10 Quality of Deliverables and Products

Introduction

Take a moment to think about how quality is handled on your projects. If you do not currently use a quality management plan this could be a difficult topic for you on the exam. This chapter will help you understand quality and its role in the project management process. In any organization, senior management is responsible for promoting an organizational approach that supports quality efforts. Team members must inspect their own work. For the exam, assume there is a quality department that helps determine quality management methods the project manager and team are required to follow.

Organizational process assets (OPAs) are often available in the form of templates and documented procedures and quality requirements. Within the quality constraints already given, the project manager and team must tailor their practices to the needs of the project.

Quality must be planned in and the quality plan must be executed against, reviewed, and changed as needed. Then, the results of the work—the deliverables—should meet the product requirements. Testing should be done before submitting the work to the customer for approval.

With this in mind, let's start with some basic definitions related to quality.

Definitions Related to Quality

The definition of quality is the same for both predictive and adaptive environments. All stakeholders must be represented in the requirements-gathering process. This makes the requirements-gathering effort, the requirements documentation, and the project scope baseline very important to the quality management effort.

Quality

Quality is the degree to which a project and the components of its product fulfill requirements. Nothing more, nothing less. Memorize this definition; it may help you get more questions right on the exam.

Here is an example of an issue with quality requirements. Imagine a project in which a large group of truck drivers are required to use tablets with touch-sensitive screens. Prior to fleet deployment and during the test process, the project manager received comments that no matter how much the drivers tapped on the screens, nothing would happen. After some discussion with truck drivers and software engineers, the project manager realized the truck drivers' hands were too rough and calloused for the touchscreens to work correctly. Here, the requirements were gathered and initial development had been done with the product owner alone, who lacked direct experience with drivers. The drivers would have been able to provide insight on their use of the technology during requirements gathering.

Organizations and project managers determine how to approach the management of quality. Ideally, this means planning quality standards and processes into projects and their products. The quality process generally involves a range of practices. This includes following the established processes, and inspecting deliverables to ensure they meet quality standards before meeting with the customer to get validation and offer delivery. Along the way lessons are learned, and preventive or corrective action may be taken on a process or deliverable. Quality processes and standards may be updated upon review of how well they are working to bring about the desired product or service features.

If asked, "Is it better to plan in quality or to inspect to find quality problems?" almost everyone will answer correctly that it is better to plan in quality. Exam questions focus on situations to see if you know how to apply this knowledge.

QUICKTEST

- Definition of quality
- Quality Management process
- Prevention over inspection
- Continuous Improvement
- Just in time (JIT)
- Quality metrics
- Mutual exclusivity
- Probability
- Normal distribution
- Statistical independence
- Standard deviation
- Interviews, brainstorming, benchmarking
- Cost-benefit analysis
- Cost of quality
- Marginal analysis
- Logical data models
- Mind mapping
- Prioritization matrix
- Test and inspection planning
- Checklists and checksheets
- Cause-and-effect diagrams
- Scatter diagrams
- Histograms
- Alternatives analysis
- Design of experiments
- Process, root cause, failure analysis
- Multicriteria decision analysis
- Affinity diagrams
- Audits
- Design for X
- Statistical sampling
- Questionnaires and surveys
- Project performance reviews
- Inspection
- Control charts
- Cost of change
- Frequent verification and validation
- WIP and cycle time

Example The project manager finds that one of the team members has created their own process for installing hardware. What should the project manager do? If this were an exam question, beginning project managers might choose a response that relates to thanking the team member for the effort. More experienced project managers might select a choice that relates to finding out if the process was a good one. The most experienced project managers, who also understand these quality processes, select the choice that relates to investigating the quality management plan to determine if a standard process should have been followed.

In an adaptive environment a project manager would likely capture quality requirements and acceptance criteria in user stories. As user stories are prioritized, quality efforts will be planned in more detail for upcoming releases and iterations. Short, time-boxed iterations ensure frequent opportunities to identify and rectify quality issues through daily standups and retrospective meetings.

Definition of Done

Agile teams define what "done" looks like throughout the project. They decide on definitions of done at the project, release, and story levels. The project level is roughed out based upon how much time and money there is to complete the project. Requirements (or product functionality increments) are prioritized at this high level. A release map is created based on how many releases are needed to get to the desired level of functionality. Releases are populated with stories, which represent functionality decomposed into smaller, more manageable pieces. If you think of the handwritten "story card" image, the definition of "done" is written on the back of the card (even though in reality story cards are now often created electronically).

Remember that in adaptive environments requirements may change frequently so the project team reviews and revises definitions of done on a regular basis. Here is an example of definitions of done using our earlier example of a project to produce touchscreen tablets for truck drivers:

- **Story** The two stories that make up feature b have been developed and integrated, documented, tested, and accepted by users in the field.
- **Release** For release 1, a working prototype touchscreen tablet has been tested and accepted by users in the field, including features a, b, d, and g.
- **Project** A working touchscreen tablet has been tested and accepted by users in the field and passed on to operations for manufacture, with features a, b, d, g, k, t, x, and y.

Grade

Different from quality, grade refers to a general classification of a product like the strength of concrete (e.g. how much weight can it hold) that can be used for various technical specifications (e.g., foundation of a building or sidewalk). You may see a situational question on the exam that uses the term "grade" in discussing quality so do not confuse the two.

Example A low grade of concrete that supports limited weight and has zero defects might be sufficient for a project's needs as long as it meets the established quality requirements (for example, a small basketball court in a playground that just needs to hold the weight of human foot traffic). It is not necessary to spend more on materials that will hold more weight than requirements call for. Similarly a high grade of concrete intended to sustain more weight could be of unacceptable quality if it is mixed, poured, or cured to low standards or otherwise fails to meet established quality metrics.

Think About It. Imagine a project to build a stadium. The concrete part of the work is two-thirds done when the buyer arrives one day and tests the strength of the concrete. The buyer finds that the concrete does not meet the requirements for strength that are clearly stated in the contract. You can imagine the problems when the buyer says, "Rip out the concrete; it is not acceptable." Whose fault is this? Why did this occur?

Could we say it is the buyer's fault for not testing the concrete sooner? You might argue that case, but isn't the real fault with the seller for not selecting the right grade of concrete and ensuring the quality of the finished deliverable before meeting with the customer to validate it? Where was their quality plan? They should have planned for when and how they would confirm they had met this requirement. Lack of attention to quality in this scenario needlessly added considerable risk to the project, which resulted in rework and additional expense.

Here is something else to consider. Have any of your customers ever said one of your deliverables was not acceptable, even though they had not provided you with a definition of what *was* acceptable? It is important to know—in advance—what acceptable quality is and how it will be measured on the project. You can then determine what you will do to make sure the project meets those requirements. It is the project manager's responsibility to make sure quality is defined in the plan for each deliverable, otherwise there will be unclear acceptance criteria, such as "the customer likes it." Performing the quality management process well helps the project manager avoid many issues on the project.

Gold Plating

Do you remember a time on a project when one of your team members delivered more than what was needed? Can you think of a time when you've had trouble keeping a project from producing a palace when all you needed was a garage, for example? Gold plating refers to giving the customer extras (extra functionality, higher-quality components, extra scope, or better performance). Gold plating is often the team's impression of what is valued by the customer, and the customer might not agree. Since most project teams have difficulty meeting the project objectives, all available effort should go into achieving those objectives, instead of into gold plating.

Sometimes gold plating is not planned, but rather arises out of a team member's efforts to do their best. The project manager must be on the lookout for team members providing more than is required for the project.

Prevention over Inspection

Is it better to inspect work to find problems or to prevent them in the first place? Which takes less effort and is less costly? Remember that quality must be planned in, not inspected in! You may see exam questions that test your understanding that failure to plan quality into a project will lead to problems later in the project.

Continuous Improvement

Continuous improvement involves continuously looking for ways to improve the quality of work, processes, and results. Within an organization it can include analysis of how quality management is planned and utilized on projects. There are several approaches to continuous improvement relevant to the exam.

- **Kaizen** The terms "continuous improvement" and "Kaizen" are taken to mean the same thing on the exam; however, in Japan, Kaizen means to alter (kai) and make better or improve (zen). Kaizen is a general term, while continuous improvement is a quality movement. In the United States and most of Western Europe, continuous improvement focuses on major improvements. In Japan, the emphasis is on smaller improvements.
- **Total Quality Management (TQM)** TQM encourages companies and their employees to focus on finding ways to continuously improve the quality of their products and their business practices at every level of the organization.
- **Six Sigma** Sigma (another name for standard deviation) indicates how much variance from the mean has been established as permissible in a process. This is a methodology for achieving organizational process improvement and high levels of correctness with extremely reduced variances. The higher the sigma, the fewer deviations (or less variance) in the process. The level of quality required by an organization is usually represented by 3 or 6 sigma.

