C4: Operations Management

Lecturer Manual

[Add institute name here]
[Add School/Department name here]

Copyright

Commonwealth of Learning
1055 West Hastings Street
Suite 1200
Vancouver, BC V6E 2E9
CANADA

Email: info@col.org

[Add institute name here]
[Add School/Department name here]

[Add address line 1]
[Add address line 2]
[Add address line 3]
[Add country]

Fax: +[Add country code] [Add area code] [Add telephone #]
E-mail: [Add e-mail address]
Website: www.[Add website address]

Acknowledgements

The Commonwealth of Learning (COL) wishes to thank those below for their contribution to the development of this course:

Course author
David Gardiner
Gardiner Consulting Group
Operations Management Consultants
Christchurch, New Zealand

Course content specialist:
Olga Kaminer, PhD
Professor, Supply Chain/Logistics/Operations Management
Faculty of Business
Sheridan Institute of Technology and Advanced Learning, Canada

Subject matter experts:
Fook Suan Chong
Wawasan Open University, Malaysia

Maurice Fletcher
University College of the Caribbean, Jamaica

Araba Intsiful
Kwame Nkrumah University of Science and Technology, Ghana

S. A. D. Senanayake
Open University of Sri Lanka, Sri Lanka

Educational designers:
Symbiont Ltd.
Paraparaumu, New Zealand

Course editor:
Symbiont Ltd.
Paraparaumu, New Zealand

Course formatting:
Kathryn Romanow
Commonwealth of Learning

COL would also like to thank the many other people who have contributed to the writing of this course.

Contents

About this lecturer manual

Introduction

The lecturer manual for the course C4: Operations Management contains answers to the teacher-marked activities in the Course Manual. Some of the answers have been supplemented by explanations.

There are ample references and extra resources mentioned in the course manual that the lecturer can use for additional examples and exercises.

Summative assessments can be used as bases for examinations. An example of an examination is given at the end of this manual.

Course outcomes

Outcomes

Upon completion of C4: Operations Management the student will be able to:

- *Discuss* operations strategy and customer requirements and demonstrate how operations management can be used to improve the competitive position of a firm.
- *Summarise* demand management and forecasting.
- *Describe* capacity management and balance aggregate demand with capacity.
- *Illustrate* the basic requirements for process design (including continuous operations, repetitive operations, batch operations and job shop operations).
- *Discuss* process improvement and the concepts of lean thinking.
- *Explain* product design and quality management techniques, including six sigma quality and process capability.
- *Outline* the role of inventory management.
- *Describe* supply chain management and supply issues, including supply chain dynamics.
- *Identify* basic project management techniques.
- *Understand* the role of performance measurement in operations management.

This course includes the following units:

1. **Unit 1:** Strategy and competitiveness: thinking about how the organisation should operate to maximise its effectiveness.
2. **Unit 2:** The nature and role of OM: how the operations management function operates and fits into the overall framework of the organisation.
3. **Unit 3:** Demand management and forecasting: to establish how much demand will be required in the future and once this is known the organisation can plan the resources required to meet that demand.
4. **Unit 4:** Capacity planning and management: once future demand is known, the firm has to balance that with sufficient capacity to deliver the goods and services required by customers.
5. **Unit 5:** Designing processes: all of business is a process and all decisions within an organisation follow processes so we have to design effective processes with the required capability to deliver goods and services.
6. **Unit 6:** Improving processes — lean thinking: customer requirements will change and technological improvements developed so the organisation will need to modify and improve processes to remain competitive.
7. **Unit 7:** Product design: products and services need to be designed to deliver to the customer exactly what the customer wants.
8. **Unit 8:** The concept of quality: this concept is about making the most of products and processes so that customers are delighted with the outcomes.
9. **Unit 9:** Inventory planning and management: production firms and service organisations require inventory of materials to work with, or to sell, so we need to determine how much material will be ordered, when those orders are placed and how much material will be held for future use.
10. **Unit 10:** Supply chain management: covers all the customer-supplier interactions from original supply all the way through to final customer and the design and operation of the entire supply chain determines the effectiveness of the end result.
11. **Unit 11:** Project management: often the subject of a course in its own right, this unit provides an operations manager

with sufficient understanding of project processes to effectively communicate with project management.

12. **Unit 12:** Performance measurement: measures how the organisation is performing and what metrics should be determined.

Timeframe

How long?

Learners are expected to spend 120 hours

[How much formal study time is required?]

[How much self-study time is expected/recommended?]

Reflection

Reflection

Some units have reflections which provide an opportunity for the student to "reflect" on what they are learning. These reflections are not assessed, but form part of the learning process.

The reflection feedback is provided in this Lecturers' Guide.

Activities

Activities

Each unit has a small number of activities scattered throughout the unit. Students should work through each activity without looking at the activity feedback which is at the end of the module. Use the activity feedback as reassurance that you have understood the activity.

Assessments

Assessments

This course has a final exam which is worth 30 per cent and covers all modules. The time allocated is three hours and the student selects any six questions from a choice of eight.

Assignments

Assignments

There is an assignment comprising three questions at the end of module 2.

There is an assignment comprising four questions at the end of module 3.

[How are the assignments are to be submitted?]

[To whom should the assignments be submitted?]

[What is the schedule for submitting assignments? End of each unit? Specific dates?]

[What is the order of the assignments? Must they be completed in the order in which they are set?]

Module 1

Introduction

Outcomes

This module introduces the subject of operations management by explaining strategy and competitive advantage and then examining how the operations function can make significant contributions to the organisation with an understanding of how the organisation competes.

Upon completion of this module students will be able to:

- *Explain* what is meant by strategy, strategic capability and competitive advantage.
- *Define* operations management and u*nderstand* the importance of operations management.
- *Define* the customer and recognise the basic requirements of the customer.
- *Describe* the transformation process.
- *Distinguish* between products and services.

Unit 1

Strategy and competitiveness

Outcomes

Upon completion of this unit students will be able to:

- *Explain* what is meant by strategy and strategic capability.
- *Explain* the concept of core competence.
- *Distinguish* between order winners and qualifiers.
- *Explain* how strategy exists at different levels in organisations.
- *Explain* the nature of competitive advantage.
- *Make* strategic decisions for an organisation.
- *Explain* operations strategy and explain the linkage with business strategy.
- *Explain* competitive capability.

Activity 1.1

Activity

Work through the following questions. You may need to go back and re-read the unit to help you.

1. What are the reasons for formulating and implementing an operations strategy?
2. How would you determine whether a company had an operations strategy or not? What specific questions would you ask and what information would you gather?
3. Find an example of an operation in your local community that has been successful in simultaneously improving quality, reducing throughput time, improving on-time deliveries and reducing costs. How has this operation been able to achieve these seemingly conflicting results?
4. Who defines the value of a product or service?

Activity 1.1 feedback

All answers are in the learning material.

Unit 2

The nature and role of operations management

Outcomes

Upon completion of this unit students will be able to:

- *Define* operations management.
- *Define* the customer and recognise the basic requirements of the customer.
- *Distinguish* between structural, infrastructural and integration decisions in operations.
- *Describe* the transformation process.
- *Understand* the importance of operations management.
- *Distinguish* between products and services.
- *Explain* the role of operations management within the context of the whole organisation and the customer experience paradigm.
- *Define* the primary activities associated with operation management.
- *Trace* the history of operations.

Activity 1.2 and feedback

Activity

The following table of production organisations has been completed for “Electrical appliances”. Complete the table for a bakery, a clothing manufacturer, a packaging company and a dairy products company.

The inputs use nouns; the transformations use verbs; and the outputs use nouns. That simple definition of language helps to visualise the process.

Organisation	Inputs	Transformation process	Outputs
Electrical appliances	Raw materials Components Printed circuit boards Insertion machines	Fabricating Assembling Inserting components in PCB Packaging	Finished goods such as stereos, TVs, DVDs, household appliances delivered to warehouses and retail stores

	People skills	Distributing	
Bakery	Flour Sugar Flavourings Packaging Energy People skills	Mixing ingredients Baking Packaging Distributing	Bakery items such as buns, bread, muffins, biscuits delivered to warehouses and retail stores
Clothing	Fabrics Threads Findings (buttons clips and clasps) Energy People skills	Laying fabric Cutting fabric Sewing garments Packaging Warehousing Distributing	Range of garments such as pants, shirts, dresses, coats delivered to retail outlets
Packaging	Paper Plastic Glue Inks Energy People skills	Preparing artwork Printing Guillotining Slitting Packing Distributing	Packaging items such as cases, cartons, boxes, packets to meet customer specifications warehoused and delivered to production facilities
Dairy products	Milk Flavourings Containers Packaging	Pasteurising Separating Mixing Packing Distributing	Dairy products such as milk, cream, yoghurt, flavoured drinks delivered to supermarkets

The following table of service organisations has been completed for "Air transport". Complete the table for a computer centre, a restaurant, a hospital and a bank.

Activity

Organisation	Inputs	Transformation process	Outputs
Air transport	Airport infrastructure Reservation system Aircraft	Reserving passengers Scheduling flights Scheduling crews	Passengers with reservations for travel Passengers safely on board aircraft

	Flight crews Cabin crews Ground staff Fuel Food	Checking-in passengers Maintaining aircraft and equipment Cleaning and provisioning aircraft Preparing meals	Passengers fed and watered during flight Passengers and luggage safely delivered to destination Freight carried and delivered
Computing centre	Computing equipment Stationery Energy People	Updating records Maintaining security Printing Enveloping Distributing	Information processed quickly and accurately for internal and/or external customers
Restaurant	Kitchen and table equipment Food Energy People Wine and drinks	Setting tables Taking orders Preparing and cooking food Waiting at tables Washing cutlery and dishes General cleaning	Guests enjoying ambience Guests fed and watered An enjoyable experience
Hospital	Medical supplies Drugs Doctors Nurses Other staff Food	Operating Nursing Dispensing drugs and medicines Preparing meals Keeping records	Well patients Long term patients New babies Trained staff Dead people (unfortunately)
Banking and finance	Bank buildings Computers Tellers Automatic teller machines (ATM)	Processing deposits and cheques Investing money Providing loans and mortgages	Money safe and available when required Safe and profitable investments Money well spent

Activity 1.3

Activity

We have discussed the differences between products and services. Think about your experiences with products and services and prepare a list of similarities between products and services.

Activity 1.3 feedback

Products and services are similar in the following ways:

- Use customer satisfaction as a key measure of effectiveness.
- Have common measures of satisfaction (for example, speed and quality).
- Require demand forecasting.
- Require product design and process design.
- Depend on location and arrangement of resources.
- Involve purchase of materials, supplies and services.
- Can be provided in high or low volumes.
- Can be standard or customised.
- Are subject to automation.
- Need an operations strategy consistent with business strategy.

As seen from this list, products and services are very similar. All organisations can benefit from improving their processes. It does not really matter whether an organisation sees itself as a manufacturer or a service provider.

Activity 1.4

Activity

Work through the following questions. You may need to go back and re-read the unit to help you.

1. Which is more important – infrastructural or structural or integration decisions? Explain your answer.
2. What does operations management mean?
3. How is the transformation process related to value?
4. Who defines the value of a product or service?
5. How would you define the customer perceived value?

Activity 1.4 feedback

All answers are in the learning material.

Module 2

Balancing supply with demand

Outcomes

Upon completion of this module, students will be able to:

- *Explain* the nature of demand.
- *Understand* the strategic role of forecasting.
- *Distinguish* between qualitative and quantitative forecasting and perform basic quantitative calculations.
- *Outline* how capacity is measured and appreciate the dilemma faced by management in matching variable demand with variable capacity.
- *Calculate* various aggregate planning scenarios.
- *Identify* various strategies for balancing supply with demand.
- *Evaluate* the application of yield management.
- *Evaluate* queues and waiting lines.

Unit 3

Demand management and forecasting

Outcomes

Upon completion of this unit students will be able to:

- *Define* demand management.
- *Explain* the nature of demand.
- *Understand* the strategic role of forecasting.
- *Distinguish* between qualitative and quantitative forecasting.
- *Explain* forecast accuracy.
- *Define* forecast value added.
- *Perform* basic quantitative calculations on forecasting.
- *Define* and calculate seasonal indices.
- *Use* regression analysis to develop long-term trends.
- *Discuss* other approaches to forecasting.

Reflection 2.1

Reflection

Reflection 2.1

Excluding the changing behaviours demonstrated by the customer, what factors would influence demand?

Reflection 2.1 feedback

A number of factors influence demand such as changes in technology, competitor initiatives or pricing levels. Forecasting helps firms to focus attention on the factors that influence demand and establish a relationship between those factors and the actual demand.

