Unit 42: Quality and Business Improvement Techniques

Unit code: D/600/0312

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit focuses on how the processes of value, risk and quality management can be integrated into continuous improvement activities. It gives learners the knowledge and skills required to carry out a value engineering activity – a function-oriented, systematic team approach used to analyse and improve the value in a product, facility, system or service.

Unit introduction

The concept of improving effectiveness and efficiency at work to drive down costs, meet deadlines, improve quality and boost productivity is crucial to surviving in a competitive environment. All processes need to be evaluated to ensure continuous improvement in both quality and productivity.

Businesses need to understand the importance of taking action before rejects or defective products are produced, thus avoiding unnecessary expense and halting production, with all its inherent problems.

Most quality systems also implement value and risk management techniques. Value and risk management are now fundamental components of best practice and are widely recognised as essential activities in the search for improved performance. Whilst risk and value management possess separate origins, they share many characteristics and are increasingly seen as complementary activities.

This unit focuses on how the processes of value, risk and quality management can be integrated into continuous improvement activities. It gives learners the knowledge and skills required to carry out a value engineering activity. This is a function-oriented, systematic team approach used to analyse and improve the value in a product, facility, system or service. This is a powerful tool for solving problems and/or reducing costs while improving performance/quality requirements. By enhancing value, customer satisfaction should also increase.

The unit also covers potential failure modes and effects analysis (FMEA). FMEA is a technique used to identify and eliminate possible causes of failure. The technique requires a sequential, disciplined approach by engineers to assess systems, products or processes in order to establish the modes of failure and the effects of failure on the system, product or process. The unit will enable learners to apply the technique of examining what might fail, looking at the possible results of such a failure and analysing what could cause it. Solutions to the potential failures are then prioritised so that the most significant ones are dealt with first.

Properly applied statistical control can prevent problems and lead to continuous improvement in product quality and productivity. The unit aims to enable learners to acquire and apply basic statistical techniques, statistical process control and process capability studies to a process.

Learning outcomes

On completion of this unit a learner should:

1 Be able to apply the principles and processes of value management

2 Be able to apply the principles and techniques of potential failure modes and effects analysis

3 Be able to apply basic statistical techniques and statistical process control procedures

4 Be able to carry out a process capability study.

Unit content

1 Be able to apply the principles and processes of value management

Principles: definitions of cost, value, value added and non-value added activities; concept of function; reasons for poor value

Total cost model: showing costs related to function; cost of function equation; identification of added and non-value added activities

Supply chain map: showing costs related to function; aligned to Porter's value chain model

Value analysis: tools eg Gage's 12 steps, function analysis system technique (FAST) diagrams, value trees, problem solving tools and techniques; management activity eg identifying customer requirements, setting quantifiable objectives and targets, analysing the function of the product or process, identifying and allocating the costs of the functions, identifying the added and non-value added activities within the process, finding the most appropriate alternatives, detailed proposal (develop alternatives into detailed proposals, present findings from value management activities, prioritise and rank the alternatives, carry out risk assessment of the alternatives, provide costed recommendations and implementation plan for management approval)

2 Be able to apply the principles and techniques of potential failure modes and effects analysis (FMEA)

Principles: definitions of FMEA (failure mode, failure effect, causes of failure); application eg concept, design, product, machine, process, system; teamwork; standard FMEA reports; benefits and limitations of FMEA

Techniques: identify the element of design/process under consideration; identify the FMEA team; collect functional data; define failure modes; causes of failure; effects of failure; probability of failure; using either historical data, Delphi type technique, accident data or expert estimation; determine the severity, effect, frequency/occurrence and detection ratings; calculate the risk priority number (RPN); list current controls; analyse resultant data; determine actions required to reduce severity, detection and occurrence; use RPN to prioritise; assign responsibilities and completion dates for actions; monitor actions; re-evaluate new rankings and calculate new RPN

