

PRODUCT DISSECTION - A Tool for Benchmarking in the Process of Teaching Design

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Abstract

Product dissection and benchmarking are processes commonly employed in industry to improve product design, produce superior performance and product quality. The process, when applied in an undergraduate academic setting, can improve the process of teaching design. It has been applied to teach undergraduate mechanical engineering students at the Junior level. The students, working in teams, conducted a market study of hand held kitchen mixers, selected an appropriate sample of product units and carried out the benchmarking study by dissecting each unit. A design data base, with customer expectations as the reference variable was assembled and the 'best in class' established for both a single product and each customer expectation. A re-design exercises was carried out on a 'mid-performing' product units to bring them to 'best in class' or exceed it.

Introduction

The Manufacturing Engineering Educational Partnership [1], MEEP, has developed alternative approaches to the teaching and practice in design education. The objective was to provide students with an enhanced combination of analytical skills and hands-on experience in the design process [2]. A new course, Product Dissection [3], has now become part of a curriculum in Products Realization at MEEP schools. In this new course the students are exposed to a variety of products including disposable cameras, electric drills, internal combustion (lawn mower) engines, bicycles, and telephones. The product dissection process is a logical lead-in to the use of benchmarking in the teaching of Product Design. At the University of Washington we have piloted this process in a Junior level course (ME 395 Introduction to Product Design). Our objective was to give students a more realistic exposure to the process of product design.

The Design Process and Product Dissection

The design process is the procedure whereby the designer, starting with customer or market expectations, develops a product or a process to meet a specific demand. To

describe this process, as shown in figure 1, current textbooks focus primarily on the creation of design concepts [4], the development and analysis of detailed designs [5], material selection and, somewhat less rigorously, on the manufacturing and testing of the finished product.

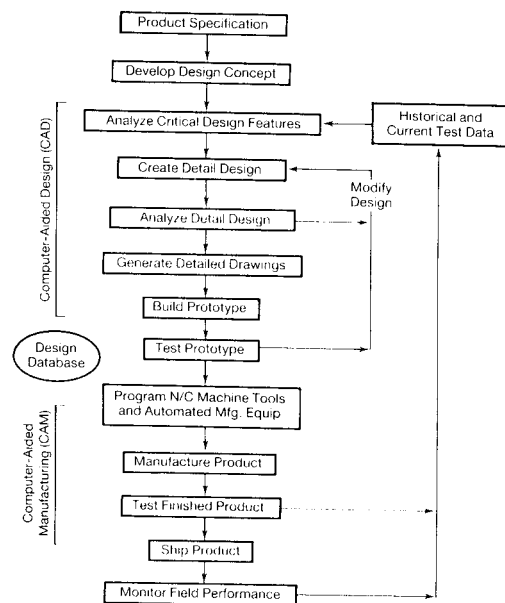


Figure 1 The Design Process (Dieter, ref. 4)

The practical, but equally important issues of product specification, analysis of critical design features, historical and/or current test data and the creation of a data base for the design process are still alien to the students.

In dissecting any given product we examine how the device works, the relationship between the parts and components and the functional and operational requirements of the product. Critical design features and the detailed implementation of the design concept to meet the product specifications can be observed and cataloged. Furthermore, the manufacturing and assembly processes employed can be inferred. Therefore, we can compliment current text books by appropriately 'closing the loop' on the design process and assemble a design knowledge data base about the product.

The Benchmarking Process

In industry, benchmarking is an accepted technique used to identify the strengths and weaknesses of a wide range of processes, procedures, and operations associated with the company business. Areas of concern ranges from customer satisfaction, product design and manufacturing, and business operations such as order entry, billing, or repair services. Benchmarking [6] typically searches for the best practices, thus leading to superior performance. The typical steps in the process are shown in figure 2.

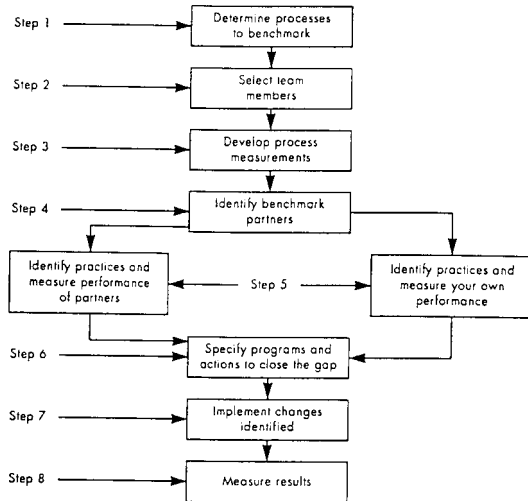


Figure 2 Benchmarking Process (from ref. 6)

Benchmarking in a University Setting

Purpose and Objective: The purpose is to emulate industry's product design process by having students, working in teams, examine, test, and re-design an industrial product to meet market demand for product superiority. The educational objective is to provide a natural setting for implementation of the design process that they will experience in industry.