Just in Time (JIT)

JIT means having suppliers deliver resources just before they are needed, thus decreasing inventory to nearly zero and decreasing unnecessary cost. A company using JIT must achieve a high level of quality in their practices; otherwise, there will not be enough materials or equipment to meet requirements because of waste and rework. A JIT system forces attention on quality as well as schedule.

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Quality-related PMI-isms. The exam may test your understanding of the need to satisfy project requirements as opposed to giving the customer extras to "make them happy." Know the following PMI-isms to answer exam questions correctly:

- Quality means meeting requirements, not adding extras.
- All product developers must know the quality standards and metrics to be used on the project.
- Quality should be checked before an activity or work package is completed.
- Quality should be considered whenever there is a change to any project constraint.
- Some quality activities may be performed by a quality department.
- The project manager should:
  - ✓ Determine the metrics to be used to measure quality before project work begins.
  - ✓ Define project quality management processes and plan for continuous improvement.
  - ✓ Recommend improvements to the organization's standards, policies, and processes, which are expected and welcomed by management.
  - ✓ Ensure that authorized approaches and processes are followed.
  - ✓ Ensure the quality standards and processes on the project are adequate to meet product quality requirements.

Overview of Planning and Managing Quality

The following references indicate that Quality Management in the predictive Process Groups model is represented by Plan and Manage Quality of Products/Deliverables in the *Examination Content Outline* (ECO). In addition, when managing procurements, you will need to ensure that the buyer and seller have the same understanding of the quality process. See the "Procurement" chapter for more information.

ECO	Process Groups Model	*PMBOK® Guide*
Domain II **Task 7** Plan and manage quality of products/deliverables	**Quality Management** Plan Quality Management — Planning Manage Quality — Executing Control Quality — Monitoring & Controlling	**Domain 2.4** Planning **Domain 2.6** Delivery **Domain 2.7** Measurement **Domain 2.8** Uncertainty

Think About It. Can you see how other tasks from domain II, such as stakeholder engagement and communications, can affect quality management? What if two team members disagree on how to approach building a deliverable? The quality management plan needs to reflect the best, agreed-upon, and bought-into approach. Skills such as conflict management and team leadership from domain I are invaluable to come to the best solution. Negotiation and team-building skills (also from domain I) support the best quality management plan and overall quality control. Take time now to review the ECO and think about these connections.

Here is an example to help you commit your understanding of quality for the exam to memory:

Example A student in one of RMC's classes looked out the window and noticed someone painting the limestone of an old building white. The student said, "That is not quality!" Let's think about this for a moment. Why would painting the limestone white not be considered "quality"? The student's issue was that the wonderful old stone was being painted instead of being cleaned. This was a disagreement with the requirements, not the quality of the work. If the painting contract

required the painter to use a certain paint and follow painting standards, and he was doing so, the work was meeting the quality requirements.

Figure 10.1 shows the Quality Management process from the Process Groups model perspective. This figure and the following discussions of Plan, Manage, and Control Quality can help you envision what the plan-driven Process Groups model of quality management looks like. It can also help you understand quality management in general.

This is not meant to suggest that agile approaches do not have their distinctions, but planning for and managing quality on projects has the same principle regardless of your project's life cycle and development approach. Following this discussion based on the Process Groups model is additional information that comes from agile methodologies.

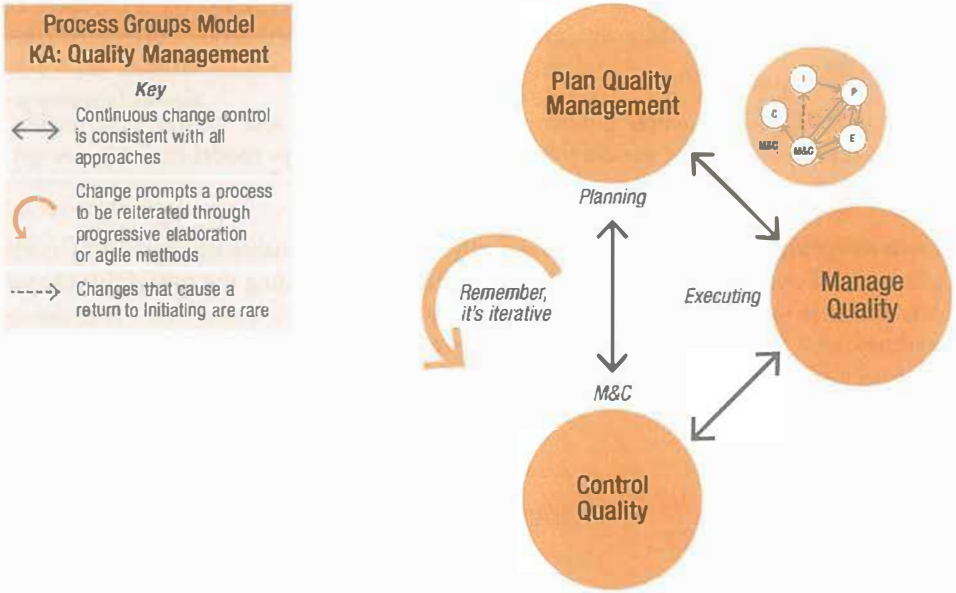

FIGURE 10.1 *Quality management process*

Think About It. Many people getting ready for the exam have limited quality management experience, so they struggle with envisioning how quality management efforts fit into managing a project in the real world. Now that you can envision the overall quality management process, walk through it as you review the following quality management process flow:

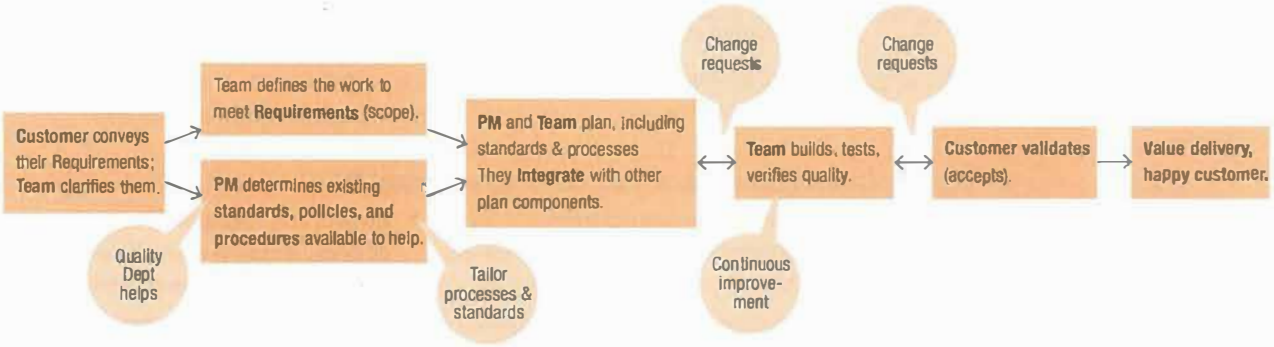

FIGURE 10.2 *Quality management process flow*

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Understanding the Differences between Plan, Manage, and Control Quality

One of the major challenges people have while studying this topic is understanding the differences between Plan, Manage, and Control Quality in the Process Groups model. Here are those three quality processes and a brief overview of each.

- **Plan Quality Management** This process focuses on defining quality for the project, the product, and project management, and planning how it will be achieved.
- **Manage Quality** This process is focused on how work is being done. Its purpose is to ensure the team is following organizational standards, policies, and processes as planned to produce the project's deliverables. The project manager also evaluates whether the quality management plan or processes need to be improved.
- **Control Quality** This process includes examining the actual deliverables produced on the project to ensure they are correct and meet the planned level of quality, evaluating variances, finding the source of problems, and recommending ways to address them.

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You are not likely to encounter differences between "manage" and "control" for quality on agile-related questions, but understanding the difference in the Process Groups model can help you get more predictive questions right.

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The following chart presents a trick for understanding the three quality management processes. Study it now to gain an understanding of the focus of each process before reading the rest of this chapter. The trick is to understand that in the "manage" process the project manager is concerned about the quality processes, procedures, and standards that are supposed to be used on the project, whereas in "control" the project manager is concerned about determining the quality of deliverables. Come back and review this chart after you read the rest of the chapter.

Plan Quality Management	Manage Quality	Control Quality
Process Group		
Planning	Executing	Monitoring and controlling
High-Level Description of What Each Process Focuses On		
• What is quality? • How will we ensure it?	• Are we following the policies, metrics, procedures, and processes as planned? • Are the procedures and processes giving us the intended results? • Will we meet the quality objectives?	• Are the results of our work meeting the standards and required metrics? • Is the variance within acceptable limits, or do we have to take action?
More Detailed Description of What Each Process Focuses On		
• Review project plans and artifacts to understand project quality requirements. • Identify quality practices and internal and external standards relevant to the product and project (OPAs and EEFs). • Tailor practices and process to the project.	• Use measurements from Control Quality to confirm that: – Policies and processes are being followed. – Policies, metrics, and processes are still appropriate for the project. – Policies and processes are effective in achieving planned quality results.	• Inspect and measure the quality of deliverables to determine whether they meet requirements. • Use the PMIS to track deviations from planned quality. • Identify the need for quality improvements (corrective or preventive action, and defect repair).

