Lean manufacturing to simply state that we wrote this case for four reasons: First, the tale of the trials and tribulations of a team undertaking its first product development project using QFD, even after training, would be of interest to others considering using QFD for product development. What we (and the team) learned is that QFD is a process. The team should select the steps that they agree they need to do within each of the phases to build each House. Second, the VOC process and (to some extent) the QFD process for a breakthrough product are different from those for a derivative product. In hindsight, it seems obvious, but the manuals don't tell you that. Third, the company really did adhere to the fundamentals of QFD. The teams had representation from all of the needed disciplines. The members were full-time, and they were co-located. Other companies may make excuses on these issues, local politics may win out, but Wiremold did it right. Fourth, the company was willing to share some real data and documents, including a real house, along with post-launch marketplace results. That's important. This case is not a fairy tale; the company didn't cut corners, and they were phenomenally successful. The student skepticism arises because they suspect a secret reason why "it really won't work in practice; it was just an interesting case". This case provides a road map to understanding the fundamental processes of QFD. Whether or not another organization possesses the will to implement QFD is a different question.

In the paragraphs that follow, we provide a detailed discussion of the process of building the First House for the instructors who intend to spend significant class time on those procedures.

The purpose of the First House is to present a picture of qualitative and quantitative data about customer desires (attributes) for use by product designers. The qualitative issues (the *whats*) are listed down the left side of the House. (Case, Figure 2) The *whats* are the headings for each of the groups that the team developed from the VOC data using the KJ method. For each heading, the team computed from the raw VOC data an absolute importance rating. The team then ranked the KJ headings to develop relative importance ranking for each. (See Case, Tables 5 and 6)

The *hows* are design issues based on the technologies and manufacturing processes available (or soon to be available) to the team. (Case) The *hows* must be *measurable*,

determined by a simple count or measurement, and controllable. Developing the *hows* is the responsibility of the team. The team members may have different viewpoints and need to remain focused on what the customers wanted and needed, not just the easiest way to make the product. (Case) The team members also needed to generate the *measurables* for each *how*. Each *measurable* needed three attributes: a numeric quantity, a unit value, and a process for measuring. For example, the *measurable* for the number of tools included the number of each (2), the units (each), and a method of determining this (a simple count). (Case)

The *hows* are listed across the top of the House and become the basis for the roof. Each *how-what* design combination is given a rank order of importance by the team. At Wiremold, the rankings for the *how-what* combinations are 1, 3, and 9, with 9 being most important. The company selected 1, 3, and 9, because those numbers allowed for significant differences to develop between the relative importance of different design features.

Some *hows* affect more than a single *what*, while other *hows* may affect only one *what*. The absolute importance of each *how* is computed by multiplying its ranking for each *what* issue that it affects by the importance number of that *how*, and summing the total. For example, “Support active devices” is a design *how* that affects four *whats*: “Meet present and future needs”, “Allows for fiber optics”, “Minimize impact of change orders”, and “Wire management blends into furniture”. Its ranking for the first of these is a 9 (assigned by the team) and a 3 for the other three customer desires (*whats*) (also assigned by the team). This *how* has a total absolute importance ranking of 78 computed as follows: $(9 \times 4) + (3 \times 4) + (3 \times 4) + (3 \times 6) = 36 + 12 + 12 + 18 = 78$. (Case, Figure 2) The absolute importance ranking for the *hows* are shown at the bottom of the First House.

The next step in finalizing the First House of Quality before it is turned over to the design engineers is to develop a visual means of communicating (reminding) the correlations between the various *hows*. The purpose of this is to keep the designer on track as to what is really important and what is moderately important so that the design will reflect the customers’ needs as determined by the team. To accomplish this, the team met to consider pairs of *hows* and to assign correlation symbols to each pair (strong negative, negative, positive, strong positive). (Case) The correlation symbols are shown in the “Roof” of the House. (Case, Figure 2)

For example, there was a strong positive correlation between “Inches of exposed cord” and “Inches of bend radius”. This symbol “#” would constantly remind the designer that these two issues were positively reinforcing. Their absolute rankings of 108 and 135 respectively would remind him that both issues were among the top four most important issues for the design. Aesthetics, a key source of past customer dissatisfaction, certainly tuned out to be important, but adaptability to future technology changes was positively very important. It is important to remember that this particular House, for which only excerpts are given in Case Figure 2, was not from either of the two projects described in the case. Never-the-less, the case did include the information that prior to the development and introduction of Raceway 4000, there appeared to be strong customer dissatisfaction with aesthetic issues, and the team had (for a while) debated whether or not they really had to deal with aesthetics. (Case)

7. How does Wiremold's product development approach compare to the internally-focused "Build It and They Will Come" approach and the external-consultant "Hire a Market Researcher to Take the Blame" approach?

This question is intended to spark a debate within the class about differing approaches to product development. It is especially useful in classes where at least some of the students have had some work experience. For this reason, we pose it at the end of the series of questions, and not at the beginning. It is intended to stimulate thinking about why an organization should implement QFD.

The "Build It and They Will Come" approach refers to the very popular motion picture entitled *Field of Dreams* in which Kevin Costner played an Iowa farmer who wanted to watch baseball in Iowa, but there was no professional baseball park in Iowa. So he built one anyway, and it turned out that there were lots of people in Iowa and nearby states who would pay to come and watch baseball games. When the professional teams found out that there was an audience in Iowa, they came too – to play and make money. It was a wonderful film because it was a fable about the American Dream. The fable, however, doesn't translate too well to new product development in the 21st century.

