PRODUCTIVITY

Slides prepared

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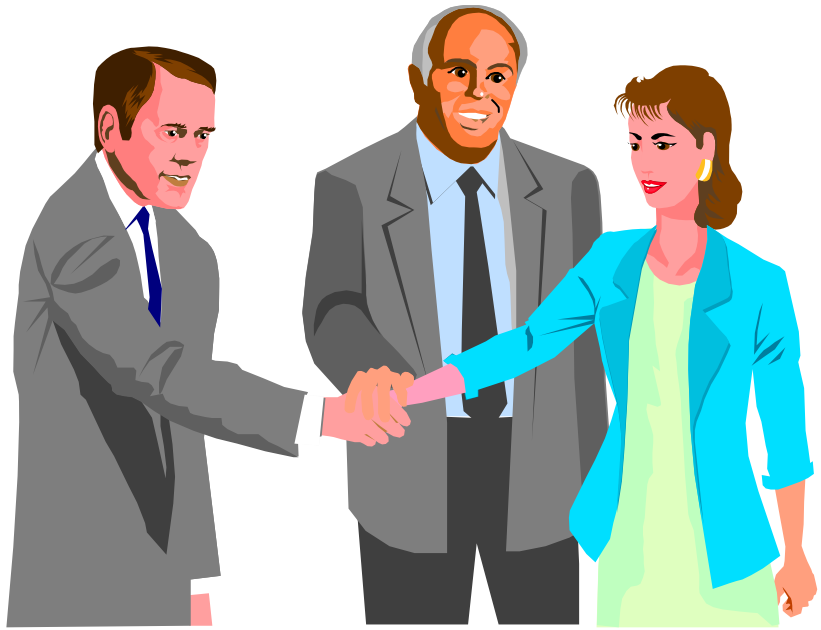
Employee Productivity



Overview

- Productivity and Human Behavior
- Designing Workers' Jobs
- Empowering Workers
- Work Methods Analysis
- Work Measurement
- Learning Curves
- Employees' Health and Safety
- Wrap-Up: What World-Class Companies Do

Productivity

- Productivity means the amount of products or services produced with the resources used
- $$\text{Productivity} = \frac{\text{Quantity of products or services produced}}{\text{Amount of resources used}}$$
- Productivity varies with the amount of production relative to the amount of resources used.

Ways to Increase Productivity

- Increase output using the same or a lesser amount of resource.
- Reduce amount of resource used while keeping output constant or increasing it.
- Use more resource as long as output increases at a greater rate.
- Decrease output as long as resource use decreases at a greater rate.

Impact of Price/Cost Change on Productivity

- When the cost of a resource increases and profit is to remain the same, some combination of the following must occur:
  - output is increased
  - resource usage is decreased
  - price of output is increased

Why do We Care About Productivity?

- Without productivity improvement, businesses do not survive in a global economy.
- Higher productivity means higher standard of living.
- The US has traditionally been the leader in productivity gains but other countries are closing the gap.

Single Factor Approach to Measuring Productivity

- Capital - Number of products produced divided by asset value
- Materials - Number of products produced divided by dollars spent on materials
- Direct Labor - Number of products produced divided by direct labor-hours
- Overhead - Number of products produced divided by dollars spent on overhead

Single Factor Approach to Measuring Productivity

- Note that the productivity of a particular resource can be increased simply by replacing some of this resource with a different type of resource.
- For example: If automation is substituted for direct labor and output volume is unaffected, direct-labor productivity increases (and capital productivity decreases).
- Our view of productivity must be toward improving the productivity of all the factors of production.