Plan Quality Management	Manage Quality	Control Quality
• Determine quality processes for the project. • Determine how you will measure and what work you will do to ensure you meet the standards. • Plan for process improvement. • Perform cost of quality, cost-benefit, and other analyses to ensure the appropriate levels of quality. • Determine roles and responsibilities for achieving quality requirements. • Plan for testing and inspection to ensure requirements, performance, reliability, and quality objectives will be achieved. • Integrate the quality management plan with other plans to balance the needs of quality with other project requirements and constraints.	• Use data-representation techniques to analyze results of quality testing. • Determine the root cause of problems/variances from plan. • Continuously improve to increase efficiency and effectiveness. • Create test and evaluation documents for use in Control Quality. • Quality audit: Determine if project activities comply with organizational and project policies, processes, procedures. • Solve problems. • Produce reports. • Share good practices with others in the organization. • Submit change requests. • Update the project plan and artifacts.	• Complete checklists and checksheets, perform tests; evaluate results. • Use data-representation methods to graphically depict testing results. • Verify deliverables. • Validate approved changes. • Recommend testing process improvements. • Use and update lessons learned. • Submit change requests. • Update the project plan and artifacts.

Desired Outcomes From Successful Quality Management

Assume for the exam that quality is properly planned and managed unless information in an exam question indicates otherwise. This means that the following outcomes should be expected as a result of quality management:

- Quality processes, procedures, and inspections are completed.
- The team has carefully inspected their own work to ensure it meets requirements (in manage and control quality)
- Product quality changes are made as needed before meeting with the customer to gain acceptance of deliverables (in validate scope).
- Changes are made to quality processes and procedures throughout the project to ensure that they are bringing the team and stakeholders the desired results.
- Few quality problems arise on the project since quality is carefully planned, executed, and controlled. However, in cases where projects are of a "research and development" nature, it is understood that trial and error is part of the project outcome.
- Stakeholder engagement and communications are of high quality so few or no misunderstandings with stakeholders should result.
- Projects routinely achieve their goals and objectives and their products deliver the value needed for the customer. This gives the customer the benefit for which the project was undertaken and contributes to advance the strategic objectives of the performing organization.

Plan Quality Management

Process Groups Model
PG: Planning
Process: Plan Quality Management

ECO
Domain II
Task 7 Plan & manage quality of products/deliverables

PMBOK® Guide
Domain 2.4 Planning

Plan Quality Management is a process to identify all relevant organizational or industry practices, standards, and requirements for the quality of the project and its product, and then plan on how to meet those standards and requirements. The main output of this process is a quality management plan.

The level of quality efforts should be tailored to the needs of the project and quality must be balanced with the other project constraints. Standards may come from within the organization or from an external resource.

That sounds easy, right? Often it is not. In many organizations, practices are not standardized. If this is true on your projects, take some time now to imagine standardized practices that would be ideal for your projects and how they might help you. Here is a practical example:

Example A construction company could establish a standardized practice for installations on home kitchen construction projects. Imagine all the installers within that organization putting together their best ideas to improve the installation work on future projects. That would be a valuable effort that could improve quality and safety while saving time and money. Each project team would then be required to review the standard and tailor it to their particular project's install.

Examples of available external standards include ISO 9000 (from the International Organization for Standardization), OSHA (from the Occupational Safety and Health Administration), and the United Nations Convention on Contracts for International Sale of Goods (CISG).

Creating the Quality Management Plan

As quality management is being planned, keep the following in mind:

- OPAs can help identify relevant standards, policies, and procedures and include lessons learned from previous projects.
- A project manager may create additional project-specific standards and procedures that are needed on how quality is defined for each piece of work.
- For the exam, understand that this effort should also include defining processes for how project management activities should be done and suggesting improvements to existing processes.
- The customer's quality standards might be specified in a contract or need to be discovered as part of the Collect Requirements process.

Quality requirements that are later used to control quality are documented, analyzed, and prioritized according to the requirements management plan. Examples of such standards are the:

- Procedure for how to install a particular custom kitchen faucet
- Average time per installation
- Acceptable number of software bugs per module
- Strength of concrete

Management plans and documentation that aid in quality planning include the:

- Stakeholder engagement plan
- List of the major project deliverables (in the requirements management plan)
- Approval requirement (in the project charter)
- Assumption log
- Stakeholder register
- Risk thresholds (in the risk management plan)
- Scope baseline
- Requirements traceability matrix

The scope baseline helps the project manager maintain the proper perspective and plan quality to the appropriate level. The assumption log provides insight into the level of quality that is assumed to be acceptable on the project. The requirements traceability matrix shows the origin of requirements related to quality and will be used to confirm that quality requirements, including external compliance requirements, have been achieved.

Artifacts of Plan Quality Management

Most quality management plans include the standard practices already discussed, along with roles and responsibilities for quality management. Reports and metrics that will be used are included, along with what parts of the project or deliverables will be measured and at what intervals. Strategies for continuous improvement of processes and procedures are also included.

Planning quality will result in a number of artifacts and updates to existing documents, including:

- Quality management plan
- Project management plan updates
- Project document updates
- Quality metrics

Planning quality management will also result in iterations of other project artifacts. Here are some examples:

- Scope baseline (Scope statement, WBS and WBS dictionary)
- Project activity list
- Requirements traceability matrix
- Budget
- Risk register (to add quality-related risks)
- Schedule
- Resource assignments

Quality Metrics

Throughout this book there is an underlying theme that the project manager must know how the project is performing compared to what was planned and be able to determine when to request changes. The only way to effectively do this is to determine metrics in advance whenever possible and decide what range of variation is acceptable.

Metrics to use on a project could represent the:

- Number of changes (to help measure the quality of the planning process)
- Variance related to resources utilization (Were more or less resources needed than planned? How big is the variance?)
- Number of items that fail inspection
- Variance of the weight of a product produced by the project compared to the planned weight
- Number of bugs found in software being developed as part of the project

Manage Quality

Process Groups Model
PG: Executing
Process: Manage Quality

ECO
Domain II
Task 7 Plan & manage quality of products/deliverables

PMBOK® Guide
Domain 2.6 Delivery Performance

The efforts for this Manage Quality process focus on making certain that the project work to create the deliverables is done according to the standards and processes established for the project in the project management plan. The project manager must also make sure that these quality standards are effective in meeting the needs of the project.

A group outside the project team, such as a quality department, often helps with this work. For the exam, assume there is a quality department unless evidence in the question suggests otherwise.

The Manage Quality and Control Quality processes work hand-in-hand. In Manage Quality, test and evaluation documents are prepared for use in Control Quality. In turn, this process analyzes measurements gathered in Control Quality and uses the quality management plan, including quality requirements, to answer the following questions:

- Are the procedures and processes being followed as planned?
- Are the quality requirements, organizational policies, and processes identified in the quality management plan producing the intended results?
- Can the processes and procedures be improved?
- How can we increase efficiency and prevent problems?
- Based on what we know now, is the work we planned the right quality work for this project and the right work to meet customer requirements?

The process of managing quality also includes evaluating all aspects of the product design to confirm the end result will meet quality requirements and identifying possible improvements to the design.

Artifacts of Manage Quality

Test and evaluation documents for use in Control Quality, such as control charts, checklists, and test plans provide a format with which to evaluate whether quality objectives have been met. Project documents such as a requirements traceability matrix may also be updated here. Quality reports interpret and document the results of both Manage and Control Quality activities. They can present information in different formats and are used to identify necessary changes to plans, policies, and processes (for Manage Quality) and to the product (for Control Quality) to ensure that quality requirements will be met throughout the life of a project.

Control Quality

The Control Quality process addresses the quality of the product, service, or result of a project. Control means measure, and in controlling quality we measure whether the product of the project conforms to requirements. This process helps ensure customer acceptance, as it involves confirming and documenting the achievement of agreed-upon goals for each deliverable.

Process Groups Model
PG: Monitoring and Controlling
Process: Control Quality

ECO
Domain II
Task 7 Plan & manage quality of products/deliverables

PMBOK® Guide
Domain 2.7 Measurement

What is needed to carry out Control Quality? Inputs include:

- Deliverables
- Test and evaluation documents (developed in Manage Quality)
- Work performance data
- Quality management plan and possibly other project artifacts
- Quality metrics (agreed-upon measures of quality developed in planning)
- Approved change requests (from integrated change control)

Although a project manager and team must be involved in quality control, a quality department may complete much of this work in large companies. The department then informs the project manager about quality issues through change requests accompanied by the necessary documentation.