A central problem in new product development for a long time has been a phenomenon that Maynard called "the Voice of the Executive". Before QFD, the product development group at Wiremold listened to the Voice of the Executive to hear what the top people (presumably they were the most knowledgeable) thought that the customers needed. The executives typically made two mistakes. First, they tended to assume that the customers would want the same things that they wanted. This was a mistake because most executives are members of very different market segments from their customers. Second, the executives took upon themselves the task of listening to the marketplace and watching competitors, and they tended to start new projects every time they had a good idea. This was a mistake because the product development people ended up with too much work and they spent their time going from one project to the next. Maynard called this "swarm" management because people would swarm from one project-of-the-week to the next, with the result that project completion was delayed. Sometimes, projects took years to complete and the products were "old hat" or "me too" by the time they were launched. So, the internal focus of the Field of Dreams approach too often results in expending excess resources on the wrong ideas for products that turn out to be late to market or out of date when they finally do appear.

The "Hire a Market Researcher to Take the Blame" approach has a different set of flaws. The problem here is that all sorts of project ideas bubble up from various operating divisions, some of which have some spare budget dollars to spend on new projects that they would like to see funded. So, in the context of an exploratory study, a product development project gets started with a study conducted by a market research consultant.⁵ The problems here are fourfold: The project is under the control (in the early stages) of a single division that may not have enough resources or all of the skill sets that will be needed to bring it to market. This means that later on other people from other divisions will have to be recruited. It also means that the other people later may not agree with the early stage decisions that were made in conducting the market research. This can lead to allegations of improper methods and/or wrong research results.

The attractive part of the approach of hiring the blamable consultant is that should the project need to be abandoned, blame can be affixed elsewhere. This reasoning tends, however, to be either defeatist (it probably won't work), defensive (not my fault), or self-interested (I got this project started because I need to look good for ...). Good opportunities may be discovered, but due to the necessities of gamesmanship, they may be wrongly discarded. Therefore, this too is a faulty process.

Wiremold's approach followed textbook solutions to these problems. Many projects were eliminated, and the remaining few were approved for funding by a senior committee that evaluated how each proposed or existing project fit with the company's strategy. (Case) This process stilled the Voice of the Executive. QFD was imposed as the product development process and the designated employees were trained. (Case) This brought order to the product development process, no more long shots or field of dreams projects. QFD also imposed a discipline. All the members of the cross-functional team had to work together, and they had to agree at the end of each phase before they moved on to the next. Down time on the project was eliminated. People couldn't hide behind excuses (I haven't got to it yet, ... I have so many other things to do.) Elapsed times for new product development projects actually shrank.⁶ Projects were staffed with the necessary skills at the beginning and adequately funded. (Case) This eliminated the gamesmanship associated with the external consultant and single division funding approach. Finally, the non-marketing members of the team (the clear majority) discovered that they learned a lot about customers, their wants and needs, and helped them to develop solutions to satisfying those wants and meeting their needs. From a cold start (what do they mean by saying ...?), (Case) they ended up liking the work and the people they met. (Case) Finally, QFD imposed a structure and a discipline for the process. The team members had to perform all the activities. Under Lean, they were permitted to decide how much work to do in each activity, but they couldn't take short cuts by eliminating phases in the process.

Therefore, we can see in this case a straightforward way to begin using QFD as a new product development process. The case shows that Lean principles are entirely compatible with QFD. The question is whether or not non-Lean companies can be successful with QFD. The authors believe that they can be, provided that they require their product development process to be managed using QFD and VOC methods. More than one company already using QFD has visited Wiremold to learn more about how to implement Lean. In other words, Lean business practices *require* QFD for the product development process, but QFD can *lead to* an interest in Lean principles. After all, if the organization can use cross-functional teams for product development, why not for continuous improvement?

EPILOGUE

Wiremold used assignments to product development teams as personnel development opportunities. The opportunity to work on one of these teams built skills in facilitation, team decision-making, and developed an awareness of the company's whole value stream. Since the company had almost no hierarchy, a returning department member often had new assignments and new responsibilities – which made life interesting and could lead to advancement. Teams physically moved their location, depending on the

stage of the project, so that every team members could experience “walking in his fellow team member’s shoes” for that segment of the development effort. For all of these reasons, many company personnel coveted an assignment to a product development team. (The authors have had students from the company privately complain that although they have been trained on QFD, they haven’t yet been named to a product development team.)

With respect to co-location, the company continues to believe that it is essential to gather all the team members together in one place. With its subsidiaries and plants scattered across the U.S., in Asia, in Europe, and in former Soviet bloc countries, the company’s headquarters site in West Hartford, Connecticut performs all product development, except for that for in-floor systems manufactured at the Walker Systems plant in West Virginia. All parts of the company use the same Lean business practices. Therefore, the product development teams in West Hartford design the production cells and build prototypes before transferring operational production to the plant that will in future produce the product. The production cell will then be kaizened six to eight months later, or earlier if necessary. The benefit of designing and producing early production runs under the eyes of the development team is that problems are immediately visible.

The company also believes that multifunctional teams with rotation into product development from the various functional areas are essential to fostering a holistic view of company operations. A key part of Lean is the construction of the value stream, which requires the company to do only those things that add value, as measured by the customer’s willingness to pay for them. Activities that do not add value (they add cost, but the customer is not willing to pay for them) are *muda* (waste). Maynard said,

Design engineers make better decisions when they have experienced first hand the customer viewpoint, and all the options that have been discussed by the team. There may be more than one way to do something, but having participated in the Voice of the Customer process gives the design engineer the ability to select the best alternative. The same thing happens when manufacturing engineers are designing the production cells. The cross-functional team may appear at first glance to be expensive, but in terms of the cost of production, the value delivered to customers, and the total elapsed development time, it is definitely the most efficient.

