Chapter 2
Fundamentals of Continuous Improvement

Answers to Questions

1. *Change* is essential for business organizations because survival depends on how well an organization can adapt to the changing demands and requirements imposed by customers and competitors. Organizations must continuously improve their products and services to meet or exceed customer expectations, and improve their processes to meet or exceed the cost, quality, and delivery speed of competitors.

2. *Incremental improvement* is represented by an S-shaped curve, while innovation improvement is represented by the jump from one S-curve to another, higher-level curve. Incremental improvement is based on the concept of kaizen**,** that is, of small incremental improvement steps. In contrast, *innovation improvement* happens when one technology is replaced by a different technology that is not subject to the same physical, technological, or organizational constraints as the original technology. The new technology represents a quantum leap beyond the old technology.

3. The concept of the *S-curve* represents continuous improvement through small, incremental steps. When a process or technology is new, incremental improvement is at first slow and much effort is required to make small gains. As more knowledge about the technology is gained, less effort is required to achieve big improvements. Over the long term the accumulated series of gains may result in significant improvement. Eventually, however, as the technology or process approaches its technological or physical limits, further improvement becomes difficult and costly.

*4. An example mentioned in the chapter kaizen leading to competitive advantage is LCD technology at RCA and Sharp. RCA developed the technology, but did not bother to refine it. After RCA sold its LCD patents, Sharp initially devoted $200 million to development LCD technology for application in hand-held calculators. It then invested another $1 billion to refine the technology. Today this technology is everywhere, in watches, industrial gauges, clocks, portable TVS, computers and automobile dashboards.

Similarly, process technologies have been improved through kaizen at all major automobile manufacturers. Toyota improved and is still improving its production system in such a manner that today its cost and time to produce cars are the lowest in the industry. Toyota made the first significant improvements to shop-floor systems, and other auto makers were forced to play catch up.

Other examples of kaizen to improve or upgrade existing systems include:

- Replacing hand soldering of circuit board with wave soldering (soldering using a wave of molten solder).
- Replacing rotary telephones with push button telephones.

- Replacing manual film advance, focusing, and aperture setting in hand-held cameras with automatic advance, focusing, and exposure.
- Replacing manual transmissions in automobiles with automatic transmissions (most motor-assisted features in cars are kaizen improvements of earlier manual features—window and door lock mechanisms, seat and rear-view mirror adjustments, etc.).
- Improving automobile engines so they require a tune-up only once every 100,000 miles (instead of every 12,000 miles).
- Improving PC microprocessors so they are ever smaller and faster.
- Replacing metal components in products with plastic components that do not rust or dent (while this application represents incremental improvement, often the process of creating and incorporating these components into existing systems requires genuine innovation improvement).

*5. One example of innovation improvement in product technology mentioned in the chapter is development of jet engine technology, which subsequently became the dominant propulsion technology in military and commercial aircraft—largely replacing propeller technology.

Other examples of new technology that eclipsed old technology are:
- The backward-first Flopsbury flop replaced the sidelong technique of high jumping.
- Steam technology replaced wind technology in transoceanic shipping.
- The iron horse replaced the stage coach as the primary mode of intercontinental transportation.
- The telegraph replaced the Pony Express.
- Laser-jet technology replaced dot matrix technology in computer printers.
- Steel superstructure construction replaced traditional load-bearing walls in construction of high-rise buildings.
- Magnetic cards replaced traditional keys for door locks in hotel rooms.
- Digital camera replaced film cameras.
- Word processors replaced typewriters.
- Stealth technology replaced electronic jamming of radar (in one sense, stealth is an incremental improvement in aircraft and ship design, yet in another sense, it is a true innovation because it largely renders conventional radar technology useless).
- Tapes replaced records.
- CDs replaced tapes.
- MP3s replaced CDs.
- Disposable diapers replaced cloth diapers.
- Electronic systems that replaced mechanical systems (examples: cash registers and control systems)
- Electronic photocopying replaced carbon paper and the ditto machines.
- Nautilus equipment replaced free weights and pulleys.

6. The theory behind frontline worker participation in continuous improvement is that workers are sometimes in the best position to notice places needing improvement and to originate

improvement ideas. They are also often able to implement improvements more quickly and efficiently than if specialists were involved. For ideas that are more technologically complex and costly to implement, workers are encouraged to prepare proposals and seek assistance from specialists. Often, however, workers implement improvements themselves without assistance or approval from managers.

7. The PDCA cycle is a structured way to apply the process of perceiving and thinking about problems and solution. It is characterized by four steps, which, in terms of continuous improvement, should be thought of as steps in a continuous cycle that has no start or finish. The four steps are the **plan step**, the **do step**, the **check step**, and the **act step**.