It is during Control Quality that the height of doors in a manufacturing process or the number of bugs per module will be measured. Quality control helps answer the following questions:

- Are the results of the work meeting agreed-upon standards and thereby meeting requirements?
- What are the actual variances from the standards and are they within acceptable limits?
- What changes in the project should be considered?

Artifacts of Control Quality

Control Quality artifacts include measurements, work performance information, verified deliverables, and possibly change requests, as well as updates to the quality management plan, issue log, test and evaluation documents, lessons learned, and the risk register.

Control Quality—Specific Terminology

To better understand questions relating to Control Quality, be familiar with the following terms:

- **Mutual exclusivity** The exam may reference statistical terms such as "mutual exclusivity." Two events are said to be mutually exclusive if they cannot both occur in a single trial.
  Example You cannot at the same time see both sides of the same coin.
- **Probability** This term refers to the likelihood that something will occur. Probability is usually expressed as a decimal or a fraction.
- **Normal distribution** A normal distribution is expressed as a chart that takes the shape of a bell curve. It is used to measure variations away from the "norm."

- **Statistical independence** This concept means that the probability of one event occurring does not affect the probability of another event occurring.

  Example The probability of rolling a six on a die is statistically independent from the probability of getting a five (or even another six) on the next roll.

- **Standard deviation (or Sigma)** A metric for a range of measurements is its standard deviation. This metric shows how far a measurement is from the mean (i.e., the average) of the measurements in the range. It signifies whether the range of measurements represents a stable process or output.

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If a situation posed in an exam question is looking forward in time, it is most likely a planning function. If it is looking back in time at processes and procedures, it is most likely part of a managing function. If it is looking back in time at results, like a deliverable, it is most likely part of a control function.

Quality Management Methods

Understanding both predictive and adaptive methods for quality management can help you get several questions right on the exam. The methods used to manage quality have been combined in this section to make it easier for you to understand them and to distinguish what tools are used in each of the three quality management processes as outlined in the Process Groups model. Notice that some methods can be used in more than one quality process.

Methods for Planning Quality

The following tools and techniques are used for quality management planning. Note that meetings can be used for any process.

Interviews, Brainstorming, and Benchmarking

You may recall learning about these techniques in the "Scope" chapter. Interviews and brainstorming can help identify appropriate ways to measure quality and the metrics or processes to be used. Benchmarking is utilized to review methodologies used by comparable projects or organizations to establish quality metrics and acceptable variance ranges, and to measure quality.

Decision-making Methods

Planning key decisions might include selecting the most critical metrics or prioritizing quality requirements. Decision-making tools and techniques for this process include:

- **Multicriteria decision analysis (or multicriteria weighted analysis)** This method uses a matrix to list and scores various factors in relation to one another. It may be used in planning quality to measure the cost of quality efforts versus their benefits.
- **Prioritization diagram** This matrix is a scatter diagram where effort is shown on the horizontal axis and the value of that effort is shown on the vertical axis. In quality planning the cost of quality efforts versus their benefits may be evaluated in this way. Note that PMI uses the term "matrix" instead of "diagram" and you may see the terms used interchangeably in project management literature. Technically there is a difference but you should know both terms since we cannot predict which will be used on the exam.

Cost-benefit Analysis

Using this data analysis technique, the project manager analyzes the benefits versus the costs of quality efforts to determine the appropriate quality level and requirements for the project. A decision-making method may be used as a tool to do this analysis. The exam will test your knowledge about the effects of quality efforts, or the lack thereof. Note that if you have poor quality, you might also have increased costs, decreased profits, low morale, low customer satisfaction, increased risk, and rework. These possibilities make the cost-benefit analysis and cost of quality important tools for consideration.

Cost of Quality (COQ)

Evaluating the cost of quality means making sure the project is not spending too much to achieve a particular level of quality. It involves balancing the costs of conformance and non-conformance to quality. There are four categories of costs associated with quality. They are prevention, appraisal, internal failure, and external failure.

- **Prevention** These are the costs associated with preventing any quality issues from occurring. There is a cost to the planning and to getting systems in place to avoid having quality issues.
- **Appraisal** These costs are associated with monitoring and controlling quality. Quality audits, and verification and validation are in this category.
- **Internal failure** This involves finding issues before the product reaches the customer. It includes waste (performing unnecessary work), scrap (defective material that cannot be sold), and rework.
- **External failure** This occurs after the product has reached the customer. The example given previously about the truck drivers and the touchscreen technology is an example of an external failure. External failures are the costliest and the impact goes beyond money to reputation.

The following table provides examples of the costs of conformance and non-conformance to quality.

Cost of Conformance	Cost of Non-conformance
– Quality training	– Scrap
– Studies	– Inventory costs
– Measuring quality of interim deliverables	– Rework of deliverables not meeting quality standards
– Customer satisfaction surveys (and work to respond to issues raised)	– Warranty costs
– Efforts to ensure everyone knows the processes to use to complete their work	– Lost business

Marginal Analysis

Cost of quality is planned and then monitored and measured throughout the project life cycle. Marginal analysis is focused on finding the point at which the benefits or revenue to be received from improving quality equals the cost to achieve it. Added attention to quality does not produce added value. When that point is reached, the project manager stops trying to improve quality.

Logical Data Models

A data model represents the types of data an organization needs to use in a particular application, and the relationships between those data types. Figure 10.3 shows part of a data model called an entity relationship diagram (ERD). It illustrates the data associated with "office location" is related to data associated with "worker." This example shows that a worker does not need to be assigned to an office location. This is a business rule that is verifiable and testable.

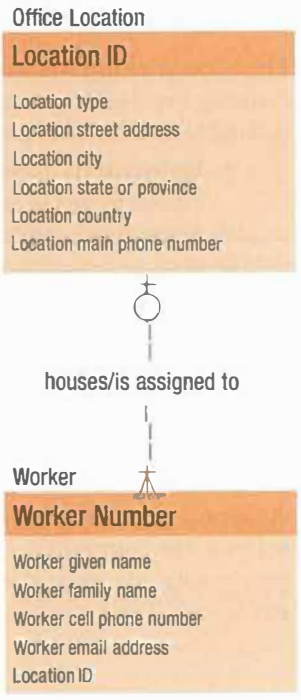

FIGURE 10.3
Logical data model

Mind Mapping

As discussed in the "Scope" chapter, a mind map is a diagram of ideas or notes to help generate, classify, or record information. It is used here to facilitate the gathering of quality requirements and illustrate their impacts on other parts of project planning.

Matrix Representations

A matrix is information represented in a row and column format. It visually represents the relationship between two or more sets of items. In planning, matrix diagrams can be used to list quality requirements in one column and their characteristics in others, for example, labels indicating levels of priority. The list could then be sorted to easily identify those that are most critical. An agile backlog is a good example of data represented as a matrix.

Prioritization Matrix (Chart)

This tool can be used to numerically rank available options. It is useful for decision analysis about quality management planning. Figure 10.4 is a prioritization matrix indicating the project manager should do the top two choices, but probably not do each unit test more than three times. On the exam you may find the word "matrix," "diagram," or "chart" used to refer to this tool.

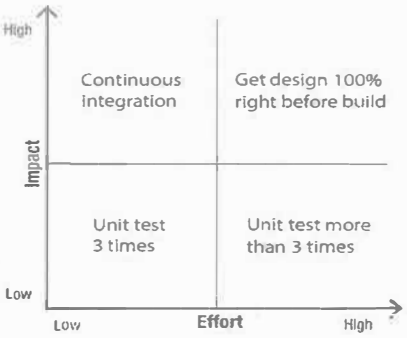

FIGURE 10.4
Prioritization matrix (diagram)

Flowcharts

Also known as process flows or process maps, these can be used in many elements of project management. They show how a process or system flows from beginning to end, how the elements interrelate, and alternative paths the process can take. Flowcharts can be used to:

- Define and communicate processes to be used on the project, avoiding errors.
- Show dependencies in a process to determine where quality problems may arise in the process.
- Study the steps of a process that is causing a quality defect. This analysis might uncover confusion among the team or point out ways the process must be adjusted to make it more effective.