Working on a real product allows the student team to discover and confront issues that the original product designers had to confront, thus instilling knowledge and experience not provided through text books.

Student Background: Prior to starting the benchmarking activities the students had completed a simple design exercise (a bird feeder), a product dissection (electric drills), and been exposed to industrial design, design for manufacturing and assembly, economic analysis, patents, and project planning. These topics were discussed in lectures, and exercises led by faculty and engineers from industry participating in our program.

Benchmarking Hand Held Mixers.

(Reference to figure 2)

Step #1 Determine the Product: The hand held mixer was selected as a logical extension of the electric drill dissection exercise. The students could use the same procedure and would be familiar with the basic product components. A one hour lecture on the benchmarking process was prepared and a handout (see reference 6) was used as the 'text' material.

Step #2 Team Selection: The course instructors selected the members for each team based on an initial questionnaire of student interests, skills, and their performance in the course. Our objective was to establish a set of equally competent teams. We had five teams, with six students per team, during the Winter Quarter 1996.

Step #3 Develop Process Measurements: We provided the students a copy of Consumers Report [7] as an example of consumer expectations, design features deemed appropriate, and testing methods used to verify product performance. Each team was requested to contemplate, act on, or study:

1. Generate a list (as many as you can think of) of features and functions that could possibly be important to the total success of a home kitchen hand mixer.
2. What factors most account for hand mixer user satisfaction? Are there other customers? What factors most account for their satisfaction?
3. What are the major costs (or cost drivers) of hand mixers?
4. Which functions in hand mixers represent the highest fraction of the cost?
5. Which functions have the greatest room for improvement?
6. Which functions have the greatest effect or potential effect for differentiating a hand mixer from other hand mixers?
8. What five factors do you believe will have the greatest impact on the success of hand mixers in the marketplace.
9. How could the five factors be evaluated? What metrics could we use?
10. Identify as many hand mixers (real ones) as you can. Evaluate them (to the extent possible without disassembly) in light of the above.
11. Which hand mixers appear to be leaders in each of the factors or features?

Step #4 Identify Benchmark Partners: Student teams conducted a market survey, from the least expensive to the most expensive models, based on item 4 in step #3 above.

From their suggestions we purchased 12 units, of varying prices for dissection.

Step #5 Identify Practices & Measure Performance:

Each team was assigned two mixers to dissect, one from the lower and one from the higher half of the price range. The teams made careful records in their design journals on all features, uniqueness of design, manufacturing or other aspects that they observed during the dissection exercise. Each team prepared a summary report on each unit dissected. The summaries were collected, and combined to form a 'design database' of the benchmarking process. The database was made available to all of the teams. Table 1 represents an example summary report of customer expectations for three sample units.

Step #6 Programs & Actions to Close the Gap: This was a critical step in the exercise. Since the data base was produced from five groups working independently, we needed to merge the data into a single data base of common customer expectations (CE's). The class was re-grouped into five new teams for this step of the process. Each team had one member from the original dissection team each bringing their two dissections to the new team. The order of progress were as follows.

- 1) Decide on a common set of customer expectations, limited to ten (10 CE's),
- 2) With the common set of CE's re- organize the data base,
- 3) Rate all mixers in the rating of 5 (Best) to 1 (worst) in each customer expectation, and finally
- 4) Determine the 'best in class' mixer (based on the highest number by adding all ratings).

Agreement on steps (1) and (3) was a challenge for a class of 30 students. Once step (1) was completed the database, as shown in Table 1, was merged to a common format and the 'best-in-class' features and unit could then be determined.

Product Re-design

Step #7 Implement Changes Identified: The original teams were now requested to pick one unit in the lower or middle rating (rating 1 through 3), assumed the role of employees of the company with the charge of bringing their product 'up to and exceeding the 'best in class' '. Because of time constraints the were asked to only consider 5 out of the 10 CE's. They produced a new set of functional requirements (FR's), design constraints (C's), and design parameters (DP's) to meet the new customer expectations (CE's). Using the design process (figure 1) as guide, new concepts were generated, analyzed and evaluated, agreement reached on final design concept, and a simple prototype of the product (or part) produced. In the 10 week quarter they had slightly less than three weeks for the entire exercise.

Step #8 Measure Results: In the absence of a final working prototype product to test we requested the student teams to provide a report in the form of a proposal to 'upper management' requesting a 'go-ahead' for the new product concept. They were required to present their new design with support from the benchmarking process as well as analysis, experiments, or simple prototyping of 'critical' elements of the design.