Reflection 2.2

Reflection

Reflection 2.2

Think of three or four reasons why a forecast value would be inaccurate.

Reflection 2.2 feedback

Forecast inaccuracy can be attributed to the following causes:

- The forecasting model or method used may not be suitable for the demand being monitored.
- The information in the forecasting process may arrive too late to be of significant value.
- True demand is not being captured and it is being confused with sales data.
- Appropriate data is not being used. This feature develops when individuals are left to source information for themselves and then this data is consolidated in some way at an organisational level.
- Forecasts are calculated from the past data that may not hold for projected data points.

Activity 2.1

Activity

Use the data in the following table to calculate mean absolute deviation MAD.

Month	Demand *D*	Forecast *F*	Deviation (*D*-*F*)	Abs deviation |*D*-*F*|
Jan	500	550	-50	50
Feb	550	600	-50	50
Mar	420	490	-70	70
Apr	500	530	-30	30
May	610	530	80	80
Jun	600	550	50	50
Jul	680	610	70	70
Aug	670	670	0	0
Sep	720	690	30	30
Oct	750	730	20	20
Sum	**6000**	**5950**	**50**	**450**
Ave	**600**	**595**	**5**	**45**

Activity 2.1 feedback

Calculate the absolute deviation between demand values and forecast values for each month. Add them up and find the average (mean) value. This is the mean absolute deviation (MAD).

$$\text{MAD} = \frac{\sum |D - F|}{n} = \frac{450}{10} = 45$$

Thus the actual demand is, on average, 45 units from the forecast value.

Activity 2.2

Activity

Use the data in the following table to calculate bias.

Month	Demand *D*	Forecast *F*	Deviation (*D-F*)	Abs deviation |*D-F*|
Jan	500	550	-50	50
Feb	550	600	-50	50
Mar	420	490	-70	70
Apr	500	530	-30	30
May	610	530	80	80
Jun	600	550	50	50
Jul	680	610	70	70
Aug	670	670	0	0
Sep	720	690	30	30
Oct	750	730	20	20
Sum	**6000**	**5950**	**50**	**450**
Ave	**600**	**595**	**5**	**45**

Activity 2.2 feedback

Bias is found by calculating the algebraic difference between demand value and forecast value for each period. To make sure that the algebraic sign is correct, ensure you subtract forecast from demand ($D - F$). The sum of the algebraic differences is divided by the sum of the demand values and expressed as a percentage.

$$\text{bias} = \frac{\sum(D-F)\text{x}100}{\sum D}$$

$$= \frac{(6000-5950)\text{x}100}{6000}$$

$$= 0.833\%$$

Thus the forecasting model has a bias in favour of demand of 0.833 per cent.

Activity 2.3

Activity

Use the data in the following table to calculate mean absolute percentage deviation MAPD and mean absolute percentage variation MAPV.

Month	Demand D	Forecast F	Abs deviation $\lvert D-F \rvert$	$\Sigma D/n$	Abs variance $\lvert D-(\Sigma D/n) \rvert$
Jan	500	550	50	600	100
Feb	550	600	50	600	50
Mar	420	490	70	600	180
Apr	500	530	30	600	100
May	610	530	80	600	10
Jun	600	550	50	600	0
Jul	680	610	70	600	80
Aug	670	670	0	600	70
Sep	720	690	30	600	120
Oct	750	730	20	600	150
Sum	**6000**	**5950**	**450**		**860**
Average	**600**	**595**	**45**		**86**

Activity 2.3 feedback

MAPD is the mean of the absolute deviation between actual demand value and forecast value divided by the mean of the demand values expressed as a percentage. In this formula description, both numerator and denominator calculate average values using the number of observations. In the formula, the number of observations, *n*, could appear in numerator and denominator and cancels each other out.

$$\text{MAPD} = \frac{\sum |D-F| \text{ x } 100}{\sum D} = \frac{450 \text{ x } 100}{6000} = 7.5\%$$

Mean absolute percentage variation (MAPV) is the average of the absolute deviation between actual demand value and mean demand value divided by the mean demand expressed as a percentage.

$$\text{MAPV} = \frac{\sum \left| D - \frac{\sum D}{n} \right| \text{ x } 100}{\sum D} = \frac{860 \text{x} 100}{6000} = 14.33\%$$

Thus the mean absolute deviation is 7.5 per cent of the mean demand (MAPD) and the variability of demand (MAPV) is 14.33 per cent.

Activity 2.4

Activity

Calculate the forecast for month six using a three-month simple moving average given historical demand for months one to five as follows: 120, 130, 110, 135, and 145.

Activity 2.4 feedback

In this example $n = 3$ and $t = 6$.

$$n = 3,\ t = 6$$

$$F_t = \frac{\text{sum of actual demand values for the chosen number of periods}}{\text{chosen number of periods}}$$

$$= \frac{D_{t-n} + \ldots\ldots + D_{t-2} + D_{t-1}}{n}$$

$$= \frac{D_3 + D_4 + D_5}{3}$$

$$= \frac{110 + 135 + 145}{3}$$

$$= 130$$

Thus, the forecast for month six using a three-month simple moving average is 130.

Activity 2.5

Activity

Calculate the forecast for month six using a five-month simple moving average given historical demand for months one to five as follows: 120, 130, 110, 135, and 145.

Activity 2.5 feedback

In this example $n = 5$ and $t = 6$.

$$n = 5,\ t = 6$$

$$F_t = \frac{\text{sum of actual demand values for chosen number of periods}}{\text{chosen number of periods}}$$

$$= \frac{D_{t-n} + \ldots\ldots + D_{t-2} + D_{t-1}}{n}$$

$$= \frac{D_1 + D_2 + D_3 + D_4 + D_5}{5}$$

$$= \frac{120 + 130 + 110 + 135 + 145}{5}$$

$$= 128$$

Thus, the forecast for month six using a five-month simple moving average is 128.

Activity 2.6

Activity

Calculate the forecast for month six using a three-month weighted moving average given historical demand for months one to five as follows: 120, 130, 110, 135, and 145. Apply weights of 0.2, 0.3 and 0.5. (In other words, apply weights of 20 per cent, 30 per cent and 50 per cent.)

Activity 2.6 feedback

In this example $n = 3$, $t = 6$.

$$n = 3,\ t = 6,\ \ w_3 = 0.2, w_4 = 0.3,\ \ w_5 = 0.5,\ \text{sum of the weights} = 1$$

$$F_t = \frac{\text{sum of (each period's demand value x each period's weight)}}{\text{sum of the weights}}$$

$$F_t = \frac{D_{t-n}w_{t-n} + ... + D_{t-2}w_{t-2} + D_{t-1}w_{t-1}}{w_{t-n} + ... + w_{t-2} + w_{t-1}}$$

$$F_6 = (D_3 \text{ x } W_3) + (D_4 \text{ x } W_4) + (D_5 \text{ x } W_5)$$

$$F_6 = (110 \text{ x } 0.2) + (135 \text{ x } 0.3) + (145 \text{ x } 0.5)$$

$$= 135$$

In this example, the sum of the weights adds up to 1. Thus, the forecast for month six using a three-month weighted moving average is 135 units

Activity 2.7

Activity

Calculate the forecast for month six using exponential smoothing given historical demand for months one to five as follows: 120, 130, 110, 135, and 145. Use an alpha factor α equal to 0.2 and you are given a forecast for month five equal to 130.

Activity 2.7 feedback

$$t = 6, F_5 = 130, D_5 = 145, \alpha = 0.2$$

$$F_t = F_{t-1} + \alpha(D_{t-1} - F_{t-1})$$

$$= 130 + 0.2 \times (145 - 130)$$

$$= 133$$

Thus, the forecast for month six using exponential smoothing with α equal to 0.2 is 133.

Activity 2.8

Month	Demand	x	y	xy	x^2
January	115	1	115	115	1
February	123	2	123	246	4
March	132	3	132	396	9
April	130	4	130	520	16
May	140	5	140	700	25
June	150	6	150	900	36
Sum		**21**	**790**	**2877**	**91**
Average		**3.5**	**131.6667**		

Activity

Given the six months sales data in the following table, develop a trend line using least squares regression analysis. Use the trend line to forecast the next three months.

Activity 2.8 feedback

The data as supplied has demand data for six months. The monthly demand is the independent variable and is assigned to the *x*-axis. The months in the *x*-axis are numbered 1 to 6. The *y*-axis is for the dependent variable and this is the observed demand.

In order to calculate *a, b* and the trend line, the values for *xy* and *x2* are required as shown in the table above.

$$n = 6, \sum xy = 2877, \sum x = 21, \sum y = 790, \sum x^2 = 91$$

$$b = \frac{n\sum xy - (\sum x \sum y)}{n\sum x^2 - (\sum x)^2}$$

$$= \frac{6\text{x}2877 - 21\text{x}790}{6\text{x}91 - 21^2}$$

$$= 6.4$$

$$n = 6, \sum xy = 2877, \sum x = 21, \sum y = 790, \sum x^2 = 91$$

$$a = \frac{\sum y}{n} - b\frac{\sum x}{n}$$

$$= 131.67 - 6.4\text{x}3.5$$

$$= 109.27$$

$\hat{y} = 109.27 + 6.4x$ trend line equation

By using Excel the calculations can be automated. The Excel software requires the data analysis add-in and the calculation is initiated using the Data menu followed by Data Analysis and then Regression. For the Input Y Range select the column of ***y***-values and for the Input X Range select the column of ***x***-values. The output report contains more data than is immediately required and the pertinent values are shown below.

SUMMARY OUTPUT	
	Coefficients
Intercept	109.27
x	6.4

Substituting x=7, x=8 and x=9 into the trend line equation provides the forecast values as shown below.

Month	***x***	**Forecast**
July	7	154
August	8	160
September	9	167

Activity 2.9

Activity

Using the observed demand data for two years is shown in the following table; perform a regression analysis on deseasonalised demand to forecast demand for the winter season in year three.

Year	Season	Observed demand
1	autumn	205
	winter	140
	spring	375
	summer	570
2	autumn	475
	winter	270
	spring	685
	summer	960
Sum of demand		3680
Average demand		460

Activity 2.9 feedback

Start by calculating the seasonal indices for autumn, winter, spring and summer.

The period average demand for autumn is (205 + 475) / 2 = 340

The period average demand for winter is (140 + 270) / 2 = 205

The period average demand for spring is (375 + 685) / 2 = 530

The period average demand for summer is (570 + 960) /2 = 765

The average demand for all periods can be calculated as 3680/8 and is given as 460.

$$\text{seasonal index} = \frac{\text{period average demand}}{\text{average demand for all periods}}$$

$$\text{seasonal index for autumn} = \frac{340}{460} = \mathbf{0.7391}$$

$$\text{seasonal index for winter} = \frac{205}{460} = \mathbf{0.4457}$$

$$\text{seasonal index for spring} = \frac{530}{460} = \mathbf{1.1522}$$

$$\text{seasonal index for summer} = \frac{765}{460} = \mathbf{1.6630}$$

Calculate the deseasonalised demand for each season by dividing the observed demand by the seasonal index for that period as shown in the following table. Then calculate the extended fields for xy and x^2 as shown in the following table.

Year	Season	Observed demand	x	Seasonal index	Deseasonalised demand y	xy	x^2
1	autumn	205	1	0.7391	277.3644	277.3644	1
	winter	140	2	0.4457	314.1126	628.2252	4
	spring	375	3	1.1522	325.4643	976.3929	9
	summer	570	4	1.6630	342.7541	1371.0164	16
2	autumn	475	5	0.7391	642.6735	3213.3675	25
	winter	270	6	0.4457	605.7886	3634.7316	36
	spring	685	7	1.1522	594.5148	4161.6036	49
	summer	960	8	1.6630	577.2700	4618.1600	64
		3680	36	8	3679.9423	18880.8616	204

$$n = 8,\ \sum xy = 18880.8616,\ \sum x = 36,\ \sum y = 3679.9423,\ \sum x^2 = 204$$

$$b = \frac{n\sum xy - (\sum x \sum y)}{n\sum x^2 - (\sum x)^2}$$
$$= \frac{8 \text{ x } 18880.8616 - 36 \text{ x } 3679.9423}{8 \text{ x } 204 - 36^2}$$
$$= 55.2648$$

$$a = \frac{\sum y}{n} - b\frac{\sum x}{n}$$
$$= 460 - 55.2648 \text{ x } 4.5$$
$$= 211.308 \qquad \therefore \hat{y} = 211.308 + 55.2648x$$

Now calculate b, a and the best estimate of $\hat{y} = a + bx$.

Thus the trend line for deseasonalised data is $\hat{y}$ = a + bx = 211.308 + 55.2648x.

