

UNIT 6

Software Quality Management

(5 Hours) — Software Project Management (CACS407)

NOTE: These notes may contain errors. Please verify important points, definitions and calculations with your textbook and teacher before relying on them.

6.1 Software Quality

6.1.1 Defining software quality

Quality has many definitions. Some commonly used ones are:

- **Conformance to requirements** (Crosby): the software does what its specification says.
- **Fitness for use** (Juran): the product satisfies the actual needs of its users.
- **IEEE definition**: the degree to which a system, component or process meets specified requirements and customer or user needs or expectations.

Quality covers both the **product** (functionality, reliability, usability, maintainability and so on) and the **process** used to build it. A good process increases the chance of a good product.

6.1.2 Importance of software quality

- Poor quality causes failures, data loss, security breaches and safety risks.
- Fixing defects late is far more expensive than preventing or finding them early.
- Quality products give customer satisfaction, repeat business and a good reputation.
- Higher quality reduces maintenance cost, which is a large part of the software life-cycle cost.
- Contracts and regulations often demand specified quality standards.
- Quality (together with cost and time) is part of the triple constraint of any project.

6.1.3 Quality views

View	Concern
User	Does it meet my needs and is it easy to use?
Developer	Does it meet the specification; is it easy to build and test?

View	Concern
Manager	Is it delivered on time and within budget with acceptable defects?
Maintainer	Is it understandable and easy to change?

6.2 Quality Management Concepts

Term	Meaning
Quality planning	Deciding which quality standards apply and how to meet them (quality plan).
Quality assurance (QA)	Process-oriented , preventive activities: standards, procedures, audits, process improvement.
Quality control (QC)	Product-oriented , detective activities: reviews, inspections, testing.
Verification	Are we building the product right? (conforms to the specification)
Validation	Are we building the right product? (meets user needs)

6.2.1 Cost of quality

Cost	Includes
Prevention	Training, standards, planning, process improvement.
Appraisal	Reviews, inspections, testing, audits.
Internal failure	Rework, re-testing, fixing defects found before delivery.
External failure	Warranty claims, complaints, support, lost customers and goodwill.

Note: The cost of failures rises steeply the later a defect is found, which is why prevention and early review pay off.

6.3 Total Quality Management (TQM)

TQM is a management approach in which *every* person in the organization is responsible for quality, and the organization continuously improves its processes to satisfy customers. Pioneers include W. Edwards Deming, Joseph Juran and Philip Crosby.

6.3.1 Principles of TQM

- **Customer focus** — quality is defined by the customer.
- **Total involvement** — all employees take part in quality improvement.
- **Process orientation** — focus on improving processes, not just inspecting results.

- **Continuous improvement (Kaizen)** — small, regular improvements using the PDCA cycle.
- **Fact-based decisions** — use data and measurement.
- **Leadership and commitment** from management.
- **Supplier partnership** and a systematic approach.

6.3.2 The PDCA (Deming) cycle

- **Plan** — identify the problem and plan the improvement.
- **Do** — implement the change on a small scale.
- **Check** — study the results against expectation.
- **Act** — standardise if it worked, otherwise repeat the cycle.

6.3.3 Tools commonly used

- Check sheets and histograms.
- Pareto charts (the vital few causes of most defects).
- Cause-and-effect (fishbone) diagrams.
- Control charts and scatter diagrams.
- Flow charts.

6.4 Six Sigma

Six Sigma (developed at Motorola in the 1980s, popularised by General Electric) is a data-driven method for reducing defects and variation in processes. A process at **six sigma** level produces only **3.4 defects per million opportunities (DPMO)**, using the conventional assumption of a 1.5σ long-term shift of the process mean.