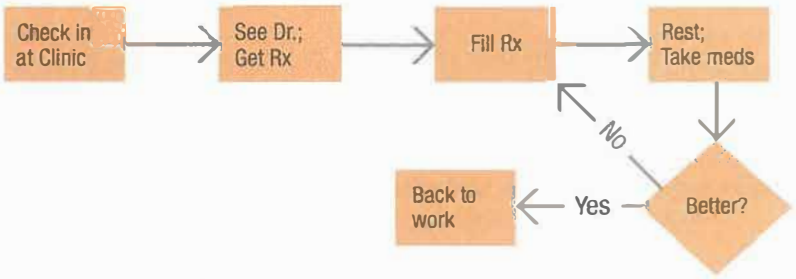

FIGURE 10.5 *A generic flowchart*

Test and Inspection Planning

Planning quality in includes determining how the team will confirm that the required level of quality has been achieved in the completed project deliverables, as well as how the deliverables will be evaluated for performance and reliability. Testing methods, which vary depending upon the type of product, service, or result being created by the project, are used to control quality. The quality management plan is created to prevent quality issues.

Methods for Managing Quality

The following methods of Manage Quality are leveraged to analyze the processes used to create the product of the project. Some of the same tools are used in Control Quality to analyze product defects.

Checklists

A checklist (figure 10.6) can be used to confirm that the steps of a process have all been completed. It may also be used to analyze defects discovered in quality inspections, to look for issues within the process, and to assess whether a deliverable meets the acceptance criteria.

FIGURE 10.6
Checklist

Cause-and-Effect (Fishbone, Ishikawa, or Why-Why) Diagrams

A team can use cause-and-effect diagrams (see figure 10.7) to confirm that policies and procedures are being followed and metrics are being used correctly, and that the procedures were adequate to produce the required level of quality in project deliverables.

In the following example, the defect "system will not install" is shown on the right and then various possible causes are listed in an effort to find the root cause of the defect.

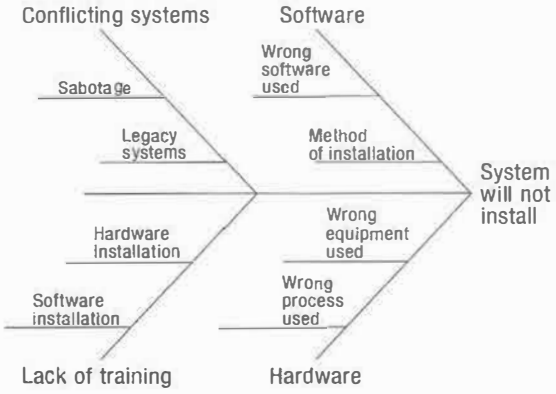

FIGURE 10.7 *Cause-and-effect diagram*

Scatter Diagrams

This diagram tracks two variables to determine their relationship to the quality of the results. Figure 10.8 shows three examples of scatter diagrams.

A regression line (or trend line) is calculated to show the correlation of variables, which can then be used for estimating and forecasting. Figure 10.8 depicts the possible resulting patterns: a proportional or positive correlation of paint quantity to drying time, an inverse or negative correlation of dryer fan speed to drying time, and no correlation between door weight and drying time.

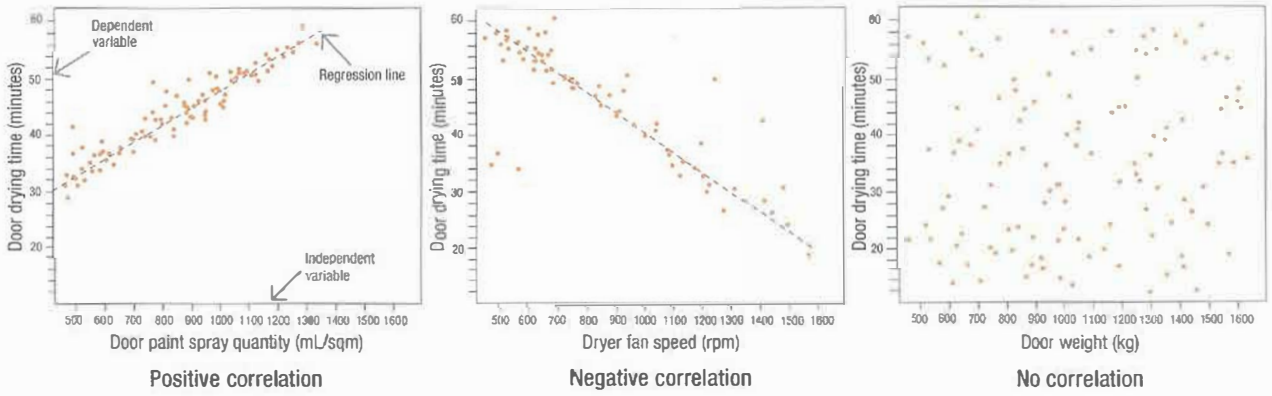

FIGURE 10.8 *Scatter diagram*

Histograms

Histograms can be used to analyze the type and frequency of defects in order to identify where the quality improvements should be focused. Figure 10.9 is an example of a histogram.

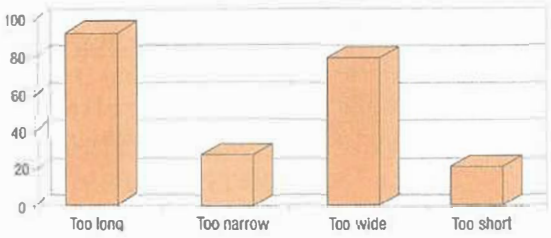

FIGURE 10.9 *Histogram*

Document Analysis

Document analysis involves reviewing the results of testing and other quality reports to identify ways in which the quality management plan and processes may not be supporting the production of deliverables that meet the project quality requirements.

Alternatives Analysis

It is important to consider all the ways to solve an issue or problem. In Manage Quality, alternatives analysis may be used to evaluate which action would best impact the results of quality management processes. For example, would a new automated testing tool be more beneficial than redefining the testing process?

Design of Experiments (DOE)

This technique can be used for alternatives analysis and can quickly discover optimal conditions in which to produce a quality deliverable. Experimentation is done to determine statistically what variables will improve quality. For example, DOE can be used to look for ways to deliver the same level of quality for less cost. DOE is a fast and accurate technique that allows the project manager to systematically change the important factors in a process and see which combinations have an optimal impact on the project deliverables.

Example Designers might use DOE to determine which combination of materials, structure, and construction will produce the highest-quality product. A caveat is that performing experiments for each variable in a process to assess its impacts on quality can be time-consuming and can overlook interactions among variables.

Process Analysis

Process analysis is part of the continuous improvement effort and focuses on identifying improvements that might be needed in project processes. Have you ever worked on a project where some of the activities or work packages were repeated? This often happens when projects have multiple installations, such as a project to install software onto hundreds of computers. The lessons learned on the first few installations are used to improve the process for the remaining installations. Though this often happens naturally, planning it into certain points in the project improves results.

Root Cause Analysis

Root cause analysis in Manage Quality seeks to identify the processes, procedures, and policies within the plan that may not work or that may need adjustment. Identifying the root cause of a quality problem helps the team to prevent it from recurring. Cause-and-effect diagrams (as showing in figure 10.7) help in root cause analysis.

Failure Analysis

This is a type of root cause analysis. It analyzes failed processes or failed components of deliverables to determine what led to failure. Corrective action or change requests are often outcomes of this analysis.

Multicriteria Decision Analysis

The project manager must facilitate quality decisions. A decision-making technique, multicriteria decision analysis is a complex method of numerically assessing options based on criteria such as time, cost, and quality. It can be used throughout a project to help the team reach agreement regarding the best way to solve a problem or improve quality. In Manage Quality, the team may use this technique when considering whether to adjust the quality management plan or specific processes or procedures. A prioritization matrix (described earlier) is a simpler decision-making technique.

Affinity Diagrams

We first saw this technique in the Collect Requirements process. In Manage Quality, affinity diagrams can help the project manager organize and group the results of root cause analysis.

Example In Control Quality you may have determined the cause of a deliverable not meeting requirements. You can use this information in the Manage Quality process to determine whether a change to the standards, policies, or procedures in the quality management plan would address the root cause of the problem.

Audits

Imagine a team of auditors walking into your office one day to check up on the project. Their job is to see if you are complying with company standards, policies, and procedures as defined in the quality management plan, and to determine whether those being used are efficient and effective. This scenario represents a quality audit. Do not think of a quality audit as a negative event. Instead, a good quality audit will look for new lessons learned and effective practices that your project can contribute to the performing organization. The work of a project is not only to produce the product of the project; it could also contribute to the best practices within the organization, making the organization better.

If you do not have a team of auditors from the quality department coming to see you on your projects, do you take on the responsibility of looking for opportunities to identify lessons learned and best practices? Although quality audits are usually done by the quality department, the project manager can lead this effort if the performing organization does not have such a department.

TRICKS OF THE TRADE®

If you see the word "audit" on the exam, the question is most likely related to Manage Quality. If you see the word "inspect" on the exam, the question is most likely related to Control Quality. We audit processes and we inspect product.

Design for X

Design for X is another way of analyzing variables to evaluate both the effectiveness of the quality management plan and the team's ability to meet objectives. The X in the name can represent an attribute of quality, such as reliability, security, or serviceability. If the plan is not delivering the intended results in relation to the variable being analyzed, Design for X can help determine what changes are needed.