Now substitute $\boldsymbol{x}$ = 10 corresponding to winter in the third year to get the deseasonalised value for that period.

when $x = 10$, the deseasonalised value for winter in the third year is

$$\hat{y} = 211.308 + 55.2648x$$
$$= 211.308 + 55.2648 \times 10$$
$$= 763.956$$

By using a program such as Excel, the calculations to get the regression line can be automated. The Excel software requires the data analysis add-in and the calculation is initiated using the Data menu followed by Data Analysis and then Regression.

For the Input Y Range select the column of y-values and for the Input X Range select the column of x-values. The output report contains more data than is immediately required and the pertinent values are shown in the following table.

SUMMARY OUTPUT	
	Coefficients
Intercept	211.308
x	55.2648

The deseasonalised forecast for winter in the third year is:

$$\hat{y} = 211.308 + 55.2648x = 763.956$$

Now multiply by the deseasonalised forecast by the seasonal index to calculate the seasonalised forecast for winter in the third year:

763.956 x 0.4457 = 340.4952 = 340 (0 dp)

Activity 2.10

Activity

Work through the following questions. You may need to go back and re-read the unit to help you.

1. Describe the four components of demand.
2. Explain the difference between qualitative and quantitative forecasting.
3. Describe the strategic importance of forecasting.
4. Describe the use of MAPD and MAPV.
5. Explain how forecasting performance might be measured.
6. Explain the expression, “Forecasting is about understanding variation”.
7. What is the difference between seasonal variation and cyclical variation?
8. Discuss seasonal variation of demand and how an organisation can respond.
9. Explain how the seasonal index is calculated.
10. What strategies are used by airlines, hotels and rental car companies to influence demand?

Activity 2.10 feedback

All answers are in the learning material.

Unit 4

Capacity planning and management

Outcomes

Upon completion of this unit students will be able to:

- *Outline* how capacity is measured and appreciate the dilemma faced by management in matching variable demand with variable capacity.
- *Calculate* various aggregate planning scenarios.
- *Discuss* the strategic planning process.
- *Identify* various strategies for balancing supply with demand.
- *Evaluate* the application of yield management.
- *Discuss* flexibility.
- *Appreciate* the customers psychology in relation to queuing.
- *Discuss* queues and waiting lines.

Reflection 2.3

Reflection

Imagine you are about to launch a new venture. It may be a factory, a restaurant, a medical centre, a retail store, a transport company, a school or a hospital (to name a few examples).

All production and service organisations usually occupy one or more facilities at one or more locations. For this new venture, the following strategic decisions need to be resolved:

1. Where will each facility be located?
2. How large, or small, will each facility need to be?
3. What process technology will be installed at each location?
4. Will the physical size of the facility be sufficient in the short term, medium term and long term?
5. When should capacity increments be installed?
6. What happens if the available capacity is too much?
7. What happens if it is too small?

Reflection 2.3 feedback

All of these questions have a major bearing on the success, or otherwise, of the organisation. If you are capable of getting it right, you will find yourself in an enviable position of being able to capitalise on every opportunity that comes your way (assuming you want to take it) and thus maximise revenues and profits. If you get it wrong, you may find yourself searching for additional capacity at a premium price or being left with excess capacity that you are unable to sell.

Reflection 2.4

Reflection

For the most part, the production planner is given a sales forecast and has to use a pure strategy or a combination of strategies.

Think of three or four capacity or supply planning decisions that the production planner could use to increase/decrease the available capacity.

Reflection 2.4 feedback

- Hiring additional staff and making staff redundant.
- Working variable days a week.
- Working overtime.
- Varying the level of inventory.
- Varying the number of orders in the backlog.
- Varying the length of the queue of customers.
- Using subcontractors to supply additional capacity.
- Outsourcing parts of the business to free up resources.
- Adding or removing temporary capacity.
- Adding or removing permanent capacity.

These are reactive measures and the controllability of these factors depends on union agreements, employment contracts, employment legislation, short-term constraints on physical capacity levels, customer requirements and preferences and the amount of money that can be tied up in inventories.

Activity 2.11

Activity

The data in the following table represents the demand forecast for 12 months commencing January for an organisation.

Month	Demand forecast
Jan	4400
Feb	3200
Mar	4000
Apr	5400
May	6600
Jun	5000
Jul	4000
Aug	3000
Sep	4800
Oct	6400
Nov	7000
Dec	6200
	60000

The organisation currently employs 25 employees. For planning purposes, each employee is capable of making 200 units a month. The cost of hiring additional staff is $600 per employee and the cost of making an employee redundant is $300. A storage charge of $1 per unit is made for inventory on hand at the end of each month. This is to cover the cost of warehousing.

(Please note that the dollar amounts are nominal for planning purposes and no attempt has been made to quantify the actual costs in this example.)

Plan 1: Develop a production plan using a level production strategy.

Plan 2: Develop a production plan using a chase capacity strategy.

Plan 3: Develop a production plan using six months at 4800 and six months at 5200.

Activity 2.11 feedback

Plan 1: Develop a production plan using a level production strategy.

Start this plan by calculating the level production rate. The annual demand is 60,000 and there are 12 monthly periods so that makes 5000 units per month.

In January, the beginning inventory is zero, the production is 5000 and demand is 4400, therefore the ending inventory is 600 units.

In February, the beginning inventory (following on from January) is 600, the production is 5000 and demand is 3200, therefore the ending inventory is 2400 units.

In March, the beginning inventory (following on from February) is 2400, the production is 5000 and demand is 4000, therefore the ending inventory is 3400 units.

Continue like this for the rest of the year.

Month	Beginning inventory on hand	Production	Demand forecast	Ending inventory on hand	Number of employees	New staff	Redundant staff
Jan	0	5000	4400	600	25		
Feb	600	5000	3200	2400	25		
Mar	2400	5000	4000	3400	25		
Apr	3400	5000	5400	3000	25		
May	3000	5000	6600	1400	25		
Jun	1400	5000	5000	1400	25		
Jul	1400	5000	4000	2400	25		
Aug	2400	5000	3000	4400	25		
Sep	4400	5000	4800	4600	25		
Oct	4600	5000	6400	3200	25		
Nov	3200	5000	7000	1200	25		
Dec	1200	5000	6200	0	25		
		60000	**60000**	**28000**			

The inventory storage cost is $28,000, the cost of employing new staff is zero, and the cost of terminating staff is zero to give a total cost for this plan of $28,000.

Plan 2: Develop a production plan using a chase capacity strategy.

In this plan the production rate varies to match the demand pattern and the number of employees is increased or decreased to match the production rate.

In January, the demand forecast is 4400, so production is set to match that rate. Beginning inventory on hand is zero, production matches demand forecast, so the ending inventory on hand is zero. To produce 4400 we need 22 staff (200 units per employee per

month) so three employees are made redundant. Their employment contract would specify the temporary nature of their employment.

In February, the demand forecast is 3200, so production is set to match that rate. Beginning inventory on hand is zero, production matches demand forecast, so the ending inventory on hand is zero. To produce 3200 we need 16 staff (200 units per employee per month) so six employees are made redundant.

In March, the demand forecast is 4000, so production is set to match that rate. Beginning inventory on hand is zero, production matches demand forecast, so the ending inventory on hand is zero. To produce 4000 we need 20 staff (200 units per employee per month) so four employees are hired.

The remaining months are calculated in a similar fashion.

Month	Beginning inventory on hand	Production	Demand forecast	Ending inventory on hand	Number of employees	New staff	Redundant staff
Jan	0	4400	4400	0	22		3
Feb	0	3200	3200	0	16		6
Mar	0	4000	4000	0	20	4	
Apr	0	5400	5400	0	27	7	
May	0	6600	6600	0	33	6	
Jun	0	5000	5000	0	25		8
Jul	0	4000	4000	0	20		5
Aug	0	3000	3000	0	15		5
Sep	0	4800	4800	0	24	9	
Oct	0	6400	6400	0	32	8	
Nov	0	7000	7000	0	35	3	
Dec	0	6200	6200	0	31		4
		60000	60000	0		37	31

The inventory storage cost is zero, the cost of employing new staff is $22,200, the cost of terminating staff is $9,300 to give a total cost for this plan of $31,500.

Plan 3: Develop a production plan using six months at 4800 and six months at 5200.

The calculations for this strategy follow the same pattern as plan 1 and 2 except that the production rate is set at 4800 for the first six months and then increases to 5200 for the rest of the year. This represents a starting position in trying to optimise the plan. The number of employees is increased or decreased to match the production rate.

Month	Beginning inventory on hand	Production	Demand forecast	Ending inventory on hand	Number of employees	New employees	Redundant employees
Jan	0	4800	4400	400	24		1
Feb	400	4800	3200	2000	24		
Mar	2000	4800	4000	2800	24		
Apr	2800	4800	5400	2200	24		
May	2200	4800	6600	400	24		
Jun	400	4800	5000	200	24		
Jul	200	5200	4000	1400	26	2	
Aug	1400	5200	3000	3600	26		
Sep	3600	5200	4800	4000	26		
Oct	4000	5200	6400	2800	26		
Nov	2800	5200	7000	1000	26		
Dec	1000	5200	6200	0	26		
		60000	60000	20800		2	1

The inventory storage cost is $20,800, the cost of employing new staff is $1,200, the cost of terminating staff is $300 to give a total cost for this plan of $22,300.

Activity 2.12

Activity

When you are waiting in a queue, it often feels like you are waiting for a very long time. Make a list of possible reasons why a customer perceives the wait time is longer than it actually is.

Activity 2.12 feedback

Johnson and Clark identified that the customer often perceives that the time in the queue is longer than it really is. They observed the following:

- Unoccupied time feels longer than occupied time.
- Pre-process waits feel longer than in-process waits.
- Anxiety makes the wait seem longer.
- Uncertain waits are longer than known, finite waits.
- Unexplained waits seem longer than explained waits.
- Unfair waits are longer than equitable waits.
- The more valuable the service, the longer the customer waits.
- Solo waiting feels longer than group waiting.
- Uncomfortable waits feel longer than comfortable waits.
- New or infrequent users feel they wait longer

Activity 2.13

Activity

1. What does the term “capacity” mean?
2. How does capacity differ from capability?
3. Why is capacity management strategically important?
4. The management of capacity for services is more difficult than for manufacturing. Why?
5. Describe the capacity considerations for a hospital and identify how this is different from a manufacturing unit.
6. What are the possible consequences of demand rate being different from design capacity rate?
7. What is yield management?
8. What industries use yield management and why?
9. Describe three strategies for expanding capacity.

Activity 2.13 feedback

All answers are in the learning material.

Assignment 1

Assignment

There are three questions in this assignment.

Question 1 40 marks

a. Lowering prices can increase demand for products or services, but it also reduces profit margins if the product or service cannot be produced at lower cost. Briefly discuss how an operations manager should approach his or her job when **competing on cost**.

b. Quality is a dimension of a product or service that is defined by the customer. Today, more than ever, quality has important market implications. Briefly discuss how an operations manager should approach his or her job when **competing on quality**.

c. As the saying goes, "time is money." Some companies do business at "Internet speed", while others thrive on consistently meeting delivery promises. Briefly discuss how an operations manager should approach his or her job when **competing on time**.

d. Flexibility is a characteristic of a firm's operations that enables it to react to customer needs quickly and efficiently. Some firms give top priority to flexibility. Briefly discuss how an operations manager should approach his or her job when **competing on flexibility**.

Answer to Assignment Question 1

a. Competing on cost 10 marks

An organisation may elect to compete purely on the basis of cost. It could achieve this by lowering prices to increase demand for products and services. However, this approach also reduces profit margins if the product or service cannot be produced at a lower cost.

Cost advantage can be gained by adopting lean thinking and cutting the cost of non-value-adding activities in the value chain. This may require additional investment in automation, a streamlining of

procedures, additional training and development, and usually results in a narrower range of products or services.

A “no frills” airline competes on the basis of cost by reducing fares for the base service — travel with no checked bags, no free food and receive just music entertainment. A customer can obtain a very cheap fare if the travel portion is all they want. If, however, the customer wants more than that they can pay extra for checked bags, food and drinks and video on demand.

Guide to marker: Look for what the operations manager should do when competing on cost.

Some students may suggest the manager should buy the cheapest, but this is not necessarily competing on cost. When competing on cost the firm delivers exactly what the customer wants (no more than the minimum requirement) and the process for delivery aims to eliminate unnecessary cost elements. Therefore the manager should implement lean thinking ideas.

b. Competing on quality 10 marks

An organisation may elect to compete purely on the basis of quality. Two aspects of quality have to be considered: high performance design which includes superior features, close tolerances, and greater durability, and consistent quality which measures the frequency with which the product meets design specifications.