- The *plan* step includes the four substeps of collecting data, defining the problem, stating the goal, and solving the problem.
- The *do* step is the implementation of the plan.
- The *check* step involves collection and analysis of data about the effects of the implemented plan.
- The *act* step represents follow-up actions based upon results from the check step.

8. Toyota employees are conditioned to ask why five times whenever confronted with a problem. This procedure assures that the root causes of a problem are identified and corrected, not merely the symptoms or superficial causes.

9. Value analysis and value engineering are techniques for assessing the value content of the elements of a product or a process. Value is based on the perception of the customer; it is the worth of something and how much customers are willing to pay for it. *Value analysis* refers to analysis of existing processes and it is a tool of continuous improvement. *Value engineering* refers to the first-time design and engineering of a product or process.

10. *Reengineering* refers to the rethinking and redesigning of business processes in order to achieve improvements in cost, quality, service and speed. Reengineering is best represented as innovation improvements, or the leap from one S-curve to another. It is a planned change to achieve innovation improvement and is the counterpart to kaizen.

11. A kaizen event focuses on a particular process, its problems and wastes. The event is conducted by a team facilitated by an expert (person experienced in lean production and team facilitation), led by the process owner (supervisor or manager who oversees the process), and include people who work in and are knowledgeable about the process. In addition to attacking problems and wastes in the process, a purpose of the event is to demonstrate and teach lean principles and methods. The event begins with a kick-off meeting, starting with a presentation about the focus and scope of the project, and a review of lean concepts and analysis methodology. The kaizen team sets measurable targets and decides on the data it needs to analyze the process. After a tour of the physical facility of the process, the team discusses its findings and creates a map out the process. Over the next few days, the team collects more data and meets several

more meetings, during which it create a more authentic, detailed map of the process. It identified areas of waste on the map, developed improvement plans, and set about immediately to begin implementing the changes.

12. The seven problem solving tools include the check sheet, histogram, Pareto analysis, scatter diagram, process flowchart, cause-and-effect analysis and the run diagram.

- The *check sheet* is a special sheet created for recording data from observations.
- The *histogram* is a graphical method for showing the frequency distribution (number of occurrences) of a variable.
- *Pareto analysis* is a tool for separating the vital few problems from the trivial many problems.
- A *scatter diagram* is a tool for revealing the potential relationship between two variables.
- A *process flowchart* shows the relevant steps in a procedure or process, and the role they play in the process.
- *Cause-and-effect analysis* is a method for listing possible causes (sources) of a given effect (problem).
- A *run diagram* is a continuous plot of results versus time for the purpose of revealing abnormalities or patterns.

13. Value stream mapping (VSM) is a flowcharting methodology that uses standard icons and diagramming principles to visually display the steps in the process and the material and information flowing through it, start to finish. The methodology focuses on the value stream, which is the sequence of all activities, both value-added and nonvalue-added, in the creation of a particular product or service. VSM starts with data collection and creating a map for the current process. That map, the current state map, is used to stimulate conjecture about opportunities for improvement and how the process *ought* to look, and to create an ideal or future state map.

14. After a problem solver has prepared a plan, he seeks consensus from everyone involved with or affected by the plan to help ensure that not only have the necessary perspectives been considered, but that the plan can be readily implemented. For example, senior-level managers pass a plan or goal to the managers below them, who translate it into a plan at their level, which they toss back to the managers above them and ask “is this what you intended?” Then senior managers modify their goal or plan to accommodate the subordinates’ plans. The process goes back and forth until both sides reach consensus. Next, the middle managers toss their plans to lower level managers, and the process repeats.
Nemawashi refers to the process of circulating a plan or proposal among affected parties to gain consensus or approval. The proposal is passed back and forth among parties and modified to incorporate their suggestions and opinions. The final formal approval is then merely a formality because consensus will have been achieved and approval tacitly conveyed.

15. A3 is the designation for a standard 11” x 17” sheet of paper commonly used in Japan. The format for every A3 is somewhat standardized, with topics listed in logical order. The

typical A3 report includes data charts, value stream maps, and fishbone and Pareto diagrams, and so on.

A3 reports can be used in a variety of ways, the three most common being for problem-solving, presenting a proposal, and describing the status of a plan, problem, or issue. Each of these kinds of reports corresponds to different steps of the PDCA cycle:

- A problem-solving A3 is written after the Plan, Do, and Check steps are completed (although it must be *started* much earlier).
- A proposal A3 is written during the Plan step but before starting the Do step.
- A status A3 is written during and after completing the Check and Act steps.