Labor Productivity

- For some firms, production labor (touch labor) represents a very small part of the firm's total costs
- For other firms, particularly service firms, direct labor cost remains a significant cost and the need to improve labor productivity is still a serious concern

Variables Affecting Labor Productivity

- Physical work environment
  - Technology, equipment, materials, lighting, layout
- Product quality
  - Defects, scrap, rework
- Employee job performance
  - Employee ability, motivation

Employee Job Performance

- Motivation is perhaps the most complex variable in the productivity equation.
- Only unsatisfied needs are motivators.
- Maslow identified five basic needs: physiological, safety, social, esteem, and self-fulfillment.
- The higher level needs (social, esteem, and self-fulfillment) might hold the most promise for motivating.
- If productivity is seen as a way to fulfill needs, higher productivity is likely to result.

Motivation

- Formal organization
- Informal groups
- Job design
- Leadership
- Union
- Psychological needs
- Economic conditions
- Personal situations

Specialization of Labor

- Advantages
  - High production rates
  - Low wage rates
  - Low skill requirements
- Disadvantages
  - High turnover, absenteeism, tardiness, grievances, sickness, and sabotage
  - Low production quality

Modifying Jobs to Provide Broader Range of Needs Satisfaction

- Cross-training -- workers perform multiple jobs
- Job enlargement -- adding similar tasks to worker's job - horizontal job expansion
- Job enrichment -- adding more management functions to job - vertical job expansion
- Team production -- organizing workers into teams; assigning management responsibility to teams

Job Design

- Can we simultaneously give workers the satisfaction they want from their work and still give the organization the productivity and efficiency to survive economically?

Guidelines for Designing Jobs and Work Environments

Workers' Job Tasks

- Avoid machine pacing of workers
- Design jobs so that workers inspect their own output
- Open work areas for communication & visual contact
- Combine job planning into workers' jobs
- Automate boring, uncomfortable, or unsafe jobs

Guidelines for Designing Jobs and Work Environments

Immediate Job Setting

- Rotate jobs that are repetitive, monotonous, boring
- Assign new workers to undesirable jobs, then transfer them to more preferred jobs
- Recruit disadvantaged persons for high-turnover jobs
- Give rest periods to workers with repetitive jobs
- Set higher pay rates for undesirable jobs

Guidelines for Designing Jobs and Work Environments

Larger Work Environment

- Select/train supervisors who openly communicate
- Develop supervisors who are comfortable with a participative team environment
- Remove physical barriers between management and other employees
- Create climate that recognizes workers & work teams
- Develop formal/informal channels of communication in all directions

Empowering Workers

- It is the employees who have control of, and know the most about, the details of production.
- To get employees to accept this responsibility, managers must first give employees the authority to act.
- The process of conveying authority from managers to workers is called worker empowerment.
- Workers accepting responsibility for production can lead to what is called internal ownership.

Steps of Work Methods Analysis

1. Make an initial investigation of the operation
2. Decide what level of analysis is appropriate
3. Get suggestions from anyone familiar with operation
4. Thoroughly describe and evaluate present method
5. Devise a new proposed method
6. Compare new and present methods
7. Modify the proposed method
8. Perform the proposed method on a trial basis
9. Install the proposed method and train workers
10. Check on new method periodically

Work Measurement

- Work measurement refers to the process of estimating the amount of worker time required to produce one unit of output.
- A goal of work measurement is to develop labor standards that can be used for planning and controlling operations.

Labor Standards

- A labor standard is the number of worker-minutes required to complete an element, operation, or product under ordinary operating conditions.
- Ordinary operating conditions refers to a hypothetical average situation ….. average or typical worker, material, machinery, environment, etc.

Labor Standards

- Labor standards are used in:
  - Cost estimation
  - Pricing of products and services
  - Incentive pay systems
  - Capacity planning
  - Production scheduling

Labor Standards

- A labor standard can be determined using one or more of the following approaches:
  - Time study
  - Work sampling
  - Predetermined time standards

  ---------- subjective ----------
  - Historical standards
  - Supervisor estimates