6.4.1 DMAIC methodology

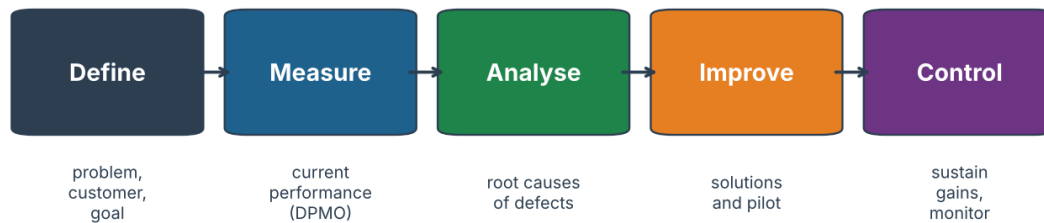


Figure 6.1 — DMAIC cycle for improving an existing process

Phase	Activities
Define	State the problem, customer requirements (CTQ - critical to quality) and project goal.
Measure	Collect data and measure current performance (defects, DPMO, sigma level).
Analyse	Find the root causes of defects (fishbone, Pareto, 5-whys).
Improve	Design and pilot solutions to remove the root causes.
Control	Standardise and monitor (control charts) to sustain the improvement.

Note: DMADV (Define, Measure, Analyse, Design, Verify) is used for designing a new process or product rather than improving an existing one.

6.4.2 Sigma levels

$$\text{DPMO} = (\text{Number of defects} \div (\text{Number of units} \times \text{Opportunities per unit})) \times 1,000,000$$

Sigma level	DPMO	Yield (% defect-free)
1σ	691,462	30.8538%
2σ	308,538	69.1462%
3σ	66,807	93.3193%
4σ	6,210	99.3790%
5σ	233	99.9767%
6σ	3.4	99.9997%

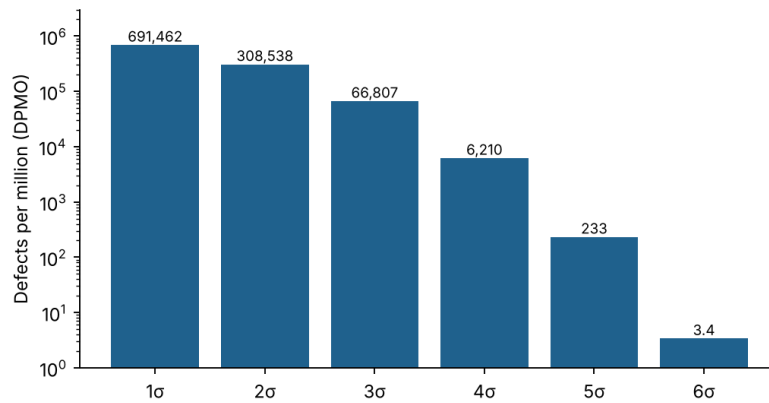


Figure 6.2 — Defects per million at each sigma level (with the 1.5σ shift)

Example 6.1 — Sigma level of a software process

In acceptance testing, 50 modules were examined. Each module has 20 opportunities for defect (for example, each input validation or business rule). A total of 30 defects were found. Find DPMO and the approximate sigma level.

Solution

Total opportunities = $50 \times 20 = 1,000$.

Defects per opportunity = $30 / 1,000 = 0.030$.

DPMO = $0.030 \times 1,000,000 = \mathbf{30,000}$.

From the normal distribution table (with the 1.5σ shift), the sigma level $\approx \mathbf{3.38\sigma}$, between 3σ and 4σ; improvement is needed to approach six sigma.

6.4.3 Six Sigma roles

- **Champion** — senior sponsor.
- **Master Black Belt** — trains and coaches.
- **Black Belt** — leads projects full time.
- **Green Belt** — leads small projects part time.
- **Yellow/White Belt** — team members with basic training.

6.4.4 TQM vs Six Sigma

Aspect	TQM	Six Sigma
Focus	Culture of continuous improvement, customer satisfaction	Reducing defects and variation using statistics

Aspect	TQM	Six Sigma
Approach	Broad, organisation-wide, PDCA	Project-based, DMAIC / DMADV
Measure	Quality objectives, customer satisfaction	Sigma level, DPMO, financial savings
People	Everyone	Trained belts, project teams

6.5 ISO 9126 Software Quality Model

ISO/IEC 9126 (first published 1991) is an international standard that defines a model of software product quality. It describes six **characteristics**, each divided into **sub-characteristics**, and also defines measures. It was later replaced by **ISO/IEC 25010** (SQuaRE series) in 2011, which adds security and compatibility as separate characteristics.