Customers want products that consistently conform to the specifications they contracted for, have come to expect, or saw advertised. An organisation can achieve product differentiation by developing expertise in product quality and process quality. The aim is to provide superior performance products that meet the specifications and are reliable.

Car companies such as Toyota and BMW compete on the basis of quality since the concepts of quality feature at the top of their priority lists. Note that both these companies will argue that they compete on other issues and not solely on quality.

Guide to marker: Look for what the operations manager should do when competing on quality. This means the manager should ensure that the product design includes all features required by the customer and the production process is close to error-free.

c. Competing on time 10 marks

An organisation may elect to compete purely on the basis of time. This involves a short delivery time which is the elapsed time between receiving a customer’s order and filling it. Firms can shorten delivery lead times by storing inventory or having excess capacity. It also involves on-time delivery which measures the

frequency with which delivery-time promises are met. Organisations measure on-time delivery as the percentage of orders shipped when promised.

On-time delivery requires the product or service to be delivered at the first customer-requested delivery time. Firms may convince themselves they are meeting delivery promises by shipping goods out the door on or before the delivery promise date and time. However, the customer does not see it this way. Customers want the product or service and they will measure on-time delivery as being the actual time the product is delivered to their location.

International courier companies use parcel tracking technology to identify the exact location of all their deliveries and they promise delivery on time. Their technology reduces the chance of losing a parcel or misdirecting it.

Another aspect of competing on the basis of time is product development speed which measures how quickly a new product is introduced. This includes the elapsed time from idea generation through to final design and production. Getting a new product to market first gives a firm an edge on the competition and this is difficult to overtake in a rapidly changing business environment.

Guide to marker: Look for what the operations manager should do when competing on time. This means that the manager is improving processes to reduce lead times, delivery times and new product development times.

d. Competing on flexibility 10 marks

An organisation may elect to compete purely on the basis of flexibility. Flexibility allows a firm to change volumes quickly or change products quickly to suit customer requirements. This is also referred to as customisation, which is the ability to accommodate the unique needs of each customer and changing product designs. Products are tailored to individual preferences. Customisation implies the operating system must be flexible to handle specific customer needs and changes in designs. Volume flexibility is the ability to accelerate the production rate quickly to handle large fluctuations in demand. The time between peaks may be years as in the construction industry, months as with a ski resort, or hours as with a postal sorting firm.

Dell computers are a good example of competing on flexibility. At the time a customer places an order for a Dell computer the actual computer does not physically exist. Dell has the manufacturing capability to assemble exactly what the customer wants and ship it to them within a few days. They facilitate this flexibility by pricing the configurations in favour of the components they can deliver. If a component (memory, hard drive or screen) is in short supply they will offer that component at a higher price and customers will be

encouraged to choose another component at a lower price and the alternative may be at a higher specification, which is even better.

Guide to marker: Look for what the operations manager should do when competing on flexibility. This means improving processes to reduce batch sizes and reducing set-up times, arranging for suppliers to deliver frequently and generally moving towards batches of one.

Question 2 30 marks

a. Provide three questions that should be considered when developing the objectives of a forecast.

b. Name three different models that could be developed and tested during the forecasting process.

c. What does "applying the model" mean?

d. Explain, using an example, the forecasting step "considering real-world constraints on the model's application".

e. Explain how one might "revise and evaluate the forecast".

f. What is the most important rule of forecasting, and what should we be trying to achieve?

Answer to Assignment Question 2

a. Provide three questions that should be considered when developing the objectives of a forecast. **6 marks**

What is the purpose of the forecast?

What variables are to be forecast?

Who will use the forecast?

What is the time frame for the forecast – long or short term?

How accurate should the forecast be?

When is the forecast needed?

b. Name three different models that could be developed and tested during the forecasting process. **6 marks**

Moving average

Weighted moving average

Exponential smoothing

Regression analysis.

c. What does "applying the model" mean? **4 marks**

After the model is tested, historical data about the problem are collected. These data are applied to the model, and the forecast is obtained. Great care should be taken so that the proper data are used and the model is applied correctly.

d. Explain, using an example, the forecasting step "considering real-world constraints on the model's application". **4 marks**

A model may predict that sales will double in the next three years. Management therefore expands the plant, but does not think about the impact this increase will have on the distribution system. What if the company cannot move the increased volume? What about raw material availability, and actions such as price-cutting by competitors.

e. Explain how one might "revise and evaluate the forecast". **4 marks**

The technical forecast should be tempered with human judgement. What relationships might have changed?

f. What is the most important rule of forecasting, and what should we be trying to achieve? **6 marks**

Forecasts are always wrong, and it is better to plan for this by having a range as a forecast, than a definitive number. This will make it easier to have contingency plans drawn up. With forecasting we are trying to minimise the size of the forecast deviation.

Question 3: 30 marks

The actual number of guests staying at an exclusive lodge has been as follows:

Quarter	Year	Actual
Summer	1	73
Autumn	1	104
Winter	1	168
Spring	1	74
Summer	2	65
Autumn	2	82
Winter	2	144
Spring	2	52
Summer	3	89
Autumn	3	146
Winter	3	205
Spring	3	98
Total		**1300**

a. Calculate seasonal indices using the above data.

b. Deseasonalise the above data, and determine the regression equation.

c. Using the regression equation determine the forecasts for year four.

Answer to Assignment Question 3

The actual number of guests staying at an exclusive lodge has been as follows:

Quarter	Year	Actual Guests	Seas. Ave	Seas. Index	Deseas. Demand		
Summer	1	73	75.6667	0.6985	104.5154		
Autumn	1	104	110.6667	1.0215	101.8072		
Winter	1	168	172.3333	1.5908	105.6093		
Spring	1	74	74.6667	0.6892	107.3661		
Summer	2	65		0.6985	93.0617		
Autumn	2	82		1.0215	80.2711		
Winter	2	144		1.5908	90.5222		
Spring	2	52		0.6892	75.4464		
Summer	3	89		0.6985	127.4229		
Autumn	3	146		1.0215	142.9217		
Winter	3	205		1.5908	128.8685		
Spring	3	98		0.6892	142.1875	**Deseas. Forecast**	**Seas. Forecast**
Total		**1300**					
				0.6985	13	130.5345	91
Total Average		108.333333		1.0215	14	133.9500	137
				1.5908	15	137.3655	219
Slope		**3.4155**		0.6892	16	140.7810	97
y-intercept		**86.133**					

a. Calculate seasonal indices using the above data. **10 marks**

0.6985

1.0215

1.5908

0.6892

b. Deseasonalise the above data, and determine the regression equation. **10 marks**

Deseasonalised data is column six above.

Y = 86.133 + 3.4155 (four decimal places)

c. Using the regression equation determine the forecasts for year four. **10 marks**

Forecast data is column eight above.

Module 3

Processes and products

Outcomes

Upon completion of this module students will be able to:

- *Distinguish* between value-adding and cost-adding processes.
- *Describe* process thinking and the strategic importance of process.
- *Describe* the perfect process.
- *Perform* statistical process control calculations.
- *Describe* the concepts of lean thinking.
- *Describe* various models for developing products.
- *Explain* the relationship between uncertainty and risk in product development together with robust design and participative product development.
- *Define* quality and the characteristics of a total quality management programme.
- *Discuss* various quality management frameworks.
- *Discuss* process capability and six sigma quality.

Unit 5

Designing processes

Outcomes

Upon completion of this unit students will be able to:

- *Analyse* the service-profit chain
- *Identify* value in a process
- *Distinguish* between value-adding and cost-adding processes
- *Describe* the strategic service vision
- *Identify* the characteristics of service operations
- *Develop* strategic decisions for process
- *Describe* the product-process matrix
- *Describe* the process industries.

Activity 3.1

Activity

Work through the following list of customer classifications (Johnson & Clark, 2008, p. 58) and try and link each one with a person you know or have met in the past.

Title	Description	Your example
Ally	Arrives in a positive frame of mind, willing to help and provide feedback to facilitate a better service. The happiness of the ally rubs off onto other customers who believe the service must be good.	
Hostage	This customer feels "locked in" contractually and requires the service but has no choice or has a potential financial penalty if he/she goes elsewhere.	
Anarchist	Simply dislikes rules and systems and will object to being told to do something, or will get upset at having to fill in forms without any rhyme or reason.	
Patient	This is the type of customer who already belongs to the organisation and feels they have little chance of escape.	
Tolerant	Will quietly sit and wait for service. They may be passive and are usually ignored. They may not jump up and down and demand immediate service that other customers demand. They will sit quietly and wait.	
Intolerant	Will not sit quietly and wait. They often cause stress and problems. The intolerant customer makes their presence and requirements known. They may not be very clear or even coherent in describing what they want, but they will make sure that	

	supply service staff are handling their problem.	
Victim	This is the recipient of a product or service when something goes wrong. They seem to attract bad luck. The process fails and for some reason the victim just happens to be the customer. It is hard to predict exactly how a victim will react.	
Terrorist	Mounts a damaging attack when you least expect it. The terrorist is a real danger as they will strike without warning and inflict as much damage as possible. They will announce their displeasure knowing other customers are listening.	
Incompetent	This customer is confused by procedures. Often the incompetent will be a first-time customer and simply does not know what to do. They may stumble around looking for answers and may do irreparable damage as they go.	
Champion	Is supportive, helpful and positive. The champion is more than an ally and goes out of their way to be helpful, co-operative and friendly. Every organisation needs champions.	

Activity 3.1 feedback

Activity 3.1 required you to think of your own examples of customer types.

Activity 3.2

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. Describe the strategic importance of process design.
2. Discuss the concept of process value.
3. Distinguish between job shop, batch, repetitive and continuous processes.
4. Describe the service-profit chain.
5. Distinguish between cost-adding and value-adding processes.
6. Discuss the impact of technology on process design.
7. Describe process flow scheduling.

Activity 3.2 feedback

All answers are in the learning material.

Unit 6

Improving processes — lean thinking

Outcomes

Upon completion of this unit students will be able to:

- *Describe* the strategic importance of process.
- *Describe* process thinking.
- *Prepare* process flow diagrams.
- *Identify* process variability.
- *Describe* the perfect process.
- *Describe* the steps for process improvement.
- *Describe* and use the seven basic tools of quality.
- *Describe* the concepts of lean thinking.
- *Apply* lean thinking ideas to services.

Activity 3.3

Activity

Make a list of two or three processes you are familiar with or choose an example below. Write down the input variables, the uncontrolled transformation variables, the controlled transformation variables and the output variables.

You may choose any process, but here are a few suggestions:

- An order being received from a customer.
- A house being built as a “spec build” (that is, built before a customer signs the order to buy it).
- A sports team being chosen.
- A letter being posted and delivered.

Activity 3.3 feedback

Consider an order being received from a customer:

- Variable inputs include the method of order receipt (email, fax, postal service, telephone, sales representative, customer service representative), the completeness of the order and the accuracy of the order.
- Controlled process variables include the amount of training given to the person receiving the order, the amount of

inventory on hand, the shipping methods available and the delivery date promised.

- Uncontrolled process variables include the attitude of the person taking the order, the day of the week, the season of the year, the customer-required date, the shift and the service team.
- Process output variables include the correctness of the order, the delivery time and the package quality.

Activity 3.4

Activity

Make a list of the steps you would introduce to an organisation that was implementing a lean thinking approach to production.

Compare your answers to the model at the end of the module.

Activity 3.4 feedback

The activities in a lean environment include:

- Developing strategies for dealing with highly variable demand.
- Focusing on reducing variability and reducing the impact of variability on production.
- Levelling the schedule for both volume and mix.
- Creating a flow of products that supports the drumbeat of expected customer deliveries.
- Monitoring customer order patterns and validating daily production.
- Producing to customer orders whenever possible at the exact day's mix using load-levelling techniques.
- Driving improvement activities so all processes can produce smaller quantities at shorter intervals.
- Creating a true mixed-model schedule as well as more repetitive demand for components being pulled from upstream processes.

Activity 3.5

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. Discuss the strategic value of lean thinking.
2. Describe the seven wastes.
3. Describe the perfect process.
4. Discuss lean thinking applied to services.
5. Discuss process variability.

Activity 3.5 feedback

All answers are in the learning material.

Unit 7

Product design

Outcomes

Upon completion of this unit students will be able to:

- *Describe* the Kano model.
- *Explain* how the voice of the customer should be used in product design.
- *Explain* quality function deployment.
- *Discuss* structured product development processes.
- *Explain* the relationship between uncertainty and risk in product development.
- *Describe* the product development portfolios.
- *Explain* robust design.
- *Explain* participative product development or concurrent engineering.