Solutions to Problems

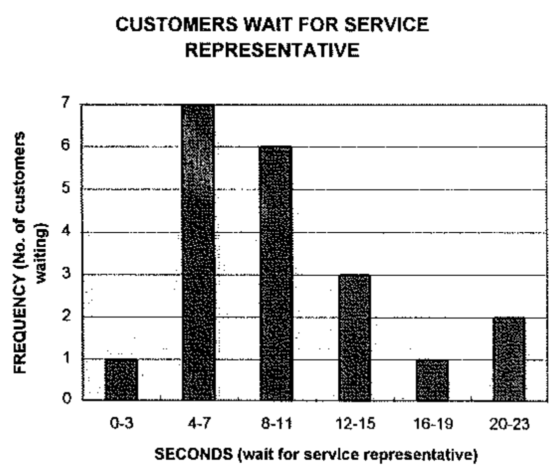
*1. The answer to this problem is somewhat open-ended. The purpose of the problem is to stimulate discussion.

One obvious question the listing of the costs raises, is, why are the overhead and administrative costs so high? To achieve big savings, a good place to begin is with the sources of the biggest costs. In the past, sources of costs associated with high overhead were ignored in cost reduction efforts, though now more companies are starting to seriously look at them. In fact, the thrust of many process reengineering programs is to improve the effectiveness and reduce costs of activities commonly labeled as overhead. Since material is the other major cost factor listed, cost reduction efforts should focus there too.

Although productivity efforts commonly focus on the shop floor and on direct labor, in the case shown even substantial cost savings in labor and processes might have relatively small effect on overall costs.

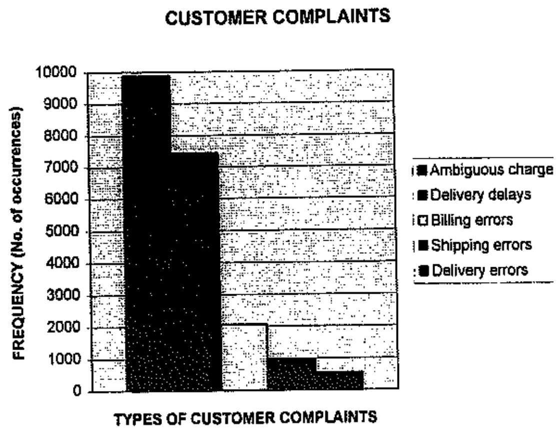
2. The histogram indicates that most customers wait 4-7 seconds.

Interval	Frequency
0-3	1
4-7	7
8-11	6
12-15	3
16-19	1
20-23	2



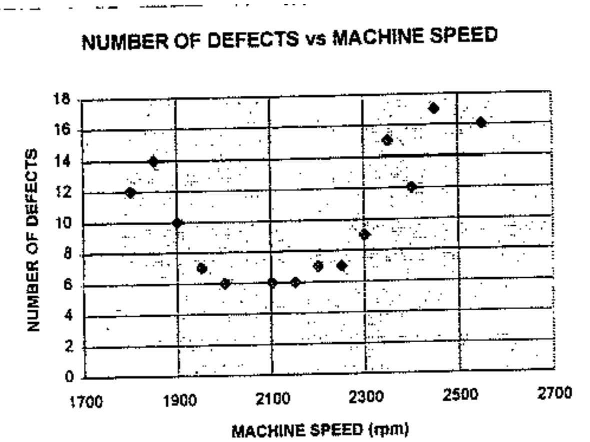
3. The histogram indicates that most complaints are for ambiguous charges. To reduce complaints this area should be addressed first.

Type of Defect	Frequency	% of Defects
Ambiguous charges	9880	47%
Delivery delays	7430	36%
Billing errors	2070	10%
Shipping errors	966	5%
Delivery errors	540	3%
	20886	100%



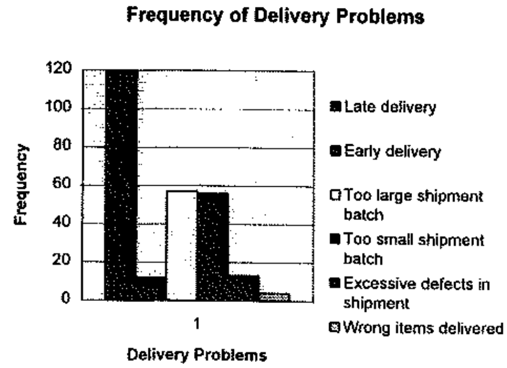
4. The pattern indicates that the number of defects decreases with increasing machine speed until approximately 2200 rpm, after which it increases. Further investigation is necessary to determine if machine speed is the cause of this defect pattern.