Results:

- 1) Students quickly zeroed in on the 'market appeal' aspects through novel ideas for 'good looking' and attractive units (our industrial design 'guru' describes this as customers 'first read'). One group provided a complete prototype to visually demonstrate all features of their device, including new, re-designed, attachments.
- 2) The ergonomic issues (the customer's 'second read') of the feel and grip of the unit depended on the size of the user's hand (which is gender related). Next, came the location and the easy and comfort in accessing the controls, and tip-over stability. They were address by all groups in rational combinations of experimental and analytical techniques.
- 3) Good use of technical resources for analysis and data gathering on performance of motors, speed controls, and drive units. One group made extensive use of the world wide web for access to detailed design information.
- 4) Team spirit grew with the use of the product dissection exercises and the subsequent team decision processes where they had to negotiate for a uniform design database.
- 5) Report presentations, both written and oral were of high quality and employed prototypes, pictures from product literature and hand drawn sketches.
- 6) The students were frustrated by their/our lack of knowledge of the 'culture' of the companies manufacturing these hand mixers.

Conclusions :

The combination of product dissection and benchmarking process is highly effective for teaching students about product design at the conceptual, implementation, and detailed design stages. They clearly grasped the complexity of a modern product but at the same time quickly realized that much of what they had learned in the previous 2.5 to 3 years of study was applicable to the design process and required analysis.

Recommendations

- 1) Start the benchmarking process early. Immediately after the product dissection exercise the student teams should start the market study.
- 2) Better integration of course text material (design process, patents, economics etc.) with the redesign effort would be beneficial. This would be excellent application of JIT in education.
- 3) Contacts in the companies making the original products would be helpful in developing knowledge of the specific company's 'design culture' and their manufacturing strategies.

References:

1. Manufacturing Engineering Education Partnership is a collaboration of Penn State University, the University of Puerto Rico-Mayagüez, the University of Washington and Sandia National Laboratories @ Albuquerque
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2. Lamancusa, J. S., J. E. Jorgensen, J. L. Castro and J. Ratner, "THE LEARNING FACTORY, - A new approach to integrating design and manufacturing into engineering curricula", Proc. 1995 ASEE Annual Meeting, Anaheim, CA.
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4. Dieter, George E, Engineering Design: a materials and processing approach, . , McGraw Hill, 2nd ed., 1991
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- 7 'Portable Mixers with A Difference'. Consumer Report, July 1991

Table 1 Summary of Benchmarking Process

MANUFACTURER	BRAUN MULTIMIX	SUNBEAM	EVERYDAY LIVING
MODEL	M870	MODEL # 2485	EL-HM 5/035
FEATURES	rating (1= poor, 5= excel.)	rating (1= poor, 5= excel.)	rating (1= poor, 5= excel.)
Aesthetics	rounded edges, sealed, continuity in design (5)	looks good (5)	plain looking w/square edges (2)
Balance (while in use)	Particularly front heavy	Good	Slightly front heavy
Beaters	Two and interchangeable	Two, non-interchangeable	Two, non-interchangeable
Cleaning	rounded edges, sealed, no vent (5)	easy to clean (2)	
Control Location	front, easy to adjust (4)		
Cord Location	back w/ swivel mount (5)	excellent, centered in back (5)	on side so it gets in the way (1)
Cord Storage			
Cost	\$55.99, good considering attachments (4)	\$ 19.99 (5)	\$8.99 (5)
Ease Of Control			bad, sideways switching speeds (3)
Eject ability	easy to press, beaters eject easily as well (4)	bad beater eject (4)	easy to eject with thumb (3)
Handle (ergonomics)	good, wide handle, OK for SM/LG hands (4)	(+) big hands, (-) small hands (4)	for male-too small (2),female-appropriate (4)
Manufacturing (Ease Of Assembly)	Moderate in part complexity	Problems with switch assembly	Had difficult parts to assemble
Noise	low, comp. to other models (5)	reasonably quiet (4)	quiet fan (4)
Operating Time	limited (10 minute intervals), no vents (1)	No limit as fan venting	No limit as fan venting
Power	220 Watts, vertical power system (5)	200 Watts, very good (5)	100 Watts
Quality	Excellent in appearance (5)	Nice in appearance (4)	Lacking in appearance (2)
Safety	power on-eject button disengages (5)		
Speed Control	Continuous (5)		
Tip over Stability	yes; wide, non-skid base (5)	fairly good (4)	unstable, w/o any supports (2)
Variable Speed	3 speeds (5)	6 speeds, very good (5)	5 speeds
Versatility, Attachments	hand blender w/container (4)	no extra attachments (4)	attachments hard to work

Weight	Medium	a little heavy (3)	extremely light weight (4)
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