Maynard also said,

We do a lot of videoconferencing between locations. We have groupware available, but as a manufacturing company working in metal and plastic, groupware isn’t all that useful – we aren’t for example producing software or documents where, I imagine, groupware would be essential.

Finally, Maynard commented,

We’re committed to remaining a manufacturing company – in the United States. We have had plants in the Far East and in Eastern Europe where hourly wages are low since the mid-1990s. They are good plants and good people. But, frankly, we have found that by consistently and rigorously applying Lean principles, we can achieve comparable costs here in the U.S., with substantial advantages in terms of lower costs of inventory and more flexible deliveries to our customers here in the U.S.

REFERENCES

Arranged by topic in the following order: Lean, Marketing Research, Product Development, Quality Function Deployment, and Wiremold.

Lean

Arnheiter, Edward D., "A Brief History of Lean Manufacturing", Appendix A to this Teaching Note, 2002

Emiliani, Bob et al, *Better Thinking, Better Results: Using the Power of Lean as a Total Business Solution*, (The Center for Lean Business Management, Kensington, CT, 2003) (Winner of a Shingo Prize in 2003 in the Research and Professional Publication category.)

Emiliani, M. L., "Cracking the Code of Business," *Management Decision*, Vol. 38, No. 2, 2000, pp. 60-79

Imai, Masaaki, *Kaizen: The Key to Japan's Competitive Success*, McGraw-Hill/Irwin, 1986

Ohno. Taiichi, *Toyota Production System: Beyond Large-Scale Production*, (Productivity Press, Portland, OR, 1988)

Shingo, Shigeo, *A Revolution in Manufacturing: The SMED System*, (Productivity Press, Portland, OR, 1985)

_____, *A Study of the Toyota Production System*, (Productivity Press, Portland, OR, 1989)

Womack, James P. and Daniel T. Jones, *Lean Thinking*, (Simon & Schuster, New York, 1996a)

_____, "Beyond Toyota: How to Root Out Waste and Pursue Perfection," *Harvard Business Review*, September 1996b

Marketing and Marketing Research

Albrecht, Terrance L., Gerianne M. Johnson, and Joseph B. Walther (1993), "Understanding Communication Processes in Focus Groups," in *Successful Focus Groups: Advancing the State of the Art*, David L. Morgan (ed.), Newbury Park, CA: Sage.

Bonoma, Thomas, "Major Sales: Who Really Does the Buying?," *Harvard Business Review*, May-June 1982

Fransson, Martha C. Gina C. O'Connor, Gary S. Lynn, Paschalina (Lilia) Ziamou, "The Extended E-Focus Group: A New Tool for Opinion Research", *Proceedings of the Conference on Telecommunications and Information Markets (COTIM97)* vol. 2, November 1997, ISBN 0-9659440-0-X, pp. 147-152

Johansson, Johny K. and Ikujiro Nonaka, "Marketing Research the Japanese Way", *Harvard Business Review*, May-June, 1987

Krueger, Richard A. (1994), *Focus Groups: A Practical Guide for Applied Research*. 2d ed., Thousand Oaks, CA: Sage

Merton, Robert K., Marjorie Fiske, and Patricia L. Kendall (1990), *The Focused Interview: A Manual of Problems and Procedures*, 2d edition, New York, NY: The Free Press

Sandberg, Kirsten D., "Focus on the Benefits: Focus groups are rarely used effectively, but their smart use can provide big payoffs", *Harvard Management Communication Letter*, Harvard Business School Publishing, Boston, MA, April, 2002

Stewart, David W. and Prem N. Shamdasani (1990), *Focus Groups: Theory and Practice*. Newbury Park, CA: SAGE

Wellner, Alison Stein, "The New Science of Focus Groups", *American Demographics*, March 2003

Product Development

Cooper, Robert G., *Winning at New Products, 3rd Edition*, (Perseus Publishing, 2001)

Chowdhury, Subir, *Design for Six Sigma: The Revolutionary Process for Achieving Extraordinary Profits*, (Dearborn Trade, 2002)

Takeuchi, Hirotaka, and Ikujiro Nonaka, "The New New Product Development Game", *Harvard Business Review*, Jan-Feb 1986

Tuominen, Kari, *Managing Change: Practical Strategies for Competitive Advantage* (American Supplier Institute, 2000)

Valle, Sandra and Lucia Avelle, "Cross-Functionality And Leadership Of The New Product Development Teams," *European Journal of Innovation Management*, January, 2003, Vol. 6 No 1, pp 32-47

Wheelright, Steven C. and Kim B. Clark, "Creating Project Plans to Focus Product Development", *Harvard Business Review*, March – April, 1992a

_____, *Revolutionizing New Product Development*, (Free Press, New York, NY, 1992b)

Quality Function Deployment

Akao, Yoji, editor, *Quality Functional Deployment: Integrating Customer Requirements into Product Design*, (Productivity Press, Norwalk, Connecticut, 1990)

Akao, Yoji, and Glenn H. Mazur, “The Leading Edge in QFD, Past, Present and Future”, *International Journal of Quality and Reliability Management*, Vol. 20, No. 1, 2003