Machine Speed (rpm)	No. of defects
1800	12
1850	14
1900	10
1950	7
2000	6
2100	6
2150	6
2200	7
2250	7
2300	9
2350	15
2400	12
2450	17
2550	16



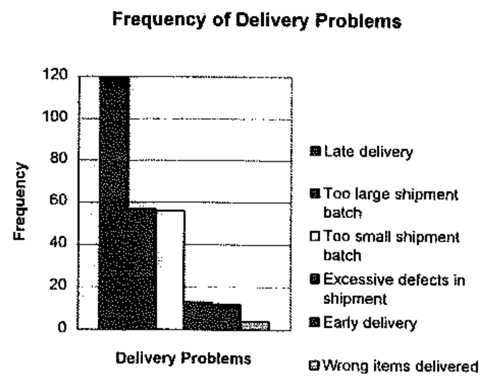
5.a.

Delivery Problem	Frequency
Late delivery	120
Early delivery	12
Too large shipment batch	57
Too small shipment batch	56
Excessive defects in shipment	13
Wrong items delivered	4



b.

Delivery Problem	Frequency
Late delivery	120
Too large shipment batch	57
Too small shipment batch	56
Excessive defects in shipment	13
Early delivery	12
Wrong items delivered	4

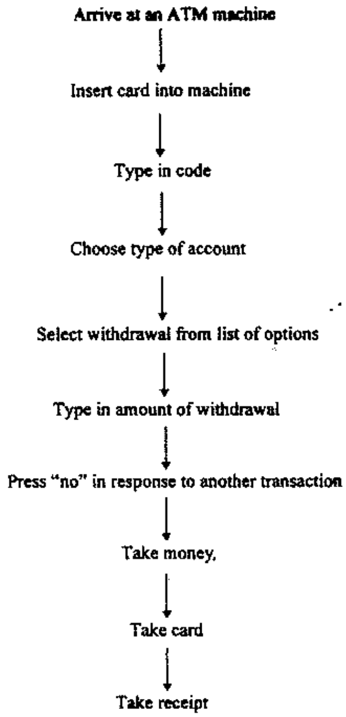


c. The sum of the delivery problems, 262, is greater than the number of deliveries, 204, because some deliveries have more than one problem. The tally sheet should be modified to permit tallying of multiple, simultaneous problems on a single delivery (e.g., too-large shipment batch *and* excessive defects in the delivery).

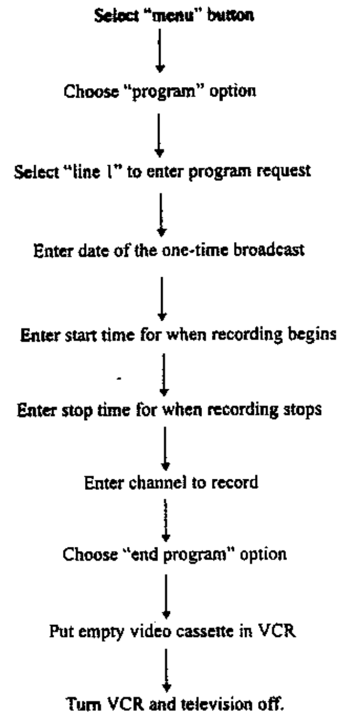
d. To find solutions to the delivery problems, begin by looking closely at the delivery process, which includes the processes of preparing shipping bills, scheduling the deliveries, and all material handling prior to delivery. A process flow diagram would be constructed and analyzed to suggest places in the process where problems originate, and data would be collected at these places using tally sheets. Cause-and-effect diagrams would also be used to identify other possible causes of problems, and the places in the process where data should be gathered. Data would then be analyzed using Pareto analysis, scatter diagrams, and so on.

*6.

a. Withdrawing money from an ATM machine.



b. Programming a VCR to record a one-time broadcast.



c. Depends on your level of experience in downhill skiing.