Time Study

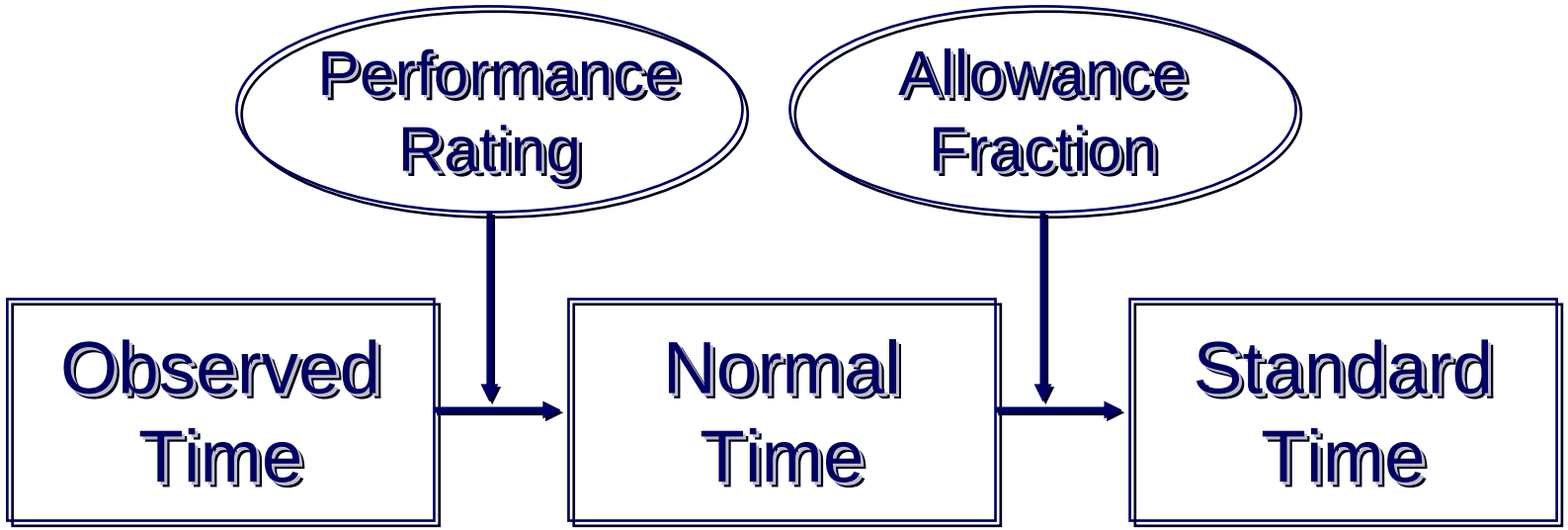
Suitable Jobs

- Job performed by a single worker in a fixed location
- Job involves repetitive short cycles
- Job expected to continue unchanged for a long period
- Job produces large quantities of output
- Resulting time standard must be very accurate

Time Study

- Analysts use stopwatches to time the operation being performed by workers
- These observed times are then converted into labor standards
- The labor standards are expressed in minutes per unit of output for the operation

Determining Labor Standards from Time Studies



Determining Labor Standards from Time Studies

1. Make sure correct methods are being used to perform the operation being studied.
2. Break the operation down into basic tasks (elements).
3. Determine how many cycles to time. A cycle is one complete set of the elemental tasks.
4. Observe and record the elapsed time for each element for the number of required cycles.

. . . more

Determining Labor Standards from Time Studies

5. For each element, estimate the observed worker's performance rating. A rating of 1.00 indicates the worker is working at normal speed.

6. Compute the allowance fraction for the operation. The allowance fraction is the fraction of time that workers cannot work through no fault of their own.

. . . more

Determining Labor Standards from Time Studies

7. Compute the mean observed time for each element:

$$= \frac{\text{(Sum of observed element times)}}{\text{(Number of cycles timed)}}$$

8. Compute the element normal time for each element:

= (Mean observed time) x (Performance rating)

. . . more

Determining Labor Standards from Time Studies

9. Compute the total normal time for the entire operation:

= (Sum of element normal times for all elements)

10. Compute the labor standard for the operation:

= (Total normal time) / (1 - Allowance fraction)

Example: Time Study Approach

In a time study of a manufacturing operation, the average time observed to complete a product was 8.6 minutes. The performance rating applied to the observed worker was 0.95 and the allowance during an 8-hour shift was 12.5% or 60 minutes.