Problem-solving

Think of how important this technique might be when encountering quality problems. Gaining a good understanding of the real problem is the first step towards finding an effective and long-lasting solution. Problem-solving can be used when considering quality improvements or to determine how best to respond to deficiencies identified in quality audits.

The following are the steps used to analyze a quality (and any) problem:

1. Define the real or root problem. It is often not what is presented or what appears to be the problem.
2. Analyze the problem.
3. Identify solutions.
4. Pick a solution.
5. Implement a solution.
6. Review the solution and confirm that the solution solved the problem.

Methods for Controlling Quality

The ultimate goal in controlling quality is to test (inspect and verify) that each deliverable meets the metrics and requirements as stated in the quality management plan, including the customer's acceptance criteria, and that the deliverable is ready to move to the Validate Scope process—which should end in customer acceptance. The following methods were explained earlier in this chapter:

- **Checklists** In Control Quality, checklists are used to determine that all required features and functions are included, and that they meet acceptance criteria. Checklists may be part of the test and evaluation documents created in Manage Quality. A quality checklist can be a list of items to inspect, a list of steps to be performed, or a picture of the item to be inspected, with space to note any defects found.
- **Root cause analysis** This method is used to identify the cause of quality problems, including defects, to determine how they can be remedied so the problem does not happen again.
- **Cause-and-effect diagrams** In Manage Quality, we discussed the application of the cause-and-effect diagram to determine the root cause of quality issues relating to plans, processes, or procedures. In Control Quality, this tool can be used to look backward at what may have contributed to defects that have occurred as well as to analyze the impact of defects on the quality and acceptability of a deliverable. Look back to figure 10.7 to review this concept.
- **Scatter diagrams** A scatter diagram can be used to control quality by comparing actual results to what was anticipated, and to estimate and forecast future outcomes based on this comparison. For review, look back to figure 10.8 and its accompanying description in the Manage Quality section.

  Example Imagine that our door manufacturer has a project to develop a new painted door product line. Scatter diagrams may be used to determine the relationship of independent variables, such as paint quantity, dryer fan speed, and door weight, to the dependent variable of drying time, or to correlate defects to other variables in the process.
- **Histograms and Pareto charts** The results of measurements taken in Control Quality are displayed on a histogram to determine the problems that need the most immediate attention or that are most likely to prevent the project from achieving its quality requirements.

Compare the histograms in figure 10.10 and note that a typical histogram (on the left) presents data in no particular order. A Pareto Chart, as shown on the right, is a commonly used type of histogram that arranges the results from most frequent to least frequent to help identify which issues are resulting in the most problems. Also known as the Pareto Principle, the 80/20 "rule" states that 80 percent of problems are due to 20 percent of the root causes. Addressing the root cause of the most frequent problems makes the greatest impact on quality.

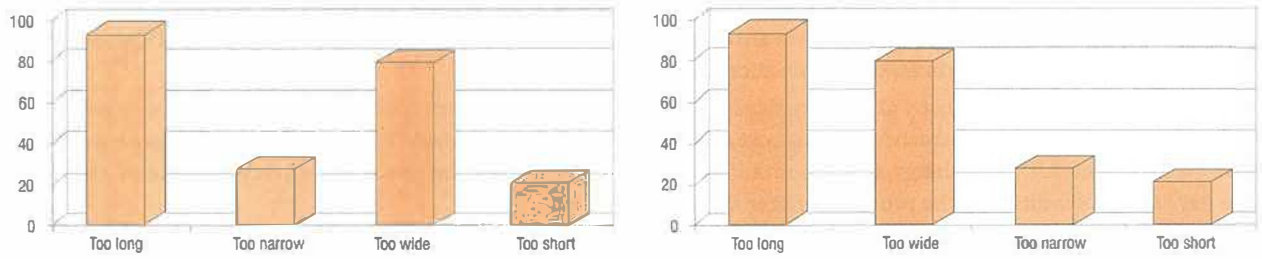

FIGURE 10.10 *Comparison of a typical histogram (left) and a Pareto Chart (right)*

The following methods are specific to Control Quality.

Checksheets

A checksheet is a type of checklist that can be used to keep track of data, such as quality problems uncovered during inspections, as well as to document how often a particular defect occurs, as illustrated in figure 10.11.

Defect	Frequency
Too long	𝍸 ||
Too narrow	|||
Too wide	𝍸 |||
Too short	||

FIGURE 10.11 *Checksheet*

Statistical Sampling

Let's think about a project to create a new process for manufacturing doors. There would be a small allowable variation in the height and width of the doors being made. The first efforts at creating the doors must be checked to ensure the doors meet requirements. But wouldn't inspecting every door take too much time? Enough doors could be sampled to confidently check requirements adherence without inspecting every door. It is best to take a sample of a population if the project manager believes there are not many defects, or if inspecting the entire population would take too long, cost too much, or be too destructive.

The sample size and frequency of measurements are determined in planning, the process is documented in managing quality and the sampling is done in control. Experimentation may be needed to determine a sample size that gives the team a safe measure of door size accuracy.

Sampling can also be done for project management activities. For example, you may initially check the on-time status for 5 out of 50 of a group's activities. If you find issues in those 5, you can assume you'll need to check for more issues among the remaining 45 activities.

Questionnaires and Surveys

Questionnaires and surveys may be used in Control Quality to gather data on details of problems or defects, or to confirm that customers or end users are satisfied with deliverables that have been deployed on the project. The results can be used to determine whether conformance to quality has been achieved.

Project Performance Reviews

The project manager or quality department may conduct periodic performance reviews to formally assess how the project is doing in terms of meeting quality requirements. This type of review involves comparing the results of control measurements to metrics identified in the quality management plan. It may bring to light changes necessary to achieve quality requirements.

Inspection

Inspections are used to verify that deliverables meet the requirements. Inspections may be referred to as walk-throughs and generally include measurement of project deliverables. Checklists and control charts may be used to capture and illustrate the data, respectively. Inspections are also used to check that previously approved changes have been made correctly, and that the changes have provided the intended outcomes (validated changes).

Control Charts

The use of control charts and their parameters are established in Manage Control and are used in Control Quality to help determine if the results of a process are within acceptable limits.

In this section we talk mostly about variances in product quality, but a control chart can also be used to represent and monitor data on project performance, such as cost and schedule variances. Outside of control charts a project manager can have control limits for many things. How about for a work package? Is one hour late in its delivery a problem? How about one day? Control limits help the project manager know when to act.

To better understand the need for control charts, imagine a door manufacturer undertaking a project to create a new production line. To make sure the production facility will create doors that meet quality standards, it's essential to monitor the processes and output so the new production line can become an ongoing business operation. Would each door be the same exact height? Weight? Not likely. Each door should be within the range of normal and acceptable limits.

Let's look at some of the related terms you should know for the exam. The following can be indicated on a control chart. As you study these terms, use figure 10.12 to envision what they mean in practice. Understanding these terms and how control charts are used can help you get a few more questions right on the exam.

- **Plotting the control chart** During the Control Quality process, samples are taken and the data are plotted in software that can render a chart (see the small squares shown on the control chart in figure 10.12). The control chart shows whether each sample is within acceptable limits. If the data does not fall within the acceptable range, the results are considered to be "out of control," which indicates a problem that needs to be fixed.
- **Upper and lower control limits** Control limits are often shown as two dashed lines and are the acceptable range of variation of a process or measurement's results. Control limits indicate what is stable versus unstable (out of control). Data points within this range are generally thought of as "in control," excluding the rule of seven (described later in this section) and are an acceptable range of variation.
- **Mean (average)** The mean is indicated by a line in the center of the control chart. A normal distribution curve represents the acceptable range of variance around a mean, and it falls within the boundaries of the control limits. In figure 10.12, the normal distribution curve is on the right side of the first control chart.
- **Specification limits** While control limits represent the performing organization's standards for quality, specification limits represent the customer's expectations—or the contractual requirements—for performance and quality on the project. Specification limits are inputs from the customer. Therefore, they can appear either inside or outside the control limits. In the first chart of figure 10.12, they are the solid lines above and below the dashed lines (which represent the upper and lower control limits). To meet the customer's specification limits, the performing organization's standards for quality (control limits) must be stricter than those of the customer. On the exam, assume that specification limits are outside the upper and lower control limits.
- **Out of control** The process is out of a state of statistical control under either of two circumstances:
  - ✓ A data point falls outside the upper or lower control limit.
  - ✓ There are nonrandom data points; these may be within the upper and lower control limits, such as the rule of seven (described next).

  Think of "out of control" as a lack of consistency and predictability in the process or a problem with its results. Also be aware that control limits may be called "tolerances" in agile environments and "out of control" is sometimes referred to as "out of tolerance."