Figure 6.3 — ISO 9126 quality characteristics and sub-characteristics

Characteristic	Meaning	Example question
Functionality	Provides functions that meet stated and implied needs.	Does the payroll compute tax correctly?
Reliability	Maintains performance under stated conditions for a period.	How often does it fail? Does it recover?
Usability	Effort needed by users to learn and use it.	Can a new clerk use it after one hour of training?
Efficiency	Performance relative to resources used.	Response time under 100 users? Memory use?
Maintainability	Effort needed to modify the software.	How long to add a new report?

Characteristic	Meaning	Example question
Portability	Ease of transferring to another environment.	Can it run on Linux as well as Windows?

6.5.1 Three views of quality in the standard

- **Internal quality** — measured on the code and documents (static properties).
- **External quality** — measured when the software is executed (behaviour in tests).
- **Quality in use** — the user's view in the real environment: effectiveness, productivity, safety and satisfaction.

6.5.2 Using ISO 9126 in a project

- Decide which characteristics matter most for the project (for a web store: usability, efficiency, security; for an embedded controller: reliability).
- Set measurable targets for each (for example, mean time between failures, response time).
- Select measures, collect data during testing, and compare with targets.
- Record the targets in the quality plan and requirements specification.

Note: Related standards: ISO 9001 (quality management systems) concerns the organization's process; CMMI and ISO/IEC 12207 / 15504 (SPICE) concern process capability and maturity.

6.6 Place of Software Quality in Software Planning

Quality must be planned, not added at the end. It appears at every step of project planning.

- **Requirements:** quality requirements (performance, security, usability) are specified with measurable targets.
- **Estimation and scheduling:** time and cost for reviews, testing and rework are included; cutting them damages quality.
- **Quality plan:** standards, reviews, test strategy, metrics, responsibilities and tools.
- **Reviews and inspections** at the end of each stage (stage gates) to find defects early.
- **Testing:** unit, integration, system and acceptance testing against the quality targets.
- **Risk management:** poor quality is a risk; critical quality risks get mitigation.
- **Configuration management** protects the integrity of reviewed and tested items (Unit 7).
- **Measurement:** defect density, defect removal efficiency, reliability, customer satisfaction.

Example 6.2 — Defect removal efficiency

Testing before release found 90 defects. After release, users reported 10 more defects. Calculate defect removal efficiency (DRE).

Solution

$\text{DRE} = \text{defects found before release} \div (\text{defects found before} + \text{after release}) \times 100$

$\text{DRE} = 90 / (90 + 10) \times 100 = \mathbf{90\%}$.

Quality activity	When	Purpose
Peer review / walkthrough	After each work product	Find defects informally and share knowledge.
Formal inspection	Requirements, design, code	Systematic defect detection using a checklist and roles.
Testing	During and after coding	Detect failures against requirements.
Audit	Periodically	Check that standards and procedures are followed.
Metrics review	Milestones	Track quality trends and decide corrective action.

Key Takeaways

- ✓ Quality means conformance to requirements and fitness for use, in both product and process.
- ✓ QA is preventive and process-oriented; QC is detective and product-oriented.
- ✓ TQM is an organisation-wide culture of continuous improvement (PDCA, Kaizen).
- ✓ Six Sigma uses DMAIC and statistics to reach 3.4 DPMO; $\text{DPMO} = \text{defects} / (\text{units} \times \text{opportunities}) \times 10^6$.
- ✓ ISO 9126: functionality, reliability, usability, efficiency, maintainability, portability (replaced by ISO/IEC 25010).
- ✓ Quality has to be planned: quality plan, reviews, testing, metrics and time/cost allowances in the schedule.

— End of Unit 6 —