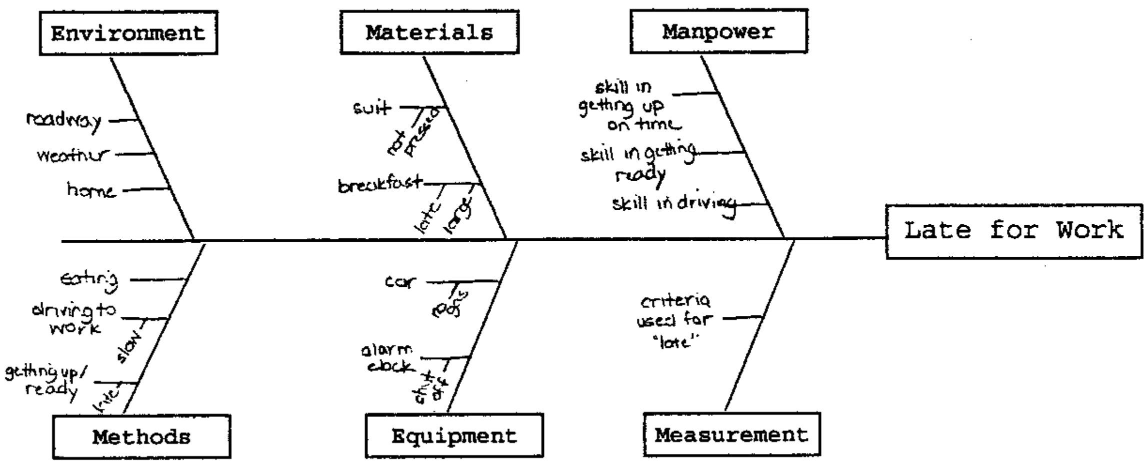
d. Depends on your experience and imagination.

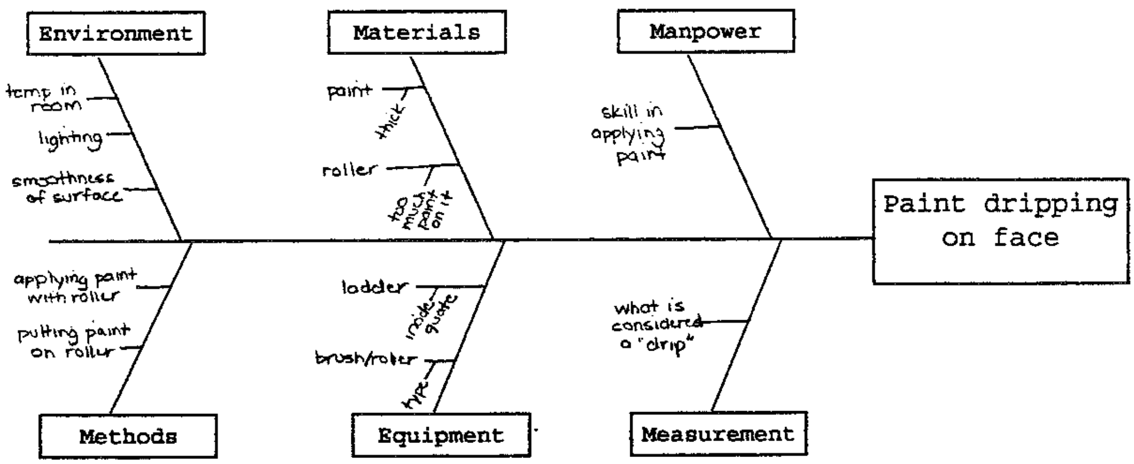
*7. Try to eliminate the steps that do not add value to the process. For example, for (a) and (b):

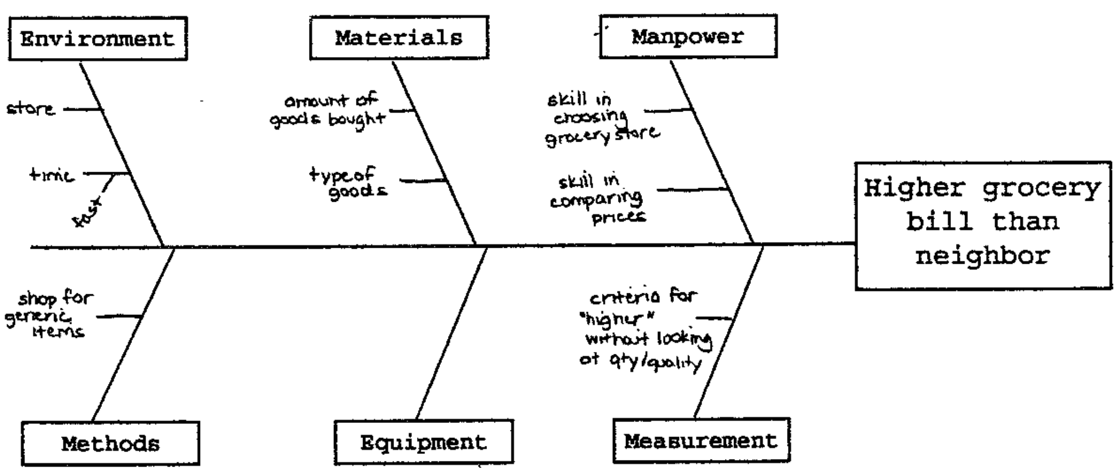
a. Select fewer buttons on the ATM. However, since all the buttons currently used are necessary, this would not result in improvement. Technology improvements might eventually lead to direct access to cash at home and eliminate the need to travel to an ATM machine. (For example, a dollar amount could be encoded on a credit card by a device attached to a home computer. This, of course, replaces one process with another that is possibly no less complicated, but it does eliminate the need to go the cash station.)