- **Rule of seven** The rule of seven is a general rule (and you may see a general rule described as a "heuristic"). It refers to a group or series of data points that total seven or more on one side of the mean. The control chart on the right in figure 10.12 has seven nonrandom data points that fall above the mean. The rule of seven tells the project manager that, although none of these points are outside the control limits, they are not random, and the process is out of control. The project manager should investigate this type of situation and find a cause.

- **Assignable cause/special cause variation** An assignable cause or special cause variation signifies that a process is out of control. (See the data point sitting on the lower control limit in the left chart in figure 10.12.) If there is an assignable cause or special cause variation, it means a data point, or a series of data points, requires investigation to determine the cause of the variation. The project manager could use additional tools, such as a cause-and-effect diagram, to try to uncover the root cause of the variation.

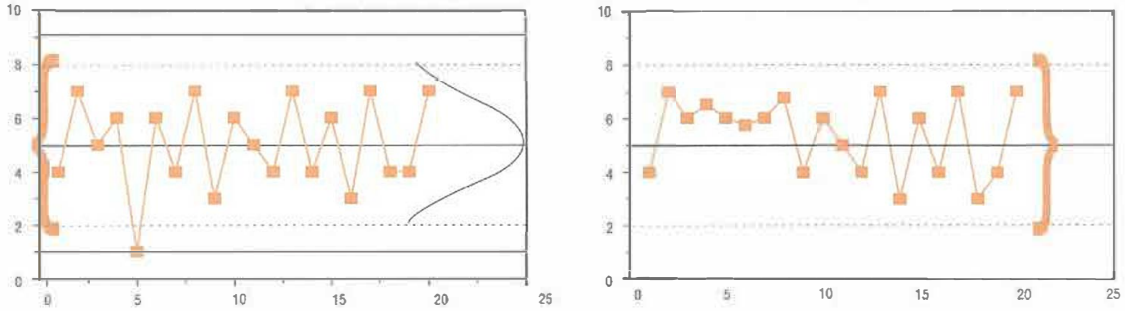

FIGURE 10.12 *Examples of control charts*

Agile Quality Management Concepts

Many of the concepts we have discussed related to the Process Groups model may be applicable to an agile or hybrid project. The following sections describe tools considered to be specific to agile. These may be used throughout the life of a project, in both adaptive and hybrid environments. It's important to understand these terms and concepts for exam questions that test your knowledge of adaptive quality management practices.

Cost of Change

We discuss in the "Stakeholders" chapter how important it is to identify and analyze stakeholders as early as possible and to diligently renew this effort throughout the project. This is because missed stakeholders with new requirements later in the project increase the cost of change. This philosophy applies to quality too. The sooner quality issues are discovered with project processes or a product increment being built, the easier and less costly it is to fix those issues and learn from them.

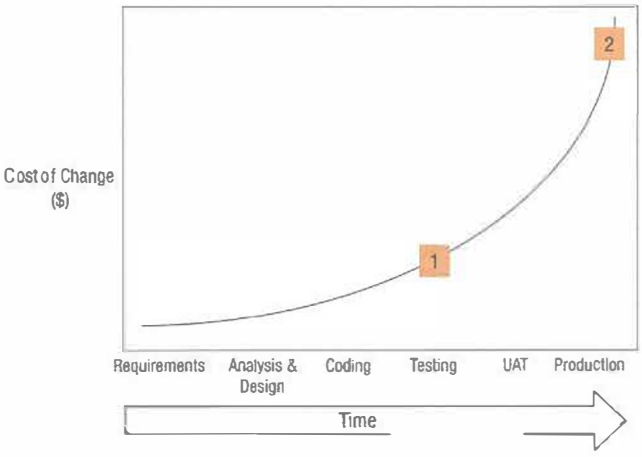

FIGURE 10.13 *Cost of change*

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Agile and hybrid processes call for iterative and incremental development and short iterations. That means that small increments of work can be evaluated and the team can get feedback on the evolving product as soon as possible. This allows for issues to be found early and resolved quickly so that added costs to the project can be avoided. This also means less rework. The cost of change curve in figure 10.13, shows that issues found during a test environment (point 1) are much cheaper to fix than issues found during production (point 2). This is an intuitive concept but visualizing it with this figure is helpful if you have not encountered it before.

Iterative and Incremental Development

The agile and hybrid use of iterative and incremental development and short iterations, and working closely together in small teams means the project manager and team are willing participants in a daily feedback loop related to the work of building the product. This fosters quick and early awareness of quality issues when they are usually still small and minor, lowering the cost of change.

Frequent Verification and Validation

Agile uses regular testing, short timeboxes, and reviews to meet the customer's needs. Frequent verification and validation is a way to discover and address human error or the misinterpretation of customer expectations, early and often. This practice is built into all agile methodologies.

Example Library software is being updated in two-week iterations. The team adds a search capability to find books by title. At the iteration review the team shows this new search function to the head librarian and staff. One of the staff suggests that the user should be able to just type the book title without putting the title in quotation marks as the demo showed. The team agreed to make this improvement.

Agile Meetings (Ceremonies) Are Focused on Quality

These types of meetings provide a way for issues to be found early in the product life cycle. One question in the daily standup—*Are there any impediments to the project work?*—can bring up potential issues and problems before there is an impact on quality or schedule. If a concern is brought up during a daily standup, the project manager must investigate and resolve that problem once the meeting is over.

Let's look at the four agile (or Scrum) ceremonies in terms of how they support quality.

Iteration Planning Meeting

The iteration (or sprint) planning meeting happens before each iteration. A lot has happened before this. The team has participated in the visioning of the product and the project, created a backlog of high-level requirements (as stories), prioritized with the help of the product owner, and have completed the high-level estimates needed to get this far. In this meeting further details for the upcoming iteration are worked out and details already documented are verified.

Daily Standup Meetings

Daily standup meetings are designed to keep forward momentum during an iteration and to communicate so that everyone knows what everyone is doing and what impediments there may be to getting the iteration's work done. No troubleshooting is done and the project manager investigates identified impediments after the meeting.

Meeting rules are meant to keep the meeting short and focused, and for participants to answer these three questions:

1. What have you done since the last meeting?
2. What are you working on today?
3. Are there any issues or impediments to your progress?

Retrospectives and Meetings

While a retrospective meeting in a plan-driven environment is typically held at the end of the project, in an agile or hybrid environment retrospectives most often take place at the end of each short, time-boxed iteration. The retrospective is an opportunity for the members of the development team to inspect and adapt their methods and teamwork. Can you see how this would be valuable to improve quality and identify issues as the product is being developed?

During the retrospective, the following questions are discussed:

1. What is going well?
2. What areas could use improvement?
3. What should we be doing differently?

Work in Progress (WIP) and Cycle Time

Work in progress (WIP) is the number of unfinished pieces of work going on at one time. Using Kanban boards are a common method of limiting work in progress. Excessive WIP is associated with several problems:

- It represents money that has been invested but isn't producing any return yet.
- It hides bottlenecks and masks efficiency issues.
- It carries the risk of potential rework if quality issues are discovered.

Agile and hybrid approaches place emphasis on limiting WIP to address these risks. Here, we'll look at some concepts related to WIP and how project managers limit WIP.

First, we'll look at lead time and cycle time. Figure 10.14 is a Kanban board that shows the difference between lead time and cycle time.

- **Lead time** This measures the length of time of an entire process. For example, from design to shipping, or from requirements gathering through development to deployment.
- **Cycle time** This measures the length of time to go through part of the process. For example, from assembly to painting, or from coding to testing.

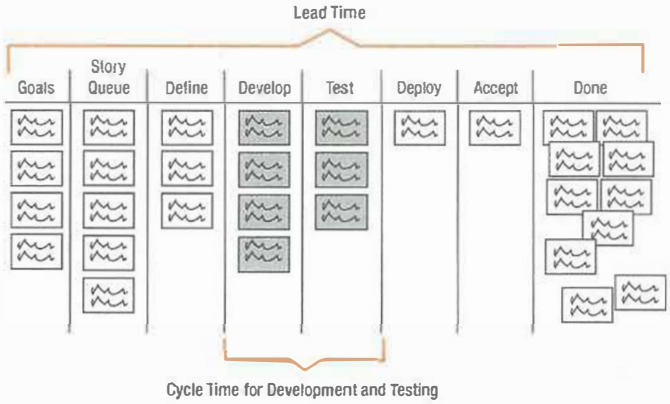

FIGURE 10.14 *Lead time and cycle time illustrated on a Kanban board*

Cycle time can be calculated by using a formula that involves WIP and throughput. Throughput is the average time it takes to complete the work (for example, the entire work of one iteration). Notice that throughput represents a global average—in this example, for an iteration—not just an average for a particular cycle time.

$$\text{Cycle time} = \frac{\text{WIP}}{\text{Throughput}}$$

Example Let's say the team has 18 points of WIP and is working at a velocity of 27 points per iteration, which is the throughput. So, 18 divided by 27 equals a cycle time 6.6 points.