Activity 3.6

Activity

Think back a few years when mobile phones that take digital photographs were introduced. Consider who wanted one. Designers introduced a “wow” factor that truly caught the imagination of millions of customers worldwide.

Now put yourself on the design team of the early models. What would you do first? How would you introduce this product?

What features would you include/exclude?

How would you sell the concept and convince people of the benefits?

Activity 3.6 feedback

With this activity you were asked to imagine yourself as part of the design team that developed mobile phones that take photographs.

The primary function of the mobile phone is to make and receive phone calls. However, with products like this, the marketing function may often try to develop a “wow” factor (this is a feature or a characteristic of the products that really catches the

imagination of the customer and makes it imperative that the customer purchases the product).

This definitely happened with the camera feature on mobile phones. It is hard to say exactly what should be done first since each example may provide a different set of circumstances and thus a different end result. Definitely two things have to happen: the technology has to work and the customers have to recognise a need for the particular feature and demand the feature.

The introduction of the feature is usually in a test market or to a group of friendly customers who can provide feedback on why they like it or why they do not like it. This introduction phase also provides valuable information that the marketing function will need when the feature is launched across more markets or to more potential customers. The duration of this introduction and market testing may take several months or even years depending on how well the feature is accepted and how the technology develops.

Think of these ideas when you read the next section of the course on Kano models and voice of the customer.

Activity 3.7

Activity

Use the **house of quality model** for the design of a laptop computer.

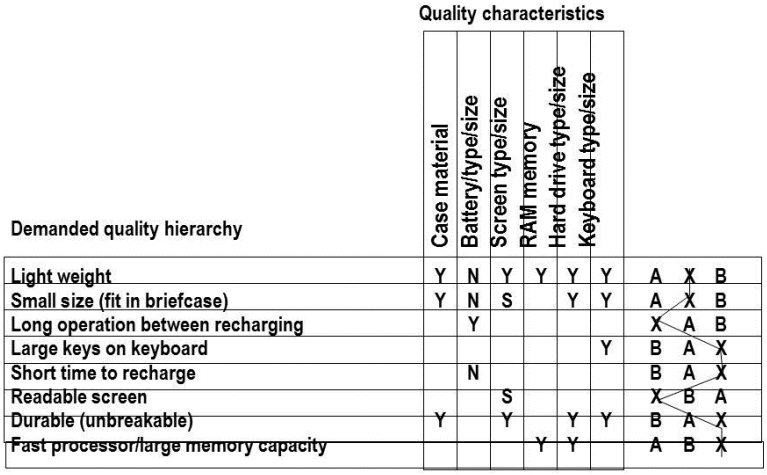
1. Start by making a list of customer requirements that will form the demanded quality hierarchy. Customer requirements state in customer terminology exactly what the customer wants with their laptop computer. List five-to-eight features a customer might want from their laptop computer.
2. Then list the quality characteristics that constitute the technical response to the demanded quality. This will be a list of five-to-eight design attributes the designer would incorporate in the laptop computer. Use generic terms such as “display type” and “memory type”.
3. Prepare the relationships matrix relating the demanded quality hierarchy with the quality characteristics hierarchy. For each entry in the demanded quality hierarchy indicate whether or not the quality characteristics have answered the customer need. For this activity just use general terms such as “yes”, “no”, “somewhat” and “mostly”.
4. Develop the quality planning table or competitive assessment which provides a qualitative benchmark comparison with other products, solutions and methods. To do this, imagine you have two competitive products in the market. They are A and B and your product is designated X. Now, for each demanded quality characteristic, rank the three products by how well they answer the customer need. (Note, this is purely hypothetical since you do not have the details of the competitive products.)
5. Construct the design planning table with the target values the design team is trying to reach. To do this properly you would need to be a designer with computer design skills. For this activity, this is not necessary. Just quantify each quality characteristic.
6. Finally, consider the correlation of technical requirements to support or impede product design. Do this by evaluating the quality characteristics for compatibility and non-compatibility.

Activity 3.7 feedback

1. The list of customer requirements that will form the demanded quality hierarchy for the laptop could include:
    - light weight (less than 2 kg)
    - small size (fit in briefcase)
    - long operation between recharging (last for one day's usage)
    - large keys on keyboard (enter data with big fingers)
    - short time to recharge (less than two hours)
    - readable screen (even in full sunlight)
    - durable (unbreakable)
    - fast processor/large memory capacity.
2. The list of the quality characteristics that constitute the technical response to the demanded quality might include:
    - case material
    - battery type and size
    - screen size and type
    - RAM memory
    - hard drive type and size
    - keyboard type and size.
3. Prepare the relationships matrix relating the demanded quality hierarchy with the quality characteristics hierarchy. At the intersection between each entry in the demanded quality hierarchy and each entry in the quality characteristics we have entered a Y for "yes", an N for "no", an S for "somewhat" and we have not used "mostly". In cases where the relationship does not exist we have left blank.

	Quality characteristics					
Demanded quality hierarchy	Case material	Battery/type/size	Screen type/size	RAM memory	Hard drive type/size	Keyboard type/size
Light weight	Y	N	Y	Y	Y	Y
Small size (fit in briefcase)	Y	N	S		Y	Y
Long operation between recharging		Y				
Large keys on keyboard						Y
Short time to recharge		N				
Readable screen			S			
Durable (unbreakable)	Y		Y		Y	Y
Fast processor/large memory capacity				Y	Y	

4. Develop the quality planning table or competitive assessment which provides a qualitative benchmark comparison with other products, other solutions and other methods. Two competitive products are marked A and B and your product is marked X. For each demanded quality characteristic, the three products are ranked by how well they answer the customer need. (Note, this is purely hypothetical since you do not have the details of the competing products.) A joining line is created to show your product X.



5. The design planning table will have the target values that the design team is trying to reach and this is written in the basement part of the house. We have not included these values since this requires technical computer design skills

6. Finally, the correlation of technical requirements to support or impede product design does not, in this case, suggest any negative correlation.

Activity 3.8

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. How is the problem of technology choice related to process selection and product design?
2. How much detailed technical knowledge on the part of managers is required to make a decision regarding selection of computer hardware?
3. Suppose you need to select a computer terminal to use in your office. What performance characteristics of the technology would you assess? How would you get the necessary information to make the decision?
4. What is the main obstacle to using a manufacturing approach to the delivery of services?

Activity 3.8 feedback

1. How is the problem of technology choice related to process selection and product design?

   Technology choice has a significant effect on process selection and product design. Technology choice is sometimes called manufacturing geometry and, in simple terms, means the combination and sequencing of production machines and the labour requirements to make it all happen.

   So, if we have a fully automated line with robotic machines, the product has to be capable of being made and assembled using automated lines and robots.

   If the product is to be produced using human labour with little or no automation, the process design has to be designed so as to minimise the labour effort.

   Technology choice decision is usually made first, followed by process selection and product design. Simultaneous engineering (or concurrent engineering) is the term applied to the simultaneous design of process and product.

2. How much detailed technical knowledge on the part of managers is required to make a decision regarding selection of computer hardware?

Strict technical knowledge is not required, but the manager needs to ask questions and be assured that the answers are satisfactory. Often with technical products (such as computers) managers are afraid to ask questions because it makes them look stupid. The reality is that managers should ask all the questions and insist on satisfactory answers.

3. Suppose you need to select a computer terminal to use in your office. What performance characteristics of the technology would you assess? How would you get the necessary information to make the decision?

   For an exercise like this you should develop a checklist and make sure the essential items on that list are being addressed. If you have used a computer terminal before you probably have some idea of the requirements. If not, you should check with people who have used a computer terminal in similar circumstances to your planned usage.

   Typical characteristics relate to hardware properties and software capability, the type of technology proposed and technical issues such as screen clarity, definition, colours, reliability, service and so on.

4. What is the main obstacle to using a manufacturing approach to the delivery of services?

   In most cases in this course we have not made a distinction between manufacturing and services because the general principles of operations management can be applied to both. With manufacturing, the output is usually tangible, the customer is not present during production, the product is produced and then consumed and any errors can be corrected before the customer is aware an error has occurred. The opposite applies to services because the output is usually not tangible, the customer is often present during the production phase, the product is often produced and consumed simultaneously and the customer is present when errors occur.

Unit 8

The concept of quality

Outcomes

Upon completion of this unit students will be able to:

- *Define* quality.
- *Define* the characteristics of a total quality management programme.
- *Discuss* the four traditional categories of quality costs.
- *Distinguish* between inherent capability and capability to meet specifications.
- *Explain* the process capability ratio C_p.
- *Explain* the process capability index C_{pk}.
- *Discuss* six sigma quality.
- *Explain* the concept of design for six sigma.

Activity 3.9

Activity

Classify the following costs as:

- external failure costs,
- internal failure costs,
- appraisal costs, or
- prevention costs.

Activity 3.9 feedback

Example	Type of cost
A manufacturer realises that there is a potential fault in their products and issues a product recall to correct it.	External failure cost.
Purchasing works with suppliers to ensure the required standard of raw materials are delivered.	Prevention cost.
Testing equipment is maintained for accuracy.	Appraisal cost.
A production run produces product that	Internal failure cost.

Example	Type of cost
does not meet specification and has to be run again.	
A customer claims a replacement product while under warranty.	External failure cost.
A staff training course is run to introduce new procedures.	Prevention cost.
A sample is tested and the incorrect measurements taken, so another sample has to be tested.	Internal failure cost.
Inwards goods are inspected on arrival to ensure they meet specification.	Appraisal cost.
Reject material has to be disposed at a hazardous materials dump.	Internal failure cost.
A new product is designed so that it can easily be manufactured with current equipment.	Prevention cost.
A customer tells a friend they have received poor service from a firm and discourages the friend from using that service.	External failure cost.
A new production process is tested to ensure it is capable of meeting specification.	Appraisal cost.

Activity 3.10

Activity

Calculate the process capability for the following examples:

If specifications say the oven temperature must be 175 ± 5°C and the standard deviation of temperature readings is 0.9°C. Calculate C_p.

If specifications say the oven temperature must be 175 ± 5°C and the standard deviation of temperature readings is 0.9°C.

Calculate C_{pk} if currently the process mean is 177°C.

Activity 3.10 feedback

$$C_p = \frac{\text{Upper Tolerance Limit - Lower Tolerance Limit}}{6\sigma}$$

$$= \frac{(175 + 5) - (175 - 5)}{6 \text{ x } 0.9}$$

$$= \frac{180 - 170}{5.4}$$

$$= 1.85$$

The closest tolerance limit in this example is the upper tolerance limit (175 + 5 = 180)

$$C_{pk} = \frac{\text{Upper Tolerance Limit - the current process mean}}{6\sigma}$$

$$= \frac{(175 + 5) - 177}{3 \text{ x } 0.9}$$

$$= \frac{3}{5.4}$$

$$= 0.56$$

Activity 3.11

Activity

Work through the following questions. You may need to go back and re-read the unit to help you.

1. What is quality?
2. Are the traditional costs of quality appropriate in today's business environment? Explain your response.
3. Explain process capability.
4. Explain how six sigma quality could be used by an organisation to improve its competitive position.

Activity 3.11 feedback

All answers are in the learning material.

Assignment 2

Assignment

There are four questions in this assignment.

Question 1 50 marks

Cole & Sons Shoemakers Co. Ltd. is a shoemaking company established by the entrepreneur, Edward Cole, in the 1950s. The company has been designing and producing leather shoes and supplying them to various retailers including specialty shoe stores and department stores throughout the country for nearly 60 years. In the early 1970s, the business went through a major change in its operations. David and John Cole, Edward's two sons, introduced changes which has led the company into rapid diversification (also producing sports and leisure shoes) and growth from a localised shoe producer into a major player in the global shoe market.

However, the core vision and direction of the company has not changed. It remains a high-volume, low-customisation shoe producer whose aim is to minimise costs. Also, Edward (as an entrepreneur) always believed that if you keep a high level of inventory, you can minimise dissatisfaction from customers.

About a year ago Edward retired, and David (a natural leader with excellent interpersonal skills) assumed the position of president, while John (skilled in operations management) remained as director of operations.

The brothers always dreamed of radically changing the company's operations style to better suit the needs for survival in today's business environment (they started by changing the name of the company into Sneakers.com). One day, John approached David and suggested the change of their operations into a lean thinking (just in time production) environment.

Help John explain the theory of lean thinking to David (assuming David has no explicit knowledge on this topic) in a simple way. Enhance your explanation with an appropriate analogy or example.

Answer to Assignment Question 1

Cole & Sons Shoemakers Co. Ltd.

John should explain to David that lean thinking as a philosophy of operations:

- eliminates waste
- involves everyone
- seeks continuous improvement.