b. The user should be able to go directly to the "program" option (and eliminate the select "menu" button step). The user should also be able to directly enter the date of the program (and eliminate the select "line 1" to enter the program request). The steps for entering the date, start time, stop time and channel for a program could be eliminated by the simply entering the code specified for each program in the TV listings. These codes are unique for each program.

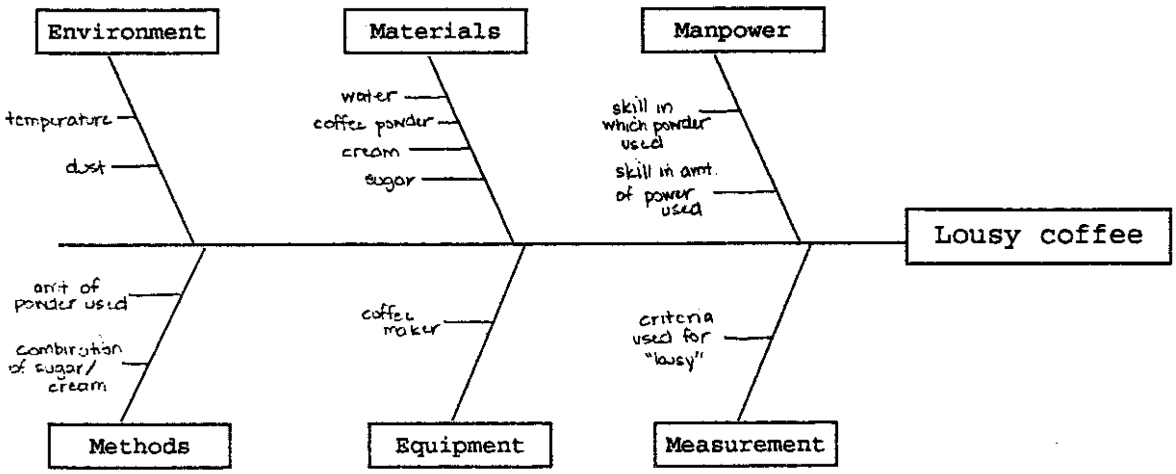
*8.a.

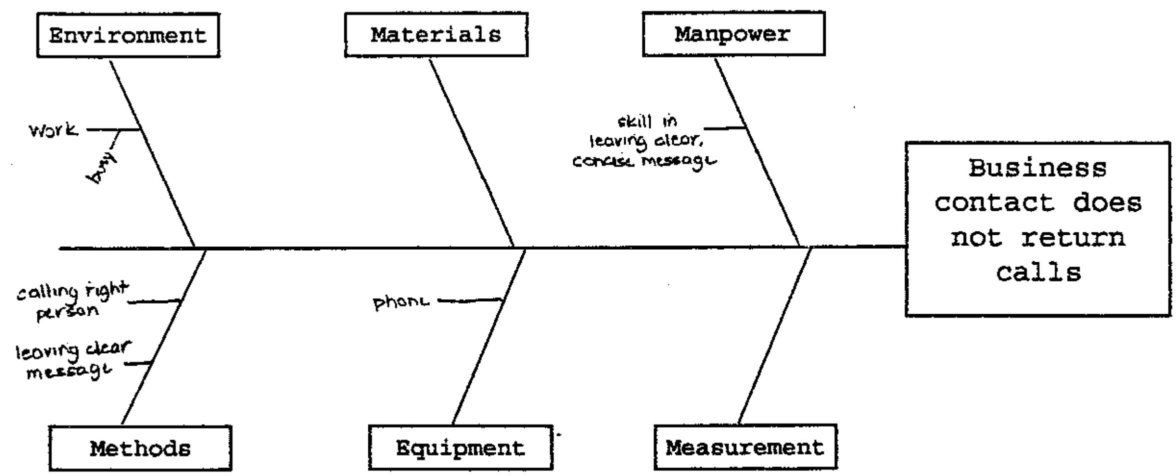

Environment
Materials
Manpower
roadway
weather
home
suit
not pressed
breakfast
late
large
skill in getting up on time
skill in getting ready
skill in driving
Late for Work
eating
driving to work
slow
getting up/ ready
late
car
gas
alarm clock
shut off
criteria used for "late"
Methods
Equipment
Measurement