Cycle Time = 18/27 = 6.6

(or 6.6 days for a 10-day iteration)

In other words, each of the cycles in question are on average 6.6 points worth of work.

Long cycle times mean there may be too much WIP, which increases risk and quality issues. Agile and hybrid approaches avoid this by breaking the work down into small batches and focusing on finishing these and getting customer acceptance as soon as possible.

Defects

Agile and hybrid projects also track the defect cycle time. This is the amount of time between when the defect was introduced to the time it was fixed. By doing so, the project team can keep the cost of change to a minimum. Some project teams actively track their average defect cycle time and set goals for the quick resolution of defects. This can minimize the cost of fixing defects.

Keep Project Environments Open and Safe for People

A student in an RMC class confided in the instructor that they had discovered a defect on an iteration for webpage development and were afraid to tell their project manager. The project manager, they said, would often call people out in daily standups and embarrass them. The student was hoping that the defect would be caught later when it was hard to trace back the work to them.

As we've said before, defects found later increase the level of risk to the project. Think back to that cost of change curve. It is less costly for the defect to be fixed as soon as it is known rather than later when the finished product is too complex to troubleshoot.

It is important for the project manager to create an environment where people feel comfortable to speak up and note issues as soon as possible. Project managers should take every opportunity to let team members know they can bring up issues and ask for help. By identifying problems early, the project can stay on track and save time and money.

Quality Management Outcomes: A Summary

Good quality management creates the opportunity to deliver a product with few or no defects, and that is fit for the purpose as defined by documented definitions of done and acceptance criteria. Product delivery and project closure should be in line with the approved schedule and budget, and at the agreed levels of quality. The product should meet the organization's and customer's business goals and objectives for which the project was chartered.

Quality management, in concert with stakeholder engagement efforts, should result in customer satisfaction, and successful and improved procurements (through good supply chain integration practices). Through teamwork and servant leadership the team and organization should benefit from continually improved processes, decision-making capabilities, and productivity. Project team satisfaction and motivation should be maintained or enhanced.

Understanding the Tools and Techniques Used in Quality Management

As you have read through this chapter, have you found yourself asking questions like, "Now, when are all these tools and techniques used?" or "What are the differences between the three parts of the quality management process again?" People tend to struggle with these concepts. The following exercise will help.

10.1 Exercise

Take time to research in this book the different methods that are created or used in each of the quality management processes. Then, in your Exercise Notebook, identify whether the following tools are used in planning, managing, and/or controlling quality. Remember that some tools and techniques are used in more than one quality management process. Think about the ways they are used for different purposes in each process.

1. Affinity diagrams
2. Alternatives analysis
3. Benchmarking
4. Brainstorming
5. Cause-and-effect diagrams
6. Checklists
7. Checksheets
8. Control charts
9. Cost of quality
10. Cost-benefit analysis
11. Design for X
12. Document analysis
13. Flowcharts
14. Histograms
15. Inspection
16. Interviews
17. Logical data model
18. Matrix diagrams
19. Meetings
20. Mind mapping
21. Multicriteria decision analysis
22. Performance reviews
23. Problem-solving
24. Process analysis
25. Questionnaires and surveys
26. Root cause analysis
27. Scatter diagrams
28. Statistical sampling
29. Test and inspection planning
30. Testing/product evaluations

Answer

	Tool	Used in Plan Quality Management	Used in Manage Quality	Used in Control Quality
1.	Affinity diagrams		X	
2.	Alternatives analysis		X	
3.	Benchmarking	X		
4.	Brainstorming	X		
5.	Cause-and-effect diagrams		X	X
6.	Checklists		X	X
7.	Checksheets			X
8.	Control charts			X
9.	Cost of quality	X		
10.	Cost-benefit analysis	X		
11.	Design for X		X	
12.	Document analysis		X	
13.	Flowcharts	X	X	
14.	Histograms		X	X
15.	Inspection			X
16.	Interviews	X		
17.	Logical data model	X		
18.	Matrix diagrams	X	X	
19.	Meetings	X		X
20.	Mind mapping	X		
21.	Multicriteria decision analysis	X	X	
22.	Performance reviews			X
23.	Problem-solving		X	
24.	Process analysis		X	
25.	Questionnaires and surveys			X
26.	Root cause analysis		X	X
27.	Scatter diagrams		X	X
28.	Statistical sampling			X
29.	Test and inspection planning	X		
30.	Testing/product evaluations			X

As we've said before, defects found later increase the level of risk to the project. Think back to that cost of change curve. It is less costly for the defect to be fixed as soon as it is known rather than later when the finished product is too complex to troubleshoot.

It is important for the project manager to create an environment where people feel comfortable to speak up and note issues as soon as possible. Project managers should take every opportunity to let team members know they can bring up issues and ask for help. By identifying problems early, the project can stay on track and save time and money.

Quality Management Outcomes: A Summary

Good quality management creates the opportunity to deliver a product with few or no defects, and that is fit for the purpose as defined by documented definitions of done and acceptance criteria. Product delivery and project closure should be in line with the approved schedule and budget, and at the agreed levels of quality. The product should meet the organization's and customer's business goals and objectives for which the project was chartered.

Quality management, in concert with stakeholder engagement efforts, should result in customer satisfaction, and successful and improved procurements (through good supply chain integration practices). Through teamwork and servant leadership the team and organization should benefit from continually improved processes, decision-making capabilities, and productivity. Project team satisfaction and motivation should be maintained or enhanced.

Understanding the Tools and Techniques Used in Quality Management

As you have read through this chapter, have you found yourself asking questions like, "Now, when are all these tools and techniques used?" or "What are the differences between the three parts of the quality management process again?" People tend to struggle with these concepts. The following exercise will help.

10.1 Exercise

Take time to research in this book the different methods that are created or used in each of the quality management processes. Then, in your Exercise Notebook, identify whether the following tools are used in planning, managing, and/or controlling quality. Remember that some tools and techniques are used in more than one quality management process. Think about the ways they are used for different purposes in each process.

1. Affinity diagrams
2. Alternatives analysis
3. Benchmarking
4. Brainstorming
5. Cause-and-effect diagrams
6. Checklists
7. Checksheets
8. Control charts
9. Cost of quality
10. Cost-benefit analysis
11. Design for X
12. Document analysis
13. Flowcharts
14. Histograms
15. Inspection
16. Interviews
17. Logical data model
18. Matrix diagrams
19. Meetings
20. Mind mapping
21. Multicriteria decision analysis
22. Performance reviews
23. Problem-solving
24. Process analysis
25. Questionnaires and surveys
26. Root cause analysis
27. Scatter diagrams
28. Statistical sampling
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Answer

	Tool	Used in Plan Quality Management	Used in Manage Quality	Used in Control Quality
1.	Affinity diagrams		X	
2.	Alternatives analysis		X	
3.	Benchmarking	X		
4.	Brainstorming	X		
5.	Cause-and-effect diagrams		X	X
6.	Checklists		X	X
7.	Checksheets			X
8.	Control charts			X
9.	Cost of quality	X		
10.	Cost-benefit analysis	X		
11.	Design for X		X	
12.	Document analysis		X	
13.	Flowcharts	X	X	
14.	Histograms		X	X
15.	Inspection			X
16.	Interviews	X		
17.	Logical data model	X		
18.	Matrix diagrams	X	X	
19.	Meetings	X		X
20.	Mind mapping	X		
21.	Multicriteria decision analysis	X	X	
22.	Performance reviews			X
23.	Problem-solving		X	
24.	Process analysis		X	
25.	Questionnaires and surveys			X
26.	Root cause analysis		X	X
27.	Scatter diagrams		X	X
28.	Statistical sampling			X
29.	Test and inspection planning	X		
30.	Testing/product evaluations			X

Putting It All Together

Do you think you understand quality management now? The following exercise will help you review the information you have learned.

10.2 Exercise

Using our library example, match the work described with the Quality Management process (processes may be used more than once).

1. Plan Quality Management
2. Manage Quality
3. Control Quality

Work

A. Ask the city council for their expectations about the quality levels of the library furniture.

B. Coordinate the date and time for the planned city inspection of the foundation.

C. Discuss the one inspection failure with the construction foreman.

D. Ask IT director to report the number of defects found during software testing.

E. Create a change request to the design after a problem is discovered.

F. When choosing a moving company to pack and move the existing books, ask for insurance claims on their last three moves.

G. Hire a cybersecurity audit for the patron login functionality.

Answer

A. 1

B. 2

C. 3

D. 2

E. 3

F. 1

G. 2