Blondin, S., S. Cancellieri, D. Grace, and S. Maynard, “We Designed It With Our Ears”, (QFD Institute, *Proceedings of the 6th Symposium on QFD*, 1994)

Cohen, Lou, *Quality Function Deployment: How to Make QFD Work for You*, (Addison-Wesley, 1995)

Cristiano, John J., Jeffrey K. Liker, and Chelsea C. White, III, “Customer-Driven Product Development Through Quality Function Deployment in the U.S. and Japan”, *Journal of Product Innovation Management*, 17:286-308, 2000

Griffin, Abbie and John R. Hauser, “The Voice of the Customer”, *Marketing Science*, Vol. 12, Iss. 1 (Winter), 1993

Huang, G.Q. and K.L. Mak, “Synchronous Quality Function Deployment (QFD) Over the World-Wide Web”, *Computer and Industrial Engineering*, 42:425-431, 2002

Hauser, John R., “Quality Function Deployment” in *Marketing Encyclopedia*, Jeffrey Heilbron, Ed., American Marketing Association, Chicago, IL, 1995

_____, “How Puritan-Bennett Used the House of Quality,” *Sloan Management Review*, Vol. 44, No. 3, 1993

_____, and Don Clausing, “The House of Quality,” *Harvard Business Review*, May-June, 1988

Hunt, Robert A., and Fernando B. Xavier, “The Leading Edge in Strategic QFD”, *International Journal of Quality and Reliability Management*, Vol. 20, No. 1, 2003

Kawakita, Jiro, *KJ Method: a Scientific Approach to Problem Solving*, (Tokyo, Kawakita Research Institute, 1975)

O’Neal, Charles R. and William C. LaFief, “Marketing’s Lead Role in Total Quality”, *Industrial Marketing Management*, 21, 133-143, 1992

Terninko, John, *Step-by-Step QFD: Customer-Driven Product Design, Second Edition*, (St. Lucie Press, Boca Raton, Florida, 1997)

Yang, Kai and Basem El-Haik, *Design for Six Sigma: A Roadmap for Product Development*, (McGraw-Hill, 2003)

Wiremold

Dow Jones, “Legrand Acquires Wiremold”, *New York Times*, p. C4 (Col. Company News), July 18, 2000

Harr, Dan and Christopher Keating, “Wiremold Selling Itself to Grow; French Buyer Will Make Company a Global Player”, *Hartford Courant*, p. E1, July 18, 2000.
Dun & Bradstreet, Hoover’s

Harr, Dan, “Manufacturing Efficiencies Easier Said Than Done”, *Hartford Courant*, p. E1, Mar 8, 2002

LEX COLUMN: Schneider/Legrand, *The Financial Times*, January 16, 2001, p. 22.

The Wiremold Company’s web page: www.wiremold.com.

Womack, James P. and Daniel T. Jones, “A Harder Case” in *Lean Thinking*, Simon & Schuster, New York, 1996, pp 125 – 150.

TEACHING NOTE ENDNOTES

¹ Wiremold® is a registered trademark of The Wiremold Company.

² The Shingo Prize, awarded annually, is named after Mr. Shigeo Shingo, a consultant to Toyota. Among his contributions was the development of methods to reduce the amount of time needed to set up production equipment for any particular production run. Mr. Shingo’s contributions enabled a cash-short Toyota in post-World War II Japan to make frequent change-overs from one part number to another so as to avoid producing large amounts of parts inventory. Wiremold under Art Byrne essentially adopted and implemented the Toyota Production System in its entirety, except that it was called (initially) Just-in-Time (JIT) or (later) Lean.

³ This is confirmed by the statement, “Normally, discussions with customers identify 100-400 customer needs including basic needs (what the customer just assumes that a spirometer will do), articulated needs (what the customer will tell you that he, or she, or they want the spirometer to do), and excitement needs (those needs, which, if they were fulfilled would delight and surprise the customer). However, it is difficult for a team to work with 100-400 customers simultaneously. Hauser, 1995, pp. 304-305

⁴ The example given is that of a well-known consumer products company that sent a “team to watch a consumer do her laundry at home. When asked whether she had problems doing the laundry, she said no. But they observed as she used a screwdriver to open a new box of detergent and poked a stick into the wash so that the powder dissolved. When asked about these actions, she replied, “I didn’t think about them.”” Sandberg, p. 3

⁵ One of the authors had a very painful experience with a project of this type that ended up being abruptly terminated because the CEO did not agree with the market research results.

⁶ Shortening new product development times is very important. See Wheelright and Clark, 1992a.

Table TN-1 : Summary of Influencers in Wire Management Selection Decision

| | |
|---------------------------------------|---|
| Architects | Particularly for new construction, architects play a key role in the design of buildings and with the specification of systems supporting the building (HVAC, electrical, water, etc.). Key motivations are aesthetics and functionality. Architects may have specification authority or merely recommendation authority. |
| Building Engineers | Building engineers are responsible for making sure all building components meet safety and building code specifications. They will attest to the products' compliance with these regulations. Note that in many cases the architect may assume these responsibilities. |
| Interior designers | These people are primarily concerned with the esthetics of the Wiremold product; how does it fit in with the décor; is it obvious or does it blend into the background. Obviously esthetics are more of a concern in an office setting rather than an industrial setting. |
| Building owners | Building owners typically are concerned with achieving the lowest cost. This may be on the price of the materials alone, materials plus installation or total cost over some time period, such as five years. |
| Contractors | Contractors look for ease of installation (reflecting their cost to install the materials) or margin available (if they can markup the material cost when passing it on to the building owner) |
| Distributors | Distributors look at their margins (They may sell to the contractor or to the building owner.) as well as how well the supplier helps them with inventory (return policies, quickness of delivery, minimum order size, ability to drop ship directly to the job site, etc.) |
| Users (those who occupy the building) | Users are concerned with how well the system enhances their operation (maintenance and upgrading costs) as well as the esthetics of the installed system. They also are concerned with minimizing interruption of work when their wiring system requires upgrades. |