Compute the labor standard.

Example: Time Study Approach

- Observed time = 8.6 minutes
- Performance rating = 0.95
- Allowance fraction = 0.125
- Normal time = Observed time x Performance rating
  = 8.6 x 0.95
  = 8.17 minutes
- Standard Time = Normal time / (1 - Allowance)
  = 8.17 / (1 - .125)
  = 8.17 / (0.875)
  = 9.337 minutes

Work Sampling

- The work of one or more employees is randomly sampled at periodic intervals
- Noted is the proportion of the total operation that is accounted for in one particular activity
- The results of these studies are used to:
  - Set allowances used in labor standards
  - Set labor standards

Work Sampling

Suitable Jobs

- Job performed by a single worker in a fixed location
- Job involves repetitive short cycles
- Job expected to be changed periodically as customer orders change
- Job produces relatively small quantities of output
- Resulting time standard used for accounting cost standard, pricing analysis, and production planning

Example: Work Sampling

A work sampling study was performed on an electronic assembly operation at OK Instruments. The study covered an 8-hour shift with a single worker. The results of the study were:

Activity	% of Worker's Time
Assemble Units	80
Allowances	20

If the worker received a performance rating of 1.20 on the Assemble Units activity and 400 units were assembled during the study, what is the labor standard for this operation?

Example: Work Sampling

1) Compute the average time per assemble:

$$= \frac{\text{Total Minutes of Assembly Work}}{\text{Number of Units Assembled}}$$

$= .8(480)/400 = .960$ minutes per unit

2) Compute the normal time per unit:

= (Average Time per Unit)(Performance Rating)

$= .960(1.20) = 1.152$ minutes per unit

Example: Work Sampling

3) Compute the labor standard:

= Normal Time/(1 – Allowance Fraction)

= 1.152/(1 - .20) = 1.44 minutes per unit

Predetermined Time Standards

- Commonly used for new operations or new products
- When labor standard must be determined in advance of performing an operation
- Utilize data that have been historically developed for basic body movements, elements of operations, and entire operations
- Many predetermined time standard systems are used:
  - Work factor
  - Methods-time measurement (MTM)
  - Basic motion time (BMT) study
  - … and others

Predetermined Time Standards

Suitable Jobs

- Job performed by many workers over a compact area
- Tasks may involve little repetition, but if repetitious – the cycles are very long
- Workers must be observed by a single analyst
- A moderate degree of accuracy in the labor standard is desirable, but a time study is too costly
- Only large elements of work need to be observed
- Little detail is needed in setting the time standard

Subjective Methods

Suitable Jobs

Any job or group of jobs in which:

- Very accurate labor standards are not required, or
- The cost of time study, predetermined time standards, and work sampling is prohibitive

Learning Curves

At the start of production runs:

- Workers are unfamiliar with their tasks
- Time it takes to produce the first few units is high