John should explain to David that lean thinking is a set of techniques for managing operations, including:

- basic working practices
- design for manufacture
- operations focus
- small simple machines
- layout and flow
- total productive maintenance
- set-up reduction
- total people involvement
- visibility
- JIT supply.

John should explain to David that lean thinking as a method of planning and control has:

- pull scheduling
- Kanban control
- levelled scheduling
- mixed modelling
- synchronisation.

Question 2 30 marks

"The only acceptable performance is zero defects." Discuss the application of that phrase to each of the following situations:

- surgeons performing elective surgery
- builder constructing a house
- machinists fabricating automobile engines
- lawyers defending accused child molesters
- grocers stocking the supermarket deli display
- investment counsellors giving financial advice
- police officers apprehending a suspect
- Inland Revenue Department (government tax collection) recording tax payments
- merchants selling exercise equipment
- students completing an assessed assignment.

Answer to Assignment Question 2

All except the last one: Expect students to demand error-free performance from surgeons, lawyers and other professionals. A builder building a house may allow the owner to occupy the dwelling and make minor corrections as faults are discovered. In larger construction projects a contingency is often held back (sometimes 10 per cent) to use as a lever for satisfactory project completion. Police officers must go “by the book”, and exercise equipment merchants must exhibit honest sales tactics.

On the last one, however, students hedge a bit as their own performance is called into question. We've started lively class discussion by posing the question, “If zero-defect performance is so important when you consume goods and services, why aren't you willing to provide it?”

Question 3 10 marks

How do you determine quality in products?

For example, how do you distinguish a good car (or piece of furniture, garment, medicine or golf ball) from a bad one? Does the item’s price influence your thinking? What are society’s beliefs regarding a relationship between price and quality? Are these beliefs realistic?

Answer to Assignment Question 3

This exercise begins with the appearance of an individualistic response, then turns to direct student attention to the price/quality relationship. Generally, society believes there is a positive correlation between the price of an item and its quality. When we have nothing else to use as a “measure” of quality, we often look at its price relative to that of competing brands and infer the level of quality.

In examining the degree to which these beliefs are realistic, we must ask two questions:

1. Does the price reflect cost of manufacture or simply more profit on low-cost items?
2. What is the true quality/cost relationship? Increasingly, evidence suggests that high quality costs less to produce, not more.

Guide to markers: It is difficult to pre-assign marks to this question since we are looking for an appreciation of what quality actually is. So we are looking for a convincing argument.

Question 4 10 marks

How do you determine quality in services?

For example, how do you distinguish between a good lawyer (or accountant, lecturer, athlete, hairdresser or surgeon) from a bad one? Does the service price (fee charges or salary received) have any influence on your thinking? Does society pay the same attention to price when judging the quality of services as it does in the case of goods? Why or why not?

Answer to Assignment Question 4

We've directed student thinking to the price/quality relationship. For services, there is evidence of an even stronger belief that high price denotes high quality. With services, we've less to measure and therefore tend to rely more on surrogate measures such as price.

Guide to markers: It is difficult to pre-assign marks to this question since we are looking for an appreciation of what quality actually is. So we are looking for a convincing argument.

Module 4

Inventory, supply chain, projects and measurements

Outcomes

Upon completion of this module students will be able to:

- *Explain* the reason for having inventory.
- *Explain* various inventory models including sales and operations planning, material requirements planning (MRP) and manufacturing resource planning (MRP II).
- *Discuss* the theory of constraints.
- *Define* supply chain management from a strategic view.
- *Discuss* the bullwhip effect or demand amplification.
- *Define* collaborative supply chains.
- *Describe* the nature of project management and the strategic nature of projects.
- *Describe* project organisation structures.
- *Discuss* the critical chain method.
- *Describe* measurements for business excellence.
- *Describe* the Hoshin process for setting goals and using measurement systems.
- *Describe* the balanced scorecard approach to performance measurement.

Unit 9

Inventory planning and management

Outcomes

Upon completion of this unit students will be able to:

- *Explain* the reason for having inventory.
- *Explain* why the economic order quantity is not appropriate for modern business.
- *Describe* a fixed-order quantity model and a periodic review model.
- *Describe* how lead times and safety stock affect inventory management.
- *Describe* the process for sales and operations planning.
- *Describe* material requirements planning (MRP).
- *Describe* manufacturing resource planning (MRP II).
- *Explain* a bottleneck process.
- *Discuss* the theory of constraints.
- *Explain* the theory of constraints logical thinking process.
- *Discuss* the drum-buffer-rope.
- *Describe* the operations scheduling process.
- *Differentiate* between backward and forward scheduling.

Activity 4.1

Activity

Now that we have introduced the subject, reflect on what inventory does for an organisation. Think of an organisation with which you are familiar and try answering these questions:

1. How much inventory should the organisation have?
2. When should you pay for it?
3. How much should you pay for it?
4. What happens if you have too much inventory?
5. What happens if you have too little inventory?
6. Where is inventory stored?
7. How much storage space is required?
8. How is inventory transported?
9. How much inventory is transported at one time?
10. How is inventory stored?
11. What happens if the inventory is a hazardous substance (or dangerous to handle)?
12. How do you keep track of what inventory you have?
13. What is the value of the inventory you have?
14. What can you do with the inventory you do have?
15. We could consider many more questions at this stage but the above give some idea of where we are heading.

Activity 4.1 feedback

Inventory costs money so when an organisation obtains more inventory it costs it more money. If it obtains a lot more inventory it costs it a lot more money. That money is now tied up with the inventory investment and cannot be used for any other purpose. While inventory is being held it may appreciate in value but, more than likely, it will depreciate. Appreciation arises in times of rising prices and currency fluctuations. Depreciation is more common as customers are not prepared to pay full price for something that is not brand new or fresh.

Inventory hides problems and compensates for poor delivery performance, high levels of scrap and rework, poorly maintained equipment, incorrect quantities used and supplied, and poor buying

decisions. Inventory, in this sense, encourages ineffective behaviour and poor performance.

Inventory requires storage places. Warehouses, storage sheds, retail shelves, containers and transport systems are built to hold and manage inventory. This is a real concern when the items held are large, bulky and carry little value. Foam used in packaging and upholstery is an example of a product made almost entirely of air that is relatively cheap to make but expensive to store.

Inventory slows production as batches of product move through production systems. When more inventories are used, transport systems are bigger, slower, clumsier and less able to cope with changing customer demands.

Inventory encourages obsolescence or may even become obsolete. The use-by date on supermarket items encourages households to buy in smaller quantities and hold smaller quantities in their homes to prevent the goods expiring.

Inventory requires special handling conditions and may be hazardous to store. Dangerous chemicals and flammable liquids need specially constructed storage areas and staff need specialist training when handling and using these items.

Inventory is counted, administered, managed and may also be insured against loss. These actions take time and money for the people involved.

Activity 4.2

Activity

Now that we have introduced the subject of material requirements planning, try answering this question:

What data is required to develop a very basic MRP?

Activity 4.2 feedback

Material requirements planning (MRP) is a set of techniques that uses the master production schedule, bills of material and inventory data to calculate the requirements of component materials.

MRP uses the master production schedule which is the list of products, quantities and dates for the next few months. It starts with each specific item and quantity listed and calculates the quantities of all components and materials required to make those items and the date those items must be available for use.

To calculate the quantities of all components and materials required it uses the bill of materials indicating the quantities of components to be used to make each product. Bills of materials are also called formulas, recipes, formulations or ingredient lists.

MRP explodes the bill of material, adjusts for inventory quantities on hand or already on order, and calculates net requirements that are offset by the lead time.

The inventory data needed for a basic MRP system includes lead time required to obtain or manufacture all products and materials, the quantity to order or the batch size and the quantity on-hand or the current inventory balance.

The master production schedule entries are translated into gross requirements for all materials by time period.

The gross requirement is the total requirement of an item generated from the master production schedule and subsequent levels in the bill of material. The gross requirement is balanced with inventory on hand, scheduled receipts and safety stock to calculate net requirements.

The net requirement is the result of applying a gross requirement against inventory on hand, allocations, scheduled receipts and safety stock. The net requirement is then lot-sized and offset for lead time and becomes a planned order.

MRP calculates the net requirements by subtracting current stocks and current on order quantities from the overall gross requirement. The explosion process is controlled by the bills of material. If net requirements are greater than zero, order receipts must be planned. The order release is offset from the required order receipt date by the lead time.

MRP outputs include planned orders, order release notices, changes in open orders due to rescheduling, and inventory status data. The resulting planned order releases which become the detailed production schedules are examined for availability of resources for each time period. If the capacity is inadequate to meet the schedule, the MPS is modified and the MRP programme is run again. The procedure is repeated until the MPS and available capacity have a reasonable match.

Activity 4.3

Activity

Work through the following questions. You may need to go back and re-read the unit to help you.

1. Explain why the economic order quantity model is not appropriate for modern business.
2. Explain the difference between MRP and MRP II.
3. Explain the sales and operations planning process.
4. Explain why sales and operations planning is performed at the aggregate level.
5. Explain the theory of constraints.
6. Explain how the drum-buffer-rope works.
7. Explain the difference between a capacity-constrained resource and a bottleneck.
8. Explain why an organisation might carry safety stock.

Activity 4.3 feedback

All answers are in the learning material.

Unit 10

Supply chain management

Outcomes

Upon completion of this unit students will be able to:

- *Define* supply chain management from a strategic view
- *Discuss* the bullwhip effect or demand amplification
- *Define* collaborative supply chains
- *Explain* the triple-A approach to supply chains
- *Discuss* the strategic role of inventory in supply chains
- *Discuss* the criteria for supplier selection.

Activity 4.4

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. Explain the bullwhip effect. In particular, explain how it happens and what can be done to minimise adverse effects.
2. Describe the Triple-A supply chain approach.
3. Explain vertical integration as a means to secure more linkages in the supply chain.
4. Evaluate the criteria for selecting a supplier.

Activity 4.4 feedback

All answers are in the learning material.

Unit 11

Project management

Outcomes

Upon completion of this unit students will be able to:

- *Define* a project.
- *Describe* the nature of project management.
- *Discuss* the strategic nature of projects.
- *Describe* project organisation structures.
- *Discuss* the role of the project manager.
- *Discuss* project management processes.
- *Define* a critical path.
- *Discuss* project risk and uncertainty.
- *Discuss* the critical chain method.
- *Outline* what makes a project successful.

Activity 4.5

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. What is a project?
2. What makes a project different from other business activities?
3. What is project "creep" and what should be done to prevent it?
4. Explain the critical chain method.
5. What makes a project successful?
6. As a project manager, how would you ensure that your project is successful?

Activity 4.5 feedback

All answers are in the learning material.

Unit 12

Performance measurement

Outcomes

Upon completion of this unit students will be able to:

- *Describe* measurements for business excellence.
- *Describe* the Hoshin process for setting goals and using measurement systems.
- *Describe* the balanced scorecard approach to performance measurement.
- *Describe* how the closed-loop management system links strategy and operations.
- *Describe* benchmarking.

Activity 4.6

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. Describe the balanced scorecard approach.
2. Evaluate Hoshin planning as a strategic planning system.
3. Evaluate Hoshin planning as a performance measuring system.
4. What are some financial measurements for an organisation?
5. What are some operational measurements for an organisation?
6. How can innovation and learning be measured?
7. What is an appropriate measurement for internal processes?
8. What performance measurements are suitable for a call centre?
9. How does benchmarking benefit an organisation?

Activity 4.6 feedback

All answers are in the learning material.

Operations Management Exam Questions

Guidelines

The allocated exam time is three hours.

The student should answer **six questions** from a choice of **eight**.

Each question should take about 30 minutes to answer.

Lecturer to choose **eight** questions from the 15 provided below. Choose only one from each heading.

Strategy and competitiveness

Question 1

"The battle is won not in the boardroom but in the laboratories, on factory floors, at service counters and in computer rooms. Companies that fail to exploit fully the strategic power of operations will be both hampered in their own attacks and vulnerable to those of competitors that do exploit its power."

Discuss.

Answer

The direct quotation in the following four paragraphs is sourced from Robert H. Hayes and David M. Upton (1998) 'Operations-based strategy,' California Management Review, 40(4): 8–25. This provides the context on which the question is based.

> The battle is won not in the boardroom but in the laboratories, on factory floors, at service counters and in computer rooms. Operations' role is larger than just that of implementer of strategy; it is the foundation for – indeed, the driver behind – successful strategic attacks and defences. The important implication for company leaders: companies that fail to exploit fully the strategic power of operations will be both hampered in their own attacks and vulnerable to those of competitors that do exploit this power.
>
> Nowhere is this clearer than in cases where large companies that have established a powerful, well-entrenched competitive position (possibly by following a clear strategy) are attacked successfully by competitors that lack both position and strategy. Indeed, again and again we observe small companies that – although lacking the advantages of size, experience, established position and proprietary

technology – take on big companies and in a relatively short time push their way to industry dominance. Why were the former leaders so vulnerable? Why didn't they react more promptly and vigorously to such attacks – even after extended periods of time? And how are some companies, in contrast, able to defend themselves successfully?

