Modern QA's Roots: From 1800s Industry to Today

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Abstract

Nowadays, ensuring quality in the products we develop and deliver to customers and users is quite challenging. The main reason is that the time to go to production is very short. Execution environments and integrations are complex and comprehensive. We are building modern, sophisticated features that are not easy to test, and trying to manage all these workflows under tight schedules.

To conduct quality assurance in the most efficient way, we can apply several approaches. Looking back over the last 100 years of quality, we see that quality is a living and evolving cycle. To better understand the approaches we use today, it's important to be familiar with the background and original ideas that shaped them. ***Because actually, most pressing challenges in today's fast-paced software delivery still mirror the problems industrial pioneers faced over a century ago. Therefore, the solutions developed by those leaders can ease modern development challenges.***

Some of those fundamental quality assurance approaches are:

- Lean Development – Lean focuses on eliminating waste, improving flow, and delivering value efficiently [1] — principles are applied far beyond manufacturing. A fundamental practice of Lean development is TQM (Total Quality Management) – Evolving over decades, TQM emphasizes organization-wide quality responsibility, customer focus, and continuous improvement. [2].
- Prioritization and focusing on value. One example is Pareto Principle (80/20 Rule) – Vilfredo Pareto was an economist/sociologist who first noted and reported his observation that about 80 % of wealth was concentrated in about 20 % of a population in the late nineteenth-century [3].
- Continuous improvement: A core method is PDCA Cycle (Plan-Do-Check-Act) – Originally developed by Walter Shewhart [4] and popularized by W. Edwards Deming. It provides a structured, iterative approach to solving problems and refining processes.
- Bug analysis and prevention methods like FMEA, SWOT Analysis, Taguchi Model and Six Sigma.

These fundamental approaches, along with several others, have gradually evolved to shape modern QA practices. This paper argues how they bridge to today's methodologies and that teams achieve better QA outcomes when they apply classic quality principles as guiding intent, not just tools.

Biography

Mesut Durukal is a Quality Assurance and test automation enthusiast with experience in several domains. Along with having proficiency in CMMI and experience in Agile practices under his belt, he has taken various roles like Quality Owner, Hiring Manager and Chapter Lead in the organization, leading multiple QA squads in multinational projects.

He has expertise in test automation and integration to CI/CD platforms supporting continuous testing with logging, reporting and root cause analysis packages from scratch. Besides, he has been facilitating test processes and building test lifecycles in the projects.

1 Introduction

Looking back at 100 years of quality, it can be understood that multiple principles have been applied together to form a mature quality assurance approach. Understanding why these principles gained popularity and what key benefits they bring is essential. In this way, aiming to incorporate their greatest strengths into our everyday practices would be easier.

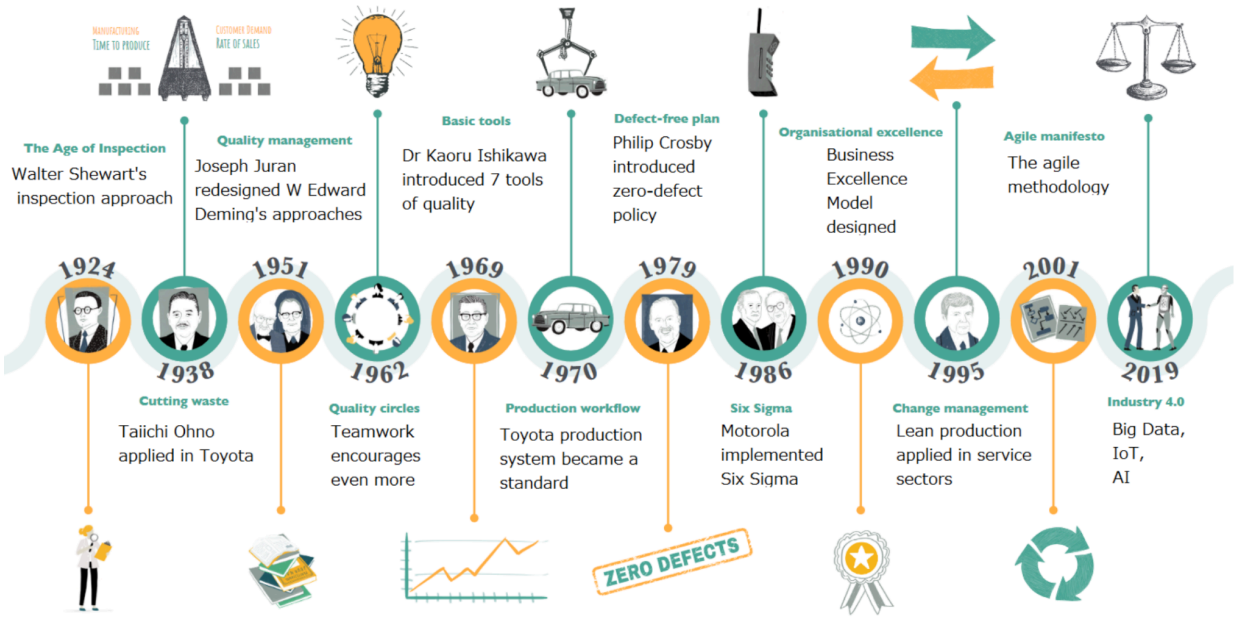

Figure 1: 100 years of quality [5]

2 Principles shaping today's Quality Assurance

2.1 Lean Development

The development of Lean Manufacturing has taken over two centuries. Let's take a quick look at this extensive background.

- Eli Whitney – Early 1800s: Whitney [6] initiated the use of **interchangeable** parts, moving production away from handcrafting and toward standardization. This already sounds familiar in terms of today's struggles and the good practices: **reusability**, scalability, and consistency.
- Frederick Taylor – Early 1900s: Known for Scientific Management, Taylor emphasized **efficiency**, standard procedures, and task optimization. His work inspired the need for structured, measurable processes in both manufacturing and quality practices. Again, we can see a bridge between today and the early 1900s, since ensuring efficiency is one of the biggest efforts in today's world. This is why we are spending a significant time to find the optimum **metrics** and measure the maturity of processes.
- Frank & Lillian Gilbreth – Early 20th Century: The Gilbreths introduced time and motion studies and process charts, laying the foundation for waste identification and process mapping. Their work was a method focused on improving work efficiency by **analyzing** and optimizing the movements of workers [7]. They used techniques like filming workers to identify wasteful actions and reduce fatigue. Their work laid the foundation for scientific management and we can relate it to modern **root cause analysis** and **post-mortem** studies for avoiding the same issues in the future.

- Henry Ford – 1910s–1920s: Ford revolutionized production with the moving assembly line [8] and continuous flow manufacturing. These innovations demonstrated the power of **minimizing wait times** and maximizing throughput. These principles have founded the key objectives in **automated software delivery pipelines** today.