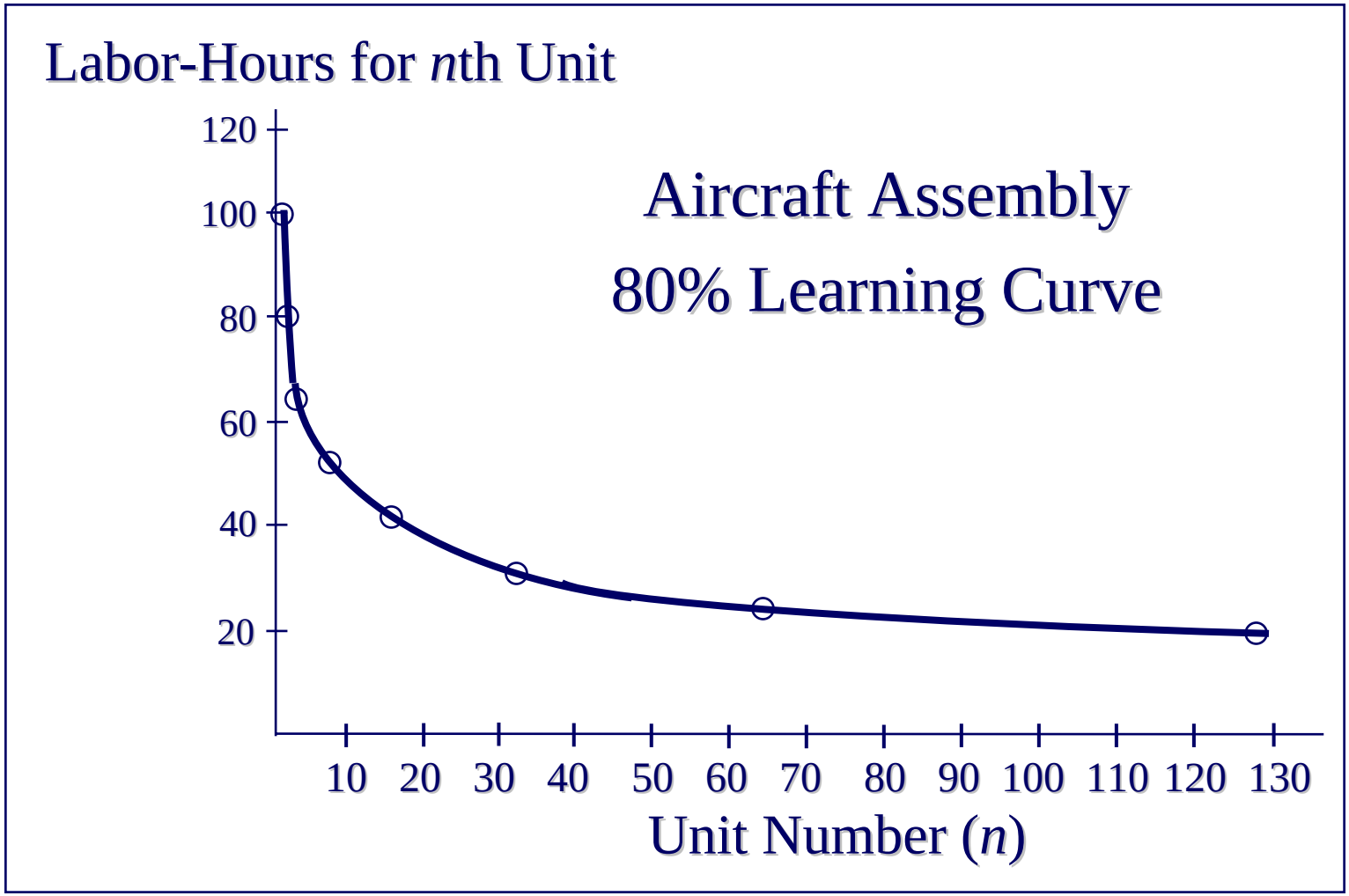
As the workers learn their tasks:

- Their output per day increases up to a point
- Then their output levels off to a rather constant rate

Learning Curves

- Most aircraft manufacturing tasks experience an 80% learning rate
- Labor-hours required to assemble an aircraft is reduced by a factor of 0.8 as the production quantity doubles
  - If first aircraft assembled requires 100 labor-hours
  - Second aircraft would require 80 labor-hours
  - Fourth aircraft would require 64 labor-hours
  - Eighth aircraft would require 51.2 labor-hours
  - … and so on

Learning Curves



Learning Curves

By analyzing workers' learning situations, we are able to estimate:

- The average number of labor-hours required per unit for N units in a production run
- The total number of labor-hours required to produce N units in a production run
- The exact number of labor-hours required to produce the *n*th unit of a production run

Learning Curves

Three approaches to learning-curve problems are:

- Arithmetic analysis
- Logarithmic analysis
- Learning curve tables

Learning Curves

Arithmetic Analysis

- The simplest approach to learning-curve problems
- If we wish to find the labor-hours required to produce *n* units, and *n* just happens to be a number that is one of the doubled values, then this approach works

Example: EZ Machine Shop (A)

Learning Curve - Arithmetic Analysis

EZ Machine Shop has a contract to manufacture 100 turbines. The first 20 turbines have been completed. The labor-hours required for a portion of the completed turbines are listed below. Use this data to estimate the shop's learning rate in manufacturing the turbines.

Unit No.	Labor-Hours	Unit No.	Labor-Hours
1	140	5	95
2	118	10	81
3	109	15	75
4	102	20	68

Example: EZ Machine Shop (A)

Learning Curve - Arithmetic Analysis

Compute the learning rate for each of the “doubles”.

Units 1 and 2	118/140	=	.8429
Units 2 and 4	102/118	=	.8644
Units 5 and 10	81/95	=	.8526
Units 10 and 20	68/81	=	.8395

(.8429 + .8644 + .8526 + .8395)/4 = .8499

The approximate learning rate is 85%.

Learning Curves

Learning-Curve Tables

A table of learning curve coefficients (Table 18.12) allows us to compute:

- The labor-hours for the *n*th unit in a production run
- The total labor-hours for the entire production run, where the *n*th unit is the last unit in the run

Example: EZ Machine Shop (B)

Learning-Curve Tables

The manager of EZ Machine Shop wants a good estimate of the total labor-hours required to manufacture the entire 100 turbines. Also, he is curious about how many labor-hours will be needed for the last (100^{th}) unit. Use the observed 85% learning rate and 140 labor-hours required for the first turbine to compute your estimates.

Example: EZ Machine Shop (B)

Learning-Curve Tables

Total Labor-Hours Required for 100 Units
= (Hours for 1st unit)(Table total time: 85%, 100th unit)

In Table 18.12, locate the line for the 100th unit and read across to the Total Time column under the 85% learning rate. The value is 43.75.

Total Labor-Hours Required for 100 Units
= 140(43.75) = 6,125 labor-hours

Example: EZ Machine Shop (B)

Learning-Curve Tables

Labor Hours Required for the 100^{th} Unit

= (Hours for 1^{st} unit)(Table unit time: 85%, 100^{th} unit)

In Table 18.12, locate the line for the 100^{th} unit and read across to the Unit Time column under the 85% learning rate. The value is .340.

= 140(.340) = 47.6 labor-hours

(100^{th} unit will require 34% of the time 1^{st} unit required)

Learning Curves

Logarithmic Analysis

The following relationship allows us to compute T_n, the labor-hours required to produce the nth unit:

$$T_n = T_1(n^b) \text{ and } b = \log r/\log 2$$

where: T_1 = labor-hours to produce the first unit

b = slope of the learning curve

r = learning rate percentage

Example: EZ Machine Shop (C)

Logarithmic Analysis

Compute, using logarithmic analysis, the labor-hours required for the 50^{th} turbine (assuming an 85% learning rate and 140 labor-hours required for the 1^{st} unit).

$$b = \log (.85)/\log (2) = - 0.234465253$$

$$T_{50} = 140(50^{-0.234465253})$$

$$= .399623 \text{ or } .400$$

(Our result agrees with the value in Table 18.12)

Learning Curves

- Selecting a learning rate
  - Industry journals
  - Historical experience
- Uses and limitations
  - Products and services tend to be custom designed
  - Batches tend to be small
  - Product/services tend to be complex.... learning occurs quickly

Employee Health & Safety

- Several regulations and government agencies monitor and control;
  - OSHA - safety and health in the workplace. Federal... pro-active
  - Worker's Compensation - safety and health in the workplace. State .... re-active
  - EPA - Environmental protection outside of the workplace. Federal... pro-active
- Safety and Health departments in plant