Most studies of this phenomenon focus on cases where the key to the attacker's success was the development of a new technology and/or the identification of an emerging market. Strategy then becomes primarily a matter of finding the right 'position' in that market and then moving there. But there are many other examples where radical new technologies and markets play a minor role: the attackers exploit technologies that are available to all and compete for customers who already are being served by established competitors. In such cases, the key to success is often an operations-based advantage.

Superior operations effectiveness not only serves to buttress a company's existing competitive position, but, when based on capabilities that are embedded in the company's people and operating processes, is inherently difficult to imitate. For this reason it can provide the basis for a sustainable competitive advantage even when the company adopts the same competitive position as one or more of its competitors. Moreover, this sort of competitive advantage tends to be less visible to competitors than one that is based on staking out a differentiating competitive position. As a result, they are not prompted to respond as quickly. The sustainability of a competitive advantage that is based on superior operating skills is enhanced, therefore, both because it is difficult to duplicate and because competitors may not perceive its potential effectiveness, or even its existence, until too late.

Guide to markers: This is a very open question and you should be looking for an argument that suggests the operations function has a major role to play in designing products and delivering solutions to customers. Traditionally, the operations function has taken a back-seat approach but the modern view is to treat operations as a powerful weapon. Each of the quoted paragraphs above presents a powerful story but the essence of the answer is in the final paragraph, "Superior operations effectiveness…"

Nature and role of operations

Question 2

"The customer wants quality, flexibility and service to increase while variability, lead time and costs decrease." Discuss the customer and the six basic requirements of the customer.

Answer

The customer is the next process or where the work goes next. This view can lead to internal and external customers, but the concept of satisfying the customer can only be fully implemented when considering the customer as the next process.

Most people will think of the customer as the person who buys the product or service. The payment for products and services may occur at any point in the supply chain or at the end. Essentially, the payment recognises a change of ownership for a product or the completion of the service. The person who pays for the product or service is called the end customer or final customer or consumer.

Guide to markers: The objectives of operations management should be viewed from the customer's point of view. The customer is defined as the next process or where the work goes next. Thus customers can be internal to the firm as well as external. Regardless of the type of business, internal and external customers generally have the following six basic requirements:

1. Higher level of quality.
2. Higher degree of flexibility.
3. Higher level of service.
4. Lower cost.
5. Less time or quicker response.
6. Less variability.

Customers determine the quality of the required output. So quality in this sense is to understand exactly what the customers want, when they want it, how they want it and why they want it, and then delivering that to them.

Customers do change their minds. This does not mean they are indecisive. Over a period of time they change their behaviours, preferences, styles, ideas, desires, wants, needs and relationships. Therefore, the supplier needs to understand these changes and have the capability to react to whatever volume or product is required.

The merging of products and services often makes it difficult to measure how well the customer is satisfied. Customers demand higher levels of service. Suppliers are required to truly understand the customer with objective and subjective measures.

Lower cost is always mentioned as a customer requirement. However, it is not just the price that needs to be lowered; it is the total cost to the customer. Some firms, especially in information and communications technology, refer to this as the cost of ownership.

Customers want products produced and delivered in less time. This requires a shorter cycle time, shorter delivery times and faster service response. However, the real measure is consistency of performance. This requires less variability. The output from one session is the same as the output from the next.

Demand management and forecasting

Question 3

Discuss the purpose of the demand forecasting process and the advantages for an organisation that develops an effective demand forecasting system.

Answer

The forecasting process is the business process that attempts to predict demand for products and services so that sufficient capacity, resources and materials are available in time to meet the need.

Guide to markers: the following paragraph relates to the purpose of demand forecasting. These points should be covered by the student.

The real measure, or purpose, of these forecasts in the long term, medium term and short term is to determine the level of expenditure. It will cost money to buy capacity; it will cost money to occupy a facility; it will cost money to buy raw materials and components; it will cost money to train and educate employees to perform production and service activities; and it will cost money to deliver products and services to customers.

Guide to markers: the following paragraph relates to the advantages for the organisation that develops an effective demand forecasting system. These points should be covered by the student.

How much a firm or an organisation spends is a decision entirely up to them. Depending on how much they spend and when will determine how well, or how poorly, they are able to satisfy customer demand. If they spend the right amount of money they will satisfy customer demand at the minimum cost. If they spend too much they may find they have under-utilised resources.

Capacity planning and management

Question 4

Yield management can be very effective when balancing supply with demand especially for service organisations. Discuss the business environment for yield management and how it could be used by an airline company.

Answer

Yield management is the application of discriminatory pricing to various market segments so that relatively fixed capacity can be used to satisfy customer requirements and simultaneously maximise revenue.

The objective of yield management (also known as revenue management) is to increase revenues for organisations that operate with relatively fixed capacity. The subject comes under a variety of terms including revenue management, pricing and revenue optimisation, and demand chain management.

The concept of yield management was first applied in the airline industry during the late 1970s.

The application of yield management is well practised in the airline industry with airlines offering flights for as low as one dollar but for flights at least six months later. Closer to the day of the flight, airlines may offer discounted fares on lightly loaded sectors and these bookings usually have to be paid in full, are non-transferrable to another person, and non-refundable. In some cases they are changeable, but with the payment of a change penalty fee and by paying any applicable fare adjustment. Peak-hour flights are unlikely to have many fares at lower rates since the airlines have little trouble selling these at higher rates.

Guide to markers: The student should have discussed four or five of the following bullet points and then used examples from the airline industry to illustrate the points being made.

The business environment for yield management is most effective when the following exist:

- Relatively fixed capacity and the same unit of capacity can be used in a variety of ways.
- Demand can be segmented by market and each segment has varying needs, behaviour, and willingness to pay.
- Demand is highly variable (seasonal fluctuations) and uncertain.
- Inventory is perishable (hotel room by night, airline seat by flight).
- Product can be sold in advance.
- Product can be forecast with relatively high accuracy.

- Fixed costs are high.
- Marginal costs of selling one extra unit are low.
- Price is not an indicator of quality.
- Producers are profit-oriented and have freedom of action.

Designing processes

Question 5

Womack describes the perfect process as "a process in which every step is valuable, capable, available, adequate and flexible". Discuss.

Answer

James Womack described the perfect process as one that creates exactly the right value for the customer. He acknowledged that value is hard to define for external processes and even harder to define for internal (support) processes. Each step in the process must be valuable, capable, available, adequate and flexible.

1. To be valuable it has to add value to the customer and to be recognised by the customer as adding value and not adding cost. Consider removing this step from the process and check if it is absolutely necessary.
2. The capable qualifier comes from process capability and six sigma capability. A capable process can be executed the same way with the same satisfactory result every time it is run.
3. The concept of being available is a derivative of total productive maintenance and suggests it is able to be executed every time it is necessary without waiting. This implies that production machines are available for use and not waiting for parts or maintenance.
4. The theory of constraints defines processes that are adequate. An adequate process has enough capacity to perform this step when it needs to be performed without waiting.
5. Flexible processes are lean and are based on the Toyota Production System. Each step in a flexible process occurs only at the command of the next downstream step within the time available.

Guide to markers: The student should state that the perfect process creates exactly the right value for the customer. Then they should discuss each of the five key points (valuable, capable, available, adequate and flexible).

Improving processes – lean thinking

Question 6

One of the aims of lean thinking is the elimination of waste. Discuss the seven categories of waste.

Answer

Waste is any activity that does not add value to the product or service as valued by the customer.

There are seven categories of waste:

1. overproduction — excess quantity or too early
2. waiting — queues or delays
3. transportation — unnecessary movement
4. processing — poor process design
5. motion — activities that do not add value
6. inventory — items that are adding cost and not value
7. defects — scrap or rework.

Overproduction is producing a quantity greater than required. Overproduction occurs for a number of reasons. The worst reason is that management believes that the cost of set-up can be amortised over a longer production run and that this lowers the unit cost of production.

The waste of waiting occurs whenever the flow of production is interrupted. Job shop processes are referred to as intermittent because they stop-start-stop-start. Lean thinking endeavours to eliminate the stop and make sure that materials and production flow all the way from initial process to final process.

The waste of transport is any unnecessary movement of materials or products. Inwards goods delivered to the wrong part of the building that have to be transported to the correct place is waste. Products sent in bulk to a remote location then called back to the main centre to meet customer needs represents waste of transport.

The waste of processing is the inclusion of any processing step that does not add value. It usually arises from poor process design. Examples include heating ingredients to a temperature and allowing them to cool and then having to heat them again when the rest of the process is ready. This is poor co-ordination of processing steps.

Waste of motion is the use of activities that do not add value, such as placing heavy items on the floor rather than at waist height. Assuming an operator can lift the items it is better to place them on a table rather than bending to place them on the floor and then subsequently bending to pick them up.

Inventory waste is the storage of items that are not needed. This requires storage in a warehouse and that requires additional cost which would not occur if the inventory did not exist.

Producing defects, scrap and rework is waste. Scrap is an output that is dumped at the end of processing because it does not meet customer specification. Why is that product made in the first place? It may be quicker to just throw money away or flush it down the toilet. Rework occurs when a product is made and it is determined that a defect can be corrected if it passes through the processing step again. Painting and repainting is an example. When this waste occurs the item is made twice but the customer only pays once. That is waste.

Guide to markers: Students should have clearly described each of the seven categories of waste and included the key points noted above.

Question 7

"A big breakthrough in the development of lean thinking systems was to realise the difference between process and operations; process is the total flow of production from the customer's order to the finished product while operations is a set of machines." Discuss how a focus on the process teaches us to smooth out our operations and make us more effective. (Note: Lean thinking systems are synonymous with lean production systems and just-in-time production systems.)

Guide to markers: Students should focus discussion on elimination of waste to make production flow. They should highlight inefficiencies in particular areas and how these can be improved. If companies just concentrate on individual machines it becomes too disjointed and unconnected. They need connection and flow.

Product design

Question 8

What is quality function deployment?

Answer

Quality function deployment is a methodology that identifies customer needs (the voice of the customer) and ensures these needs are met or exceeded with the technical (design) requirements throughout the product development and production process. Quality function deployment can be viewed as a set of communication and translation tools. It tries to eliminate the gap between what the customer wants in a new product and what the product is capable of delivering.

Quality function deployment is a methodology to:

- Prioritise spoken and unspoken customer excitement, performance wants and basic needs.
- Translate these needs into actions and designs such as technical characteristics and specifications.
- Build and deliver quality products and services by focusing business functions on a common goal of achieving customer satisfaction.

Quality function deployment picks up the spoken and unspoken customer requirements and maximises positive excitement such as ease of use, fun and luxurious feel. This creates value in the customers' eyes.

Traditional design aims at minimising negative aspects such as defects and poor service. The aim of traditional design in this sense is to obtain zero defects. What is the point of difference when all organisations have zero defects?

Quality function deployment is a system that implements elements of systems thinking and psychology. The systems view looks at the whole system and the psychology part looks at the customer needs, how they evaluate value and what makes a customer choose one product or service over another.

The performance wants and excitement characteristics provide an excellent opportunity for an organisation to gain competitive advantage. Knowledge about each market segment and changing customer requirements helps to hit the customer targets. Quality function deployment is epistemic and allows the invisible customer requirements to become visible.

Guide to markers: This is a fairly high-level question and the answer above is rather strategic in nature. Students could quite easily answer by discussing the house of quality which takes customer requirements and translates them into technical requirements. They may also discuss the four levels of the house of quality which eventually derives process control characteristics. When marking you should be looking for the three bullet points above.

Concept of quality

Question 9

Six sigma quality has developed from a simple way of measuring quality to an overall strategy for an organisation. Describe the six sigma approach to quality.

Answer

Six sigma quality is a business improvement approach that seeks to find and eliminate causes of defects and errors in manufacturing and service processes by focusing on outputs that are critical to customers and a clear financial return for the organisation. It is a business process that allows organisations to improve bottom-line performance, creating and monitoring business activities to reduce waste and resource requirements while increasing customer satisfaction.

Six sigma quality is a proven methodology for driving and achieving transformational change within an organisation. It is a business improvement process that focuses on customer requirements, process alignment, analytical rigour and timely execution.

In its original form it concentrated on manufacturing variables, both controlled and uncontrolled, such as temperature, pressure, flow rate and time. It also improved the process output variables such as yield, waste, capacity, downtime and production rate.