3 Understand and apply basic statistical techniques and statistical process control procedures

Basic statistics: types of data from product or process eg variable/continuous, concerned with precision measurements, other critical characteristics (such as length, weight, resistance), attribute/discrete, based on characteristics that can be counted (such as accept, reject), characteristics that cannot be measured using any other method; considerations of both types of data; types of inspection equipment eg relative cost, skill levels required, inspection time, sample size; variation eg between components, within components, machine to machine, batch to batch, time to time; causes of variation eg common/un-assignable, special/assignable; characteristics eg population, sample, sample size, frequency, mean, mode, median, range, variance, standard deviation; non-normal distribution curves eg skewed, bimodal, flat topped, anomalies, inspection effect and missing tails; characteristics of a normal distribution (interpreting the change in shape, spread and position of the distribution over time)

Graphical analysis: eg bar charts, histograms, stem and leaf diagrams, Pareto diagrams, box plots, run charts, time series charts

Statistical process control procedure: pre-process control procedure (product/process selection, identify critical characteristics, determine type of data, define the measurement system, design check sheet/chart, data collection plan, test procedure, remove special causes of variation, ensure process is capable); design of control procedure eg variable control charts (such as X and R charts), attribute charts (such as np, p, c and u); calculating sample size and frequency; calculating upper and lower control limits; use of control procedure eg plot data, monitor charts, interpreting charts and identification of out of control conditions; outcomes from use eg modify process conditions when necessary, audit process

4 Be able to carry out a process capability study

Process capability study procedure: specification limits and control chart limits; relative precision index eg high, medium, low; consequence of index; equations eg Cp, Cpk, sigma score (Z); precision and accuracy; modified control chart limits; process capability study eg graphical process capability sheet, determine process capability and parts per million outside upper and lower specification limits; analyse information; define improvement activities to improve the process capability; present findings in a process capability report

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the principles of value management	**M1** develop a detailed proposal for a value management activity	**D1** compare the significance of special and common causes of variation
P2 produce a total cost model and supply chain map for a product or process	**M2** describe the benefits and limitations of potential failure modes and effects analysis	**D2** evaluate the purpose of modified control chart limits.
P3 use value analysis tools to undertake a value management activity on a product or process [IE1, IE4]	**M3** evaluate variable/continuous and attribute discrete types of data that can be used in sampling for process control.	
P4 describe the principles of potential failure modes and effects analysis		
P5 use techniques to carry out a potential failure modes and effects analysis for a product or process		
P6 apply basic statistics on a product or process and apply graphical analysis on the data [IE4, CT5]		
P7 carry out a statistical process control procedure		
P8 perform a process capability study procedure for a given process.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key			
	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Delivery of this unit could concentrate on a particular manufacturing sector and work area, eg automotive and assembly. However, a generic approach covering a range of sectors and work areas is more likely. Centres should determine their approach through an analysis of their learners' needs and, in particular, through consideration of the range of industries that the centre is working with or preparing their learners for. Whichever approach is taken should enable learners to understand the principles of quality and business improvement and apply the relevant tools and techniques in continuous improvement activities in their area of work.

The learning outcomes are logically ordered and could be delivered sequentially. In this way, learners will begin to recognise the range of tools and techniques used in continuous improvement activities and their function and use. It is recommended that a variety of delivery methods are used, including group discussions, team and individual group activities, research, industrial visits, presentations and tutor-led learning. This approach will help to keep a more practical approach, rather than spending too much time on theory. For example, a short introduction to value management and value and non-value added activities found in a production system – followed by an industrial visit for learners to see at first hand real examples of value management.

A blend of learning materials should be used to help motivate learners and place the unit in context. These should include CD ROMs, internet research, specific study packs on lean manufacturing topics, worksheets, industrial case studies, videos/DVDs and textbooks for extended study where appropriate.