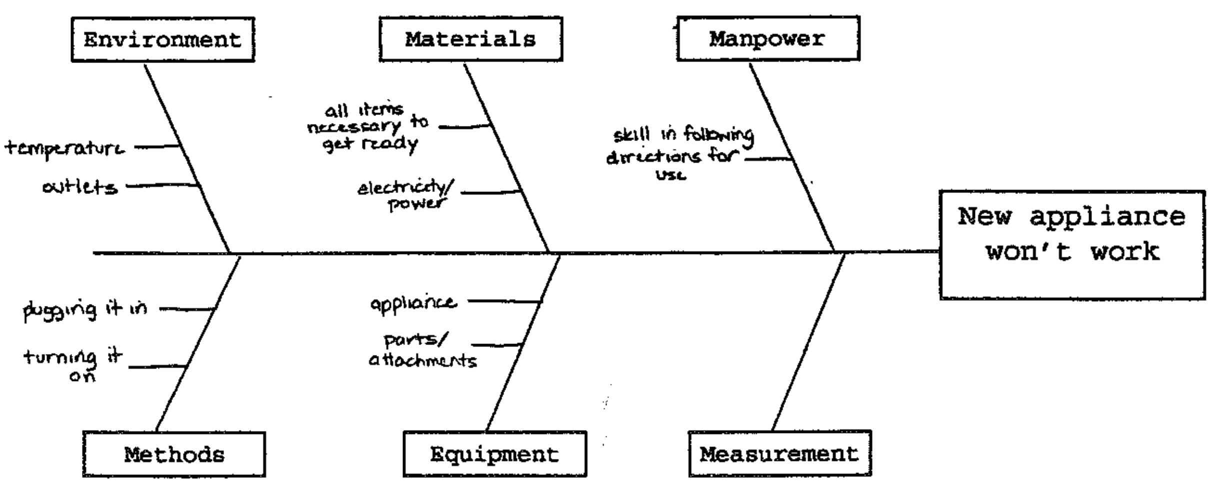

Environment
Materials
Manpower
temp in room
lighting
smoothness of surface
paint
thick
roller
too much paint on it
skill in applying paint
Paint dripping on face
applying paint with roller
putting paint on roller
ladder
inadequate
brush/roller
type
what is considered a "drip"
Methods
Equipment
Measurement


Environment
Materials
Manpower
store
time
fast
amount of goods bought
type of goods
skill in choosing grocery store
skill in comparing prices
Higher grocery bill than neighbor
shop for generic items
criteria for "higher" without looking at qty/quality
Methods
Equipment
Measurement

*8.a. (continued)







b. Various answers. Some examples follow.

Late for work: Check to see if you are getting up on time (do you hit snooze or shut off the alarm clock to sleep longer).

Paint dripping on face: Check to see if you have too much paint initially on the roller, which causes you to put too much on the ceiling.

Higher grocery bill than neighbor: Check to see the quantity of items bought and from where they were bought.

Lousy coffee: Try another brand and see what happens.

Business contact not returning calls: Check to see if she has gotten your messages (make inquiries on fax or e-mail).

New appliance won't work: Check to see if it is plugged in, is turned on, and you have followed all the directions.

*9. Various answers.