This has now been extended to include non-manufacturing variables, both controlled and uncontrolled, such as communication methods, completeness, accuracy, training, inventory levels, shipping methods, promise dates, days of the week, seasons of the year and customer required date. It improves output variables such as order correctness, delivery time and package quality.

Six sigma quality aims to align executives to the right objectives and targets, to mobilise improvement teams, to accelerate results and to govern sustained improvement.

It has been practised by Motorola for more than 30 years and other large organisations have since unravelled the mysteries and applied the gains to their operations. It has been rather slow to be implemented within smaller companies. However, now the basic concepts are more widespread within small to medium enterprises despite the start-up costs and commitment required. In fact, some of the real benefits are being achieved with service companies.

It has its foundations in statistics — well, that is where the name comes from. Originally it was termed ± six sigma capability and it measured the variation of each process. The process had to be designed such that it was capable of producing ± six standard deviations (sigma) of the process within the customer-defined process limits.

Six sigma quality allows organisations to identify customer requirements and to design, and subsequently modify, business processes to consistently achieve nothing less than the minimum of customer requirements. Keep the customer happy, supply them

with exactly what they want, when they want it and they will come back for more.

A concentration on increased reliability by making processes more repeatable helps improve production, yield and efficiency. Resources are focused on the right products and the right projects.

Guide to markers: Look for at least five of the paragraphs above. If a student described any five paragraphs then that would constitute an excellent answer.

Inventory planning and management

Question 10

Discuss the theory of constraints and how it can be applied to operations.

Answer

Goldratt explains that the goal of the firm is to make money by:

- Increasing throughput, which is the rate at which money is generated by sales.
- Reducing inventory, which is the money spent on buying items for subsequent sale.
- Reducing operating expense, which is the money spent to convert inventory into throughput.

Traditionally, management emphasises reducing operating expense and reducing inventory. Organisations take pride in proclaiming that they are on a "cost-cutting drive". They target opportunities to cut expenses and reduce inventory. Expenses are easy to cut when the organisation stops spending money. Likewise inventory is easy to reduce when the organisation stops replenishing supplies.

Looking at both operating expenses and inventory, what happens when the organisation reaches zero? Managers argue that they will not actually reach zero and they will stop before they reach that limit. But they do not tell anyone where to stop, when to stop or how to stop. They just say, "Reduce operating expenses and inventory!" The finite limit is zero.

What kind of organisation have you built when operating expense is zero and inventory is zero?

There is no finite limit to increasing throughput, which is defined as the rate at which money is generated by sales. Having raw materials sitting in the yard waiting to be processed does not make the manufacturer successful. Having products sitting in a warehouse does not make an organisation profitable. Having products sitting on the shelf in a retail store does not make the retailer wealthy.

The only way to get rich, according to Goldratt, is to make the products, sell them and get paid for them and make sure that the amount you receive exceeds the amount spent on inventory and operating expenses.

The theory of constraints requires the entire production process working together to achieve the goals of the firm. Measurement systems should encourage the increase in net profits, return on investment and cash flow. Organisations can achieve this when, at the operations level, it recognises and rewards performance based on the amount of throughput, inventory and operating expenses created.

Guide to markers: Students should have highlighted four of the key points noted above.

Supply chain management

Question 11

Discuss how the bullwhip effect (or demand amplification) occur in supply chain management.

Answer

The bullwhip effect creates large oscillations of inventory in the supply chain network. Large changes in the supply position upstream are caused by small changes in downstream demand. The effect, also known as demand amplification, can be eliminated (or minimised) by synchronising the supply chain.

The consumer sales pattern that occurs at the final retail points gets distorted and amplified as the demand is transmitted up the supply chain, especially when each link in the supply does not fully understand the dynamics of the consumer sales pattern.

The effect can occur with any range of products and at any level in the supply chain but is most noticeable with consumer commodity products. If demand for an item is relatively constant at final retail points, then the available inventory in the retail store gradually diminishes until it is time for the retailer to place a replenishment order with the wholesaler.

The wholesaler is expected to hold relatively large quantities of products so they can meet supply demands from multiple retailers. The wholesaler will usually be required to order from the manufacturer in large quantities if they want to secure favourable pricing arrangements. The wholesaler may even hold off ordering from the manufacturer until they have a very large order and thus secure even better payment and delivery terms.

At this stage the manufacturer is removed from the actual demand at retail and is confronted with a large order coming in from the

wholesaler. This may indicate that the demanded product is experiencing an increase in popularity and, to compensate for that popularity, the manufacturer schedules larger production runs. However, to be able to make the larger production runs the manufacturer must secure raw materials from their supplier. Original suppliers supply in bulk and often have large minimum and large multiple orders. Therefore, the manufacturer orders even larger quantities of raw materials from the supplier.

The bullwhip effect is a direct result of individuals making rational decisions within the supply chain infrastructure. If firms want to mitigate the effects they first have to examine the infrastructure of the supply chain rather than attempt to change the rational behaviour patterns.

Guide to markers: Students should describe many of the points above and their application to the supply chain.

Question 12

Discuss how to overcome the problems created in a supply chain when individual participants do not have communication with their suppliers beyond the first tier and do not have communication with their customers beyond the first tier.

Answer

The way to overcome these problems is to be part of a collaborative supply chain. Firms that form part of a supply chain that eventually supplies supermarkets or large retail chains should be fully aware of collaborative supply chains.

In its simplest form, collaborative supply chains eliminate internal barriers that result in costs and time that add little or no value to end consumers.

While possibly the best example of collaborative supply chains is practised by Wal-Mart Stores in the United States, most recent developments have occurred in Europe with a true focus on the consumer.

There are two distinct parts — the supply side and the demand side.

The supply side of collaborative supply chains addresses the need for rapid and efficient replenishment of products in the overall supply chain.

Traditionally, the retailer generates replenishment orders from the wholesaler or manufacturer. With collaborative supply chains, the suppliers determine the replenishment quantities based on information on stock and sales received from the retailer.

With a refined application of this process, all suppliers in the supply chain have access to current details of consumer demand at the retail level. This information may be sent electronically to

them, or they can access it themselves from the retailers' web sites. Thus, all suppliers know the true demand and they can initiate replenishment before the actual request filters through the supply chain. This allows all suppliers, not just the first tier suppliers, throughout the entire supply chain to prepare goods for despatch, confident that replenishment is required.

The delivery process speeds up and suppliers have a better understanding of true consumer demand.

Information about product movement (as recorded at the point of sale), outside factors that affect demand (such as seasonal changes), actual inventory levels, product receipts, and an acceptable agreed safety stock level are integrated electronically.

Guide to markers: Students should discuss the two distinct parts — the supply side and demand side and provide at least three strategies that could overcome the problem.

Project management

Question 13

Discuss how a project manager should manage a project to meet the various time, cost and quality constraints.

Answer

The role played by the project manager is critical to the success of every project and it is not easy to find really good project managers for every project. It certainly helps when the project manager has an understanding and an appreciation of the technical aspects associated with the project but the project manager does not have to be an expert in the field. A project manager for a project assembled to set up new information and communications technology, for example, should have an appreciation of the strategic role computers play in a business environment, but the manager does not have to be a computer technician. The technical knowledge, though, must be sufficient to be able to ask the right questions and make the right decisions.

The project manager should be able to ask penetrating questions, have credibility, sensitivity and the ability to handle stress.

Leadership and expertise in strategy are essential attributes for the project manager. The leadership is necessary to provide direction, motivation and help to all project team members and the strategy expertise is required to gain the overall perspective of the business need for the project.

A defining characteristic of the project manager is communication and people skills displayed at all times. The project manager may be dealing, at times, with a personal issue with one individual and,

at others, communicating project progress to the media and stakeholders. The project manager must be able to resolve interpersonal conflicts. This range of skills makes this role challenging and rewarding to the point that a good project manager should never complain about having a boring job.

The project basics of planning, executing and controlling resources such as people, equipment and material need to be managed to meet the quality, cost and time constraints of the project. Monitoring and control activities include measuring the volume of work being completed, the quality of work, the costs compared to budget, the attitudes of those involved including team members and customers, the co-operation of the team and the status of the work being performed compared to plan.

Management resource is often applied to the cost and time constraints, and trying to keep the project within budget. Unless the project is quite similar to other projects, or contains quantifiable work packages, the original time and cost budget is a guess and wishful thinking. Instead of concentrating solely on cost and time elements, a good project manager is managing change and risk.

A change request seeks to expand or reduce the project scope, modify policies, processes, plans or procedures, modify costs or budgets, or revise schedules. Only formally documented change requests are processed and only approved change requests are implemented.

A change of scope is allowed but it has to be approved by the customer and the project plan has to be updated to reflect the change. Project danger arises from scope creep that allows changes to creep into the project without customer approval, without an allocation for additional resources and without adjusting the project duration. Most projects have creep of some form or other and a good project manager does not allow it to happen.

The best way to prevent project creep is to establish a clear project charter and an agreed project scope statement before detailed work commences.

As for risk, the project manager should be planning all risk elements, identifying risk, performing a qualitative risk analysis, performing a quantitative risk analysis and developing a risk response plan. The project manager should be able to spot unstated assumptions. These risk elements are strategic. They may be boring, but when identified risk occurs as an event the project is able to handle it within the scope of the project. It does not arrive out of the blue.

With project management, the objectives are often unclear, measurements of success are ambiguous and the process used to manage the project does not affect success or failure. Risk develops

as a result of uncertainty and the good project manager focuses on reducing uncertainty and therefore minimising risk. The successful project manager reduces risk by ensuring all communication channels are open and by allowing all team members to express opinions and concerns.

Guide to markers: Students should discuss the attributes of a good project manager as noted above as well as the use of processes to effectively manage projects.

Question 14

Projects often exceed budgeted cost and allocated time. The reasons for exceeding cost and time are usually unexpected. A project manager may attempt to compromise on quality in order to complete on time and/or within cost. Discuss three sources of unexpected problems that eventually cause the project to exceed cost estimates and three sources of unexpected problems that eventually cause the project to exceed time estimates.

Answer

For a variety of reasons projects have a habit of running behind schedule. Most of the reasons fall back on the shoulders of the project manager who should perform a better job. Initial time estimates may be too optimistic, resources may not be available when required, activity sequencing may be incorrect, technical problems may occur, scope creep may occur, or the customer may request changes.

Unexpected problems resulting in cost increases:

- difficulties require more resources
- scope of work increases
- initial bids or estimates were too low
- reporting was poor or untimely
- budgeting was inadequate
- there were price changes of inputs.

Unexpected problems resulting in time increases:

- delays owing to technical problems
- initial time estimates were optimistic
- task sequencing was incorrect
- required resources were not available as needed
- necessary preceding tasks were incomplete
- there were client-generated changes
- there were unforeseen government regulations.

Guide to markers: Students must competently discuss all six aspects relating to cost and time increases.

Performance measurement

Question 15

Discuss the four perspectives of the balanced scorecard approach and outline how the balanced scorecard approach could be used for performance measurement.

Answer

The balanced scorecard measures business performance from four perspectives:

1. Customer
2. Internal
3. Innovation and learning
4. Financial.

1. Customer perspective

The customer perspective asks, "How do customers see us?". Organisations may have a strategic objective to add value to customers, to satisfy customer needs, to listen to customer wants, to allow customers to participate in process and product design and to act and think from a customer's viewpoint. This needs measuring. This needs measuring from a customer perspective by asking customers for their views.

2. Internal perspective

The customer perspective looks at the organisation from the outside while the internal perspective looks at the organisation from the inside and asks, "At what aspects of business should we excel?". Process design and improvement all occur internally and the results affect customers.

Processes measured as part of the balanced scorecard have the most impact on customer satisfaction. Clearly these affect lead time, throughput time, employee skills and attitudes, flexibility, availability, responsiveness and information systems.

3. Innovation and learning perspective

Innovation and learning perspective asks, "Can we continue to improve and create value?". Competitive activities constantly challenge every organisation's position. All other organisations challenge the organisation at the top of the league. Even organisations positioned somewhere in the middle have to face constant challenges for their position. Customer expectations constantly change and force organisations to be totally aware of the range and scope of those changes.

4. Financial perspective

The financial perspective asks, "How do shareholders see us?". In the end it is the bottom line that counts. Firms can have any amount

of customer satisfaction, close to perfection with internal processes, unlimited innovation and learning and still fail on financial measures.

The trick is to capitalise on the other perspectives and translate gains made into financial achievements.

Guide to markers: Key aspects of each of the four perspectives must be discussed.

References

Reading

Gardiner, D. (2010). *Operations Management for Business Excellence* (2nd ed.). North Shore, New Zealand: Pearson Education.