Formative assessment will play an important part in learners' general development, especially their achievement at the higher grades. Evaluative skills are required at distinction level and formative work in the delivery phase will encourage learners to consider how the tools and techniques being applied may be improved.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole class teaching: • introduction to unit content, scheme of work and method of assessment • outline the main principles of value and non-value added activities and • explain the total cost model and use of a supply chain map • explain the use of value analysis tools and techniques. *Individual/small group activities:* • research and practise the use of total cost models and supply chain maps • practise and apply the use of value analysis tools to a given manufacturing process.
Prepare for and carry out **Assignment 1: Principles of Value Management** (P1)
Whole class teaching: • outline the main principles of failure modes and effects analysis, describe its application and main benefits and limitations • explain and demonstrate the use of FMEA techniques. *Individual/small group activities:* • research and practise potential failure modes and effects analysis for a product or process.
Prepare for and carry out **Assignment 2: Applying Value Management Techniques** (P2, P3, M1)
Whole class teaching: • explain and demonstrate the use of different types of statistics and data from products and processes • explain and demonstrate the use of graphical analysis • explain and demonstrate pre-process control procedure and design of control procedure • explain and demonstrate calculation of sample size and frequency and upper and lower control limits • explain use of control procedures. *Individual/small group activities:* • use statistics and apply graphical analysis.
Prepare for and carry out **Assignment 3: Failure Modes and Effects Analysis** (P4, P5, M2)
Whole class teaching: • explain specification and control chart limits • explain precision index and consequence of index • explain the use of equations • describe precision and accuracy and modified control chart limits • demonstrate process capability study and define improvement activities. *Individual/small group activities:* • carry out a process capability study and produce a report for a given process.

Topic and suggested assignments/activities and/assessment
Prepare for and carry out **Assignment 4: Carrying out Statistical Process Control and a Process Capability Study** (P6, P7, P8, M3, D1, D2)
Feedback on assessment and unit evaluation.

Assessment

Assessment evidence can be collected from learners' involvement in continuous improvement activities in their workplace, case studies, assignments and projects. This should enable learners to demonstrate knowledge and understanding of the principles of quality and business improvement in a manufacturing environment.

To achieve a pass grade learners must meet all the pass criteria. For P1, they will need to describe the principles of value management. This could be achieved via a presentation to the group, or as an annotated poster. In these cases it must be remembered that the presentation skills or poster design skills respectively are not being assessed. A written task would also be a method to give learners the opportunity to meet the requirements of P1.

P2 requires learners to produce a total cost model and supply chain map for a product or process. Evidence for this criterion could be provided from the learners' involvement in continuous improvement activities in the workplace or by a work placement. If assessed directly by the tutor, suitable evidence from these activities would be standard documentation and completed observation records. If assessed during a placement, witness statements should be provided by a suitable representative and verified by the tutor. Guidance on the use of observation records and witness statements is provided on the Edexcel website. Because some learners may not have real access to this form of activity, simulation could be used to generate evidence for this criterion.

P3 expands on P2 by asking learners to use value analysis tools to undertake a value management activity on a product/process. Ideally, this can be further expanded and linked to M1, where learners can develop a detailed proposal.

P4 requires learners to describe the principles of potential failure modes and effects analysis (FMEA). This could take the form of a short report or a brief presentation and could lead into a practical assignment to cover P5.

For P5, learners could undertake a real or simulated potential failure modes and effects analysis. Ideally this would be planned as a group exercise on a given product or process. Each group could define potential failure modes, causes of failure, effects of failure and probability of failure. The severity, effect, frequency/occurrence and detection ratings can then be selected and the risk priority number (RPN) can be calculated.

P5 could then be linked to M2 by asking learners to discuss the benefits and criticisms of the FMEA technique. This could be achieved by asking learners to contribute in a group discussion held at the end of the analysis task, where they are asked to evaluate and record their experience of the technique. Care should be taken when using group work to ensure all learners have opportunities to meet the criterion.

P6 requires learners to apply basic statistics on a product or process and apply graphical analysis on the data. Learners have to carry out a statistical process control procedure for P7. Learners are then required to perform a process capability study procedure on a given process for P8. Ideally P6, P7 and P8 could be linked with a common problem, product or process. Evidence for these criterion could be provided from the learners' involvement in continuous improvement activities in the workplace or by a work placement. If this is not possible, the activities could be individual or linked simulated exercises.

To achieve a merit grade learners must achieve all of the pass grade criteria and the three merit criteria. For M1, learners should be able to develop a detailed proposal from a value management activity. M2 requires learners to describe the benefits and criticisms of FMEA. M3 requires learners to evaluate both variable and attribute types of data, in terms of the sample size, type of inspection equipment, techniques and skills required.