Source: Prepared by authors

Table TN-2 Comparison of VOC and QFD Processes for Raceway 4000 and Raceway 5500

| Derivative -- Raceway 4000 | Breakthrough -- Raceway 5500 |
|---|---|
| Develop questions and send mail survey to 100+ recipients | Develop questions (including ranking info) and conduct 100 telephone interviews (20 / team member). Data gathered by influencer segment |
| Analyze data using KJ | Analyze data using KJ |
| Second mail survey to all 90 respondents to gather ranking data | Visit 19 job sites, gather more data and analyze using KJ |
| Develop first phase First House | Prepare 3 First Houses by influencer segment |
| Phone calls to 20 customers re measurables to clarify (by team members) | Create conceptual designs and physical models |
| Visit 10 job sites | Return to the 19 job sites to show and discuss conceptual designs and physical models and gather data on reactions |
| Revise First House into 3 First Houses by product: raceway, installer tools, additional devices | Revise design (phase two design) using customer reactions |
| Build prototype of raceway design | Build prototype of phase two design |
| Build standard wall and compare to other products; measure installation times | Build standard wall and compare to other products on criteria of functionality, ease of installation, aesthetics. Develop specific performance metrics. |
| Design and build tooling Design and implement manufacturing cells | Design and build tooling Design and implement manufacturing cells |
| Marketplace Launch | Hold pre-launch party for VOC participants; obtain endorser |
| | Marketplace Launch |

Source: Prepared by authors

Table TN-3 Comparison of Characteristics of Focus Groups and KJ Methodology

| Characteristic | Traditional Focus Group | KJ Methodology |
|------------------------------|--|---|
| Speed for Data Analysis | Data transcription & interpretation time + report preparation time + report review with company personnel. 2 - 4 weeks | Meeting time for evaluators, copy statements onto sticky notes, sort on wall. 1/2 day |
| Costs | Fees for facility, participants, moderator, travel; analysis and report preparation costs | Mailing questionnaire + Employee time and travel for face-to-face visits |
| Moderator Influence | Strong | No moderator; questions developed by team members |
| Bandleader Influence | Can take over discussion | No bandleader |
| Nature of Data | Qualitative. Oral and visual; emotions; transcriptions; tapes | Qualitative. Actual words used by respondents. |
| Participant Anonymity | Low | High once words have been transcribed onto sticky notes. |
| Homogeneity of Group Members | Screening; limited contact with each other in daily life | High. All customers of company or influencers in buying decisions. May in fact know each other in daily life. |
| Stability of group | Contained and stable | Respondents opt in or out. |
| Skills of Members | Hands-on-experience may not be required. | Hands-on-experience in buying or using required. |

Source: Prepared by authors

Table TN-4 Productivity Comparison of Focus Groups and KJ Methodology

| Quality & Representativeness of Data | Traditional Focus Groups | Survey with Open-ended Questions and KJ Affinity |
|--|---|---|
| Novelty of Ideas | Desire 1 novel idea | Obtained as many novel ideas as respondents had |
| Clarity of Data | Strong due to interactions of moderator with participants | Exact words of many respondents allow major points to stand out |
| Group Synergy | Strong due to interactions of participants with one another | None |
| Diversity of competing responses for each issue | Desire 2 or more per issue | As many as respondents provide; no screens |
| Intensity: (# issues really important to participants) | Desire 1 or 2 | Measured by the levels of response; several issues may be important |
| Frequency of response: (# of ideas per participant for each issue) | Desire approx. 1 idea per participant for each issue | Most respondents will provide a statement for each question |
| Bandleader effects | Undesirable domination | Very weak; silence during the grouping phase prevents this |
| Inhibiting Effect of Group | Should be low | None possible; silence during the grouping phase prevents this effect |

Source: Prepared by authors

ADDITIONAL PEDAGOGICAL MATERIAL

The next three supplements contain additional pedagogical material that may be photocopied and distributed to students, depending on the instructor's teaching plan. Appendix A is a Note on the History of Lean Production. Appendix B is a Note on Focus Groups. Appendix C is an in-class exercise using the KJ Affinity method.

A Brief History of Lean Production¹

**Edward D. Arnheiter, PhD
Assistant Professor
Rensselaer Polytechnic Institute**

The origin of lean management can be traced to the Toyota production system (TPS); a manufacturing philosophy pioneered by the Japanese engineers Taiichi Ohno and Shigeo Shingo. The TPS is also the birthplace of just-in-time (JIT) production methods, a key element of lean production, and for this reason the Toyota production system remains a model of excellence for lean production advocates.

Just as the basic tools of total quality management (TQM) were developed and practiced at Western Electric in the 1920's, some of the principles of the TPS developed at Ford in the early part of the 20th century. In 1926 Henry Ford boasted, "Our finished inventory is all in transit. So is most of our raw material inventory." He also claimed that Ford could pull iron ore from a mine and produce a finished automobile in 81 hours². Ford's words convey the importance he placed on inventory reduction, short-cycle manufacturing, and, in general, the reduction of waste, all of which are basic aspects of the TPS. It is not surprising that Ohno greatly admired Ford and studied his accomplishments.