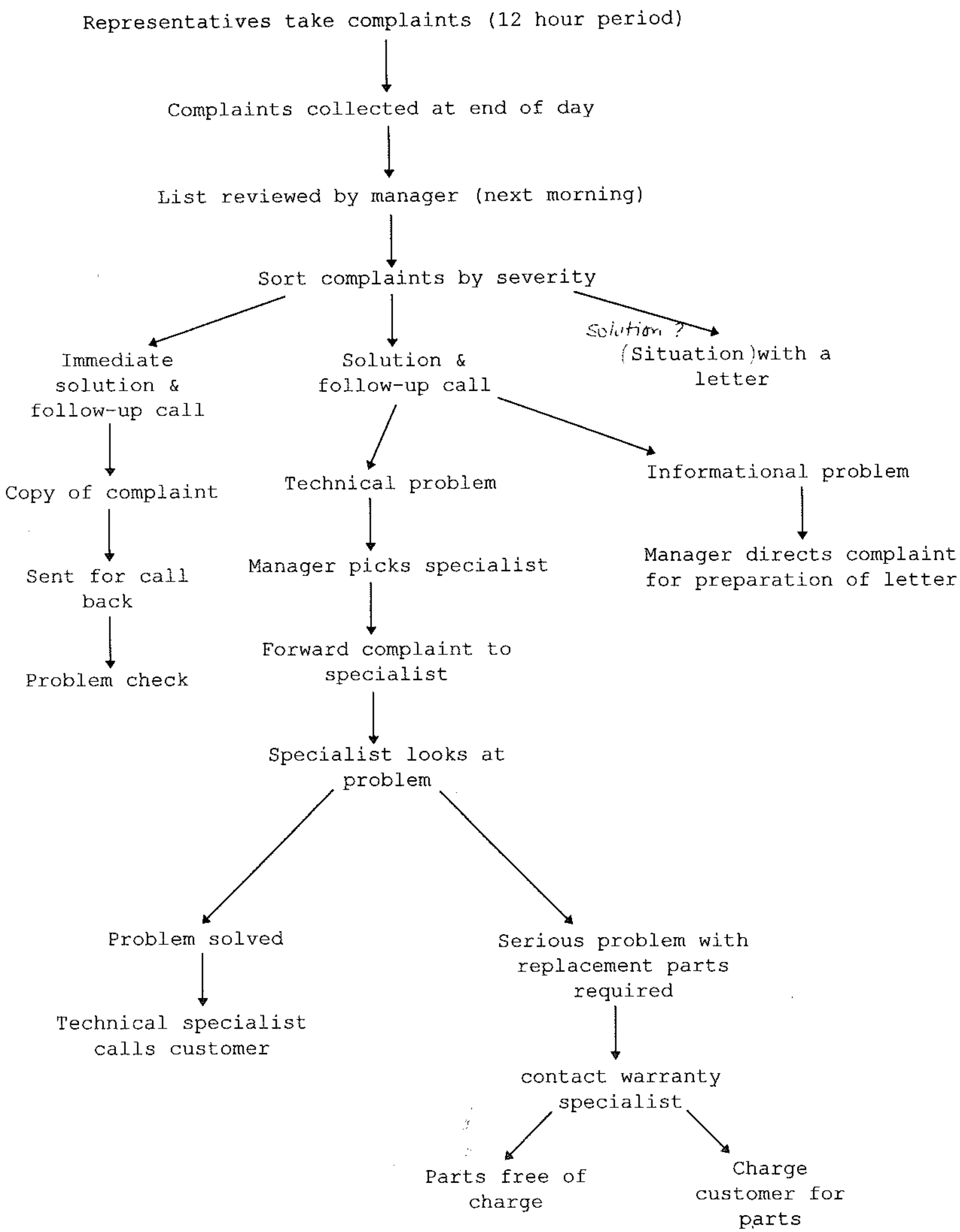
*10.a. This process is complex (and ambiguous) enough to cause different interpretations. The assignment will lead students to develop different-looking flow charts. It raises the important point of being very precise when defining a process for purposes of analysis and improvement. On the next page is one possible flow chart.

b. Every step of the process should be reviewed for improvement opportunities. Improvement can occur by redesigning each step, a sequence of steps, or even the entire process reengineering). Following are some possible ways to improve steps and portions of the process:

To improve the quality of service, the representatives who take calls can be trained to sort the complaints by severity. A computer system could be installed to help specialists decide if the technical problem is in their area of expertise. A specialist could determine from the computer system if a warranty covers the parts and charges. For informational problems, the call should be sorted and directed to the right person according to pre-specified procedure (the manager should not have to decide where every call should be directed).

The status of any problem requiring immediate attention should be updated by the specialist assigned to the problem.

Process flow chart.



11. Zemco's president might conclude that the plastic is at the end of the incremental improvement curve because, in spite of R&D efforts, no advances are happening in the plastic's

technology or profit advantage. He might decide that there are few new things to be learned about or exploited from the plastic, and to aim Zemco's R&D away from the plastic and toward looking for something new.

*12. It is important to determine the nature of the productivity efforts instituted at Division A before sending people there from Division B. The CEO of Cylo needs to examine the personnel, products and processes. It might be that equipment at Division A is older than at Division B, or that Division A is strapped with older (and possibly outdated) processes and procedures.

Perhaps, however, the differences between Division A and Division B stem from each being at a different point on the S-curve, especially with respect to the improvement thresholds for each. Division A has been operating for ten years, and possibly over that time its products and processes have been improved to the level where further improvements are very costly. Division B is younger and so are its products and processes, so possibly there is greater opportunity for improvement. Thus, perhaps, the best action for the CEO to take is the opposite of what he is considering. If Division A's products and processes have reached the improvement threshold, then transferring designers and engineers from Division B to Division A would be wasted effort and only serve to dilute Division B's improvement, whereas transferring them from Division A to Division B would enhance Division B's improvement -- and possibly have no effect on the performance of Division A.