The distinction criteria (D1 and D2) could be linked to the tasks or activities carried out for criteria P6, P7, P8 and M3. For D1, learners are required to compare and contrast the significance of special and common causes of variation. This could be achieved by the identification of special causes of variation found in the task associated with P6 and a brief explanation on the root causes of such variation. The evidence could be obtained via a written assessment or take the form of a pictorial presentation with notes (possibly using PowerPoint or OHPs) and an annotated poster. D2 may be linked to P8 if the process as a high relative precision index. Evidence of this can be obtained via a short written explanation.

All evidence must be generated in a form suitable for inclusion in the learners' portfolios. This could include standard forms (eg FMEA forms, data gathering forms, analysis charts, SPC charts, process capability charts etc), images (eg photographs, scanned images, completed charts, diagrams, plans and engineering drawings), presentation slides, written reports, witness statements and solutions to class-set problems.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1	Principles of Value Management	Learners have been asked to produce an information poster/ leaflet for new apprentices	A written task requiring learners to describe value management principles.
P2, P3, M1	Applying Value Management Techniques	Learners have been asked to produce a total cost model and supply chain map and carry out a value management activity for a product or process in the workplace.	A practical assignment evidenced through witness/ observation records and learners' process logbooks.
P4, P5, M2	Failure Modes and Effects Analysis	Learners have been asked to write a short report on potential FMEA and then carry out an FMEA analysis.	A short written task and a practical analysis exercise on a given product or process. A further written evaluation of the benefits and limitations.
P6, P7, P8, M3, D1, D2	Carrying out Statistical Process Control and a Process Capability Study	Learners need to apply basic statistics on a product or process, carry out an SPC procedure and perform a process capability study.	A practical assignment evidenced through witness/ observation records and learners' process logbooks. Further written tasks for D1 and D2.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Applying Continuous Improvement and Problem Solving Techniques	Production System Design
	Workplace Organisation and Standard Operating Procedures	Six Sigma Quality
		Teamwork in a Continuous Improvement Environment

This unit supports the Level 3 NVQ in Business Improvement Techniques, particularly:

- Unit 14: Carrying out Statistical Process Control Procedures
- Unit 17: Applying Value Management (Value Engineering and Value Analysis)
- Unit 20: Applying Basic Statistics
- Unit 21: Carrying out Potential Failure Modes and Effects Analysis (FMEA)
- Unit 25: Carrying out Capability Studies.

Essential resources

To deliver this unit centres will need to have an up-to-date reference library with computer aided learning resources and appropriate journals.

Employer engagement and vocational contexts

This unit should be delivered and assessed in a vocational context. Evidence for much of the unit could be gathered through learners' work placements.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – www.warwick.ac.uk/wie/cei
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Bicheno J – *Cause and Effect Lean: Lean Operations, Six Sigma and Supply Chains* (Picsie Press, 2000) ISBN 0951383019

Bicheno J – *The New Lean Toolbox* (Picsie Press, 2004) ISBN 0954124413

Bicheno J – *The Quality 75 Chains* (Picsie Press, 2002) ISBN 0954124405

Dale B – *Managing Quality* (Blackwell Publishers, 2003) ISBN 0631236147

Liker J – *The Toyota Way: Fourteen Management Principles from the World's Greatest Manufacturer* (McGraw-Hill Education, 2003) ISBN 0071392319

Womack J and Jones D – *Lean Thinking* (Free Press, 2003) ISBN 0743231643

Journal

International Journal of Operations and Production Management

Magazines

Engineering Technology

Manufacturing Engineer

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	identifying questions to answer, problems to resolve and analysing and evaluating information when using value analysis tools to undertake a value management activity
Creative thinkers	trying out alternatives and following ideas through when applying statistics on a product or process and apply graphical analysis.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Team workers	collaborating with others when working in a small group to define potential failure modes, causes of failure, effects of failure and probability of failure.

Functional Skills – Level 2

Skill	When learners are ...
Mathematics	
Select and apply a range of skills to find solutions	carrying out a statistical process control procedure
Use appropriate checking procedures and evaluate their effectiveness at each stage	carrying out a statistical process control procedure
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating quality and business improvement techniques
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the principles of value management and potential failure modes and effects analysis.