John Krafcik originally coined the phrase "lean manufacturing." Krafcik was a member of the research team for the book *The Machine that Changed the World: The Story of Lean Production*³. This book described the advantages that Toyota's manufacturing techniques had over traditional "batch-and-queue" production methods. High production volumes, large batch sizes, low product variation, and long product life characterize batch-and-queue production. Batch-and-queue techniques developed from economies of scale principles, which consider small batch sizes uneconomical because of the associated setup penalties. Batch-and-queue methods typically result in lower quality since defects are usually not discovered until subsequent operations or inspection of the finished product. Most manufacturing and service businesses today still operate batch-and-queue systems, even in Japan.

Key Elements of the Toyota Production System

Several aspects of the TPS have been misinterpreted. Despite the popular notion of "driving inventories to zero", the TPS is pragmatic and **does** allow for buffer inventories. Production line segments are buffered to ensure that a brief stop in one station does not immediately affect the next. To be sure, the inventory is kept small, but it is still of sufficient size to prevent major line shutdowns most of the time⁴. Another aim of the Toyota system is to reduce variability at every opportunity. These reductions include demand variability, manufacturing variability, and supplier variability. Variability reduction is today the focus of many quality efforts in light of the recent interest in "six-sigma" quality programs. The primary goal of lean production is to develop processes that are repeatable, reliable, and stable. Occasional process problems are expected, but they are considered valuable opportunities to learn and improve.

Basic Concepts in Lean Production

There are five main elements of lean production:⁵

- Value
- The Value Stream
- Flow
- Pull
- Perfection

Value implies determining what the end-user really wants or needs to see in the product or service. It is surprising how many companies never directly ask customers about their needs, likes, dislikes, problems, or complaints.

The **value stream** encompasses the entire set of activities required to bring a product from conception to detailed design, order taking and scheduling, production launch and physical transformation of raw materials, and finally to delivery into the hands of the customer. Within the value stream there are three types of activities that can consume human and material resources:

1. *Steps that unmistakably create value.* Examples of this would be spot welding a car frame together, or driving passengers from point A to point B.
2. *Steps that create no value but are unavoidable given the current technology and production equipment* (known as Type I muda). An example is the inspection of welds on an aircraft engine.
3. *Steps that create no value and are immediately avoidable* (known as Type II muda). An example would be the unnecessary double handling of an invoice by two clerks in an accounts payable department.

Flow is the general term for producing and moving parts in *small* batches, ideally using *single-piece flow* (i.e., move batch size = 1). Hybrid systems are common, consisting of single-piece-flow in some areas, and batch-and-queue practices in other areas. In wrench manufacturing, for example, steel forgings might move in a single-piece manner through a U-shaped machining cell, but then queue up at the end of the cell before moving to the chrome plating station. In fact, very few manufacturers can claim a pure single-piece-flow system throughout their entire operation.

The term **pull** implies not making anything until it is needed by the downstream customer, and utilizing a make-to-order (MTO) approach whenever possible. Pull techniques were pioneered by Toyota using their just-in-time (JIT) production methods. This is a very common technique used in the personal computer business. Dell, for example, uses their “direct sales model” to convert telephone orders from customers into finished personal computers ready for shipment in about four hours. The initial “pull” in this case is the telephone or electronic order from the customer. This method also allows Dell to customize each unit to the customer's specifications.

The complete elimination of wasteful practices, so that all activities along a value stream create value is known as **perfection**. Efforts focused on waste reduction are often pursued through continuous improvement or *kaizen* events, as well as radical improvement activities, or *kaikaku*.

Flexibility and Its Relationship to Lean Production

Flexibility is an important element of manufacturing strategy and is a key concept within lean production. The following example illustrates the importance of developing flexible production systems.

During the 1980's GM was touting its "reindustrialization" strategy. The plan called for spending approximately \$80 billion worldwide to update and automate GM assembly plants, gradually transforming them into automation showplaces, loaded with sophisticated robots and other automated equipment. GM felt it could significantly reduce direct labor costs associated with vehicle manufacturing by using technology, essentially outspending and thereby leapfrogging the competition. GM, however, ignored flexibility, one of the most important elements of the TPS. In fact, most GM plants were designed and built to produce just one model, year-after-year! GM arrogantly assumed *it* could drive consumer demand. When consumer tastes changed, GM could not adjust quickly or easily to the demand for new styles and models.

A GM assembly plant in Fairfax, Kansas fell victim to reindustrialization. Fairfax was completely renovated in 1987 as a highly automated factory, containing over 200 different robots. Unfortunately, it was designed to assemble only the Pontiac Grand Prix, and was not flexible enough to build any other GM models (although the plant has since added the Oldsmobile Intrigue to its model mix). The original design capacity of the plant was 250,000 units, but it spent many years producing only 100,000 units because GM could not sell enough cars to keep the plant fully loaded⁶. Toyota plants, on the other hand, are extremely flexible and each assembly plant can build at least three different models or platforms. If one model is not selling well, it is then a simple matter to shift production to a better selling model. Toyota's Georgetown Kentucky plant is an example of this flexible approach to manufacturing. The plant is able to produce the Toyota Camry sedan, the Sienna Minivan, and the Avalon sedan.

Glossary of Lean Terminology

Brownfield - An older, existing production facility that uses mass-production methods and a traditional organizational structure.

Chaku-Chaku – A method of production to achieve a *single-piece flow* of parts, typically by arranging machines in a U-shaped cellular layout. The cell operator unloads the machine, replacing the workpiece with a part from the adjacent upstream machine. The removed workpiece is then loaded into the adjacent downstream machine, after unloading its workpiece. This swapping of parts (by unloading and loading) continues until all of the parts in the cell have been moved downstream by one machine. The operator then moves back to the first machine and repeats the routine until all parts in the lot have moved through all of the machines in the cell. The term literally means "load-load" in Japanese.

Greenfield – A new manufacturing facility where it is possible to implement lean methods from the very beginning of production.

Heijunka – The manufacture of products using a level or uniform schedule so that during any given day, a wide variety of product models are produced. The goal is for production to mirror how the products are actually being purchased and consumed in the marketplace.

Jidoka (also called autonomation) – The development of automated machines that can halt production immediately when a nonconforming part is detected. This is accomplished with mistake-proofing or *poka-yoke* principles. Ideally, a machine with true process control would not be capable of making bad parts. It is more common, however, to first develop sensing capability within a process to know when a defective item has been made and then shut down the machine (detection during process). The simplest level of mistake-proofing would be to detect defective parts after they have been produced, and then automatically sort the good from the bad.

Just-in-Time (JIT) – This term is sometimes used synonymously with lean production, because it seeks to eliminate waste in all areas of a firm's production activities, but this interpretation is related more to what is often called "Big JIT". The classic pull system, where production at one level is initiated from a request of a higher level is usually referred to as "Little JIT". Little JIT focuses on scheduling goods inventories and providing service resources when and where needed. It works best when the production rate at final assembly is fairly uniform. But it can still typically incorporate only 60% to 70% of all parts and subassemblies regularly used in large-volume products. Big units or complex subassemblies often need to be scheduled separately under routine planning and control procedures.

Kaikaku- The radical improvement of an activity to eliminate muda. Moving or eliminating machines to facilitate better material handling and faster throughput would be an example of kaikaku. In contrast, improving a work area by developing a new quick-change fixture, and organizing the area and its tools are often the types of actions performed during traditional kaizen activities. Both initiatives in this example reduce waste, although the term kaikaku is generally reserved for the initial rethinking of a process.

Kaizen – The Japanese term for continuous incremental improvement involving everyone. In 1986, Masaaki Imai wrote *Kaizen - The Key to Japan's Competitive Success*,⁷ which became very popular with U.S. management. Kaizen is one of the most commonly used words in Japan, and means continuous improvement in ones personal life, home life, social life, and working life. Imai studied many management philosophies, theories, and tools used successfully in Japan, and organized them under a single and readily understandable common framework. Kaizen implies achieving continuous, gradual, incremental improvements, but it is more common today to use a "kaizen blitz" approach, achieving rapid change within an area by focusing significant human resources on a process for a short period of time, typically one week.

Standard work – Details the motion of the operator and the sequence of material movement through the cell. Components include the cycle time, takt time, work sequence, and the minimum needed inventory of parts on hand (standard work-in-process).

Takt Time - A calculated value representing the allowed production time for each unit, so that the pace of production matches the rate of customer demand. Takt time is equal to the available production time per day divided by the number of orders placed by customers each day.

Total Productive Maintenance (TPM): Improving the overall effectiveness of process equipment by actively involving the operators. TPM is accomplished by performing regular cleaning, daily walkarounds, and preventive maintenance.

Visual Control – The placing of tools, parts, production tasks, and indicators of system performance so anyone can walk into a workplace and visually understand its current status. Factors such as workplace organization, the work process, the schedule condition, and any abnormalities should be obvious to the observer. Overhead display boards containing a series of colored lights are often used, referred to as *andons* by the Japanese. Toyota refers to visual control as *transparency*.

Endnotes

¹ Previously unpublished. Used with permission.

² Hopp, Wallace J., and Mark L. Spearman, *Factory Physics*, 2nd Edition, New York: Irwin McGraw-Hill, 2001, p. 25.

³ Ironically, John Krafcik is not well known because he was not one of the three authors of the *Machine that Changed the World*. In 1996, two of the author's, James Womack and Daniel Jones, subsequently wrote an enormously popular sequel entitled *Lean Thinking*.

⁴ Mishina, K., and K. Takeda, *Toyota Motor Manufacturing, U.S.A., Inc.*, Case Study Teaching Note 5-693-046. Harvard Business School, 1993, p. 3-5.

⁵ Womack, James P., and Daniel T. Jones. *Lean Thinking*. New York: Simon & Schuster, 1996, p. 15-28.

⁶ Based on Jim Harbour's comments to host Hedrick Smith in the video series "*Challenge to America: Old Ways, New Game*", Films for the Humanities and Sciences, Princeton, NJ, ©1994.

⁷ Imai, Masaaki, *Kaizen: The Key to Japan's Competitive Success*, McGraw-Hill/Irwin, 1986.

Appendix B

A Note on Focus Groups*

Focus groups are the predominant form of qualitative research in marketing (Krueger 1994). They offer distinct advantages over other methods of data collection when a rich stream of data stemming from the interaction of persons in a flexible, relaxed setting is desired (Albrecht, Johnson and Walther 1993). Focus groups facilitate the disclosure of deeply ingrained and personal opinions, often strongly-held, which are the product of personal thought and reflection (Merton, Fiske and Kendall 1990). Many persons find it easier to discuss deeply held opinions in a group of peers (Krueger 1994) while others are inhibited from expressing their true feelings, attitudes, or experiences (Albrecht, Johnson and Walther 1993; Stewart and Shamdasani 1990).

The group interview which characterizes the traditional live focus group provides data quickly, usually in the space of two hours, can be held in a variety of settings with persons who meet a specified list of criteria, and produces results which are easy for the lay person to understand (Albrecht, Johnson and Walther 1993; Stewart and Shamdasani 1990). The ideal focus group would be a discussion among equals; in practice, however, a moderator is necessary to present discussion questions arranged in a logical sequence to the members of the group (Krueger 1994). The active involvement of the moderator can create both opportunities and problems for data collection and analysis.

By creating a strong context, the moderator can probe for depth and clarification of what participants say, and can allow participants to react to and build upon each others' ideas (Stewart and Shamdasani 1990). When the context weakens, however, bandleader effects can spring up to limit the usefulness of or distort the data collected from the group. Specifically, a dominant personality can take the discussion into emotionally charged territory or a person whose perceived status is higher than that of others may unintentionally inhibit the openness of the discussion (Krueger 1994; Merton, Fiske and Kendall 1990). A so-called "devil's advocate" may interrupt the continuity of the discussion and a valuable train of thought may be lost (Albrecht, Johnson and Walther 1993; Stewart and Shamdasani 1990).

The rich stream of data collected from a traditional "live" focus group includes both the oral statements made by participants, their inflections, and their non-verbal expressions of opinion, all of which may be difficult to summarize and generalize (Stewart and Shamdasani 1990). The moderator must also be alert to analyze the cues about desired responses that he or she knowingly or unknowingly provided because these may have biased the results (Albrecht, Johnson and Walther 1993; Stewart and Shamdasani 1990).

* Excerpted from Fransson, O'Connor, Lynn, and Ziamou (1997)

Appendix C

KJ Affinity Example *

A group of trainers has been asked to describe their wants for flip charts for use in their training programs. Here are their exact quotes:

| | |
|---|---|
| A. No bleed-through | M. Nondamaging to surfaces |
| B. Common markers work | N. Sheets removed with no detectable adhesive transfer |
| C. Smear Free | O. Sheets flip |
| D. All surfaces writable | P. Sheet can be removed and posted after previous sheet flipped |
| E. Portable | Q. Clean edges when torn off |
| F. Fits standard easels | R. Opaque sheet |
| G. Large enough to see printing in most meeting rooms | S. White or off-white |
| H. Free standing | T. I can move it |
| I. Stays up five days | U. Stays up a long time |
| J. Sticks to coated walls | V. Works on my walls |
| K. Sheets remove cleanly with minimum effort | W. Legible writing medium |
| L. Repositionable four times with no change in properties | |

First separate compound statements into single attributes:

G is really two requirements: G1 Large enough and G2 Writing stands out

K is really two requirements: K1 Sheets remove cleanly and K2 Easy removal from pad

Next, convert negative statements to positive attributes:

A. No bleed through = Clean next page

M. Nondamaging to surfaces = Removes cleanly from surface

Then, change specification to general requirements:

I. Stays up five days = stays up a long time

J. Sticks on coated wall = Stays on wall

L. Repositionable four times with no change in properties = Can be moved many times

S. White or off-white = G2 writing stands out

R. Opaque sheet = R1. Hides second sheet and R2. Hides surface

The initial groupings are shown on the next page:

KJ Affinity Diagram: Initial Groupings

C. Smear-free
B. Common markers work
A. Clean second page
G2. Writing stands out
W. Legible writing medium

D. All surfaces writable
G1. Large enough

E. Portable
F. Fits standard easels
H. Freestanding

O. Sheet flips on pad
P. Any sheet can be removed
K2. Easy removal from pad

R1. Hides second sheet
R2. Hides surface

J. Stays on wall
L. Can be moved many times
N. Comes off easily

Following the development of these groups, the team developed names or labels for each group. In one case they chose one of the VOC terms to describe the entire group; in others they created new group names. This is shown on the next page.

KJ Affinity Diagram: With Groups labeled

Legible writing medium

C. Smear-free
B. Common markers work
A. Clean second page
G2. Writing stands out

Usable in many different spaces

D. All surfaces writable
G1. Large enough

Many ways to stand

E. Portable
F. Fits standard easels
H. Freestanding

Free of subsurface information

R1. Hides second sheet
R2. Hides surface

Independent sheet manipulation

O. Sheet flips on pad
P. Any sheet can be removed
K2. Easy removal from pad

Rapid sheet positioning On/Off wall

J. Stays on wall
L. Can be moved many times
N. Comes off easily

Finally look for missing groups. In this example there is no group concerned with packaging so the team developed their own based on prior knowledge of product use.

Convenient packaging

Protects pads
Opens easily
Pad can be packaged

KJ Affinity method

Customer wants input for QFD House of quality

Legible writing medium

Many ways to stand

Independent sheet manipulation

Rapid sheet positioning on/off wall

Usable in many different spaces

Free of subsurface information

Convenient packaging

The instructor may want to use this example as a class exercise. Original VOC quotes should be placed on Post-it-Notes and given to the students. They progress through the exercise by first placing the notes on the board and follow the example contained in this Appendix. Different groups of students will come up with different groups and group labels, but after discussion a consensus is usually reached that is similar to the final set contained in this Appendix.

Endnotes

* Terninko, John, Step-by-Step QFD: Customer-Driven Product Design, 2nd ed., (St. Lucie Press, Boca Raton, Florida, 1997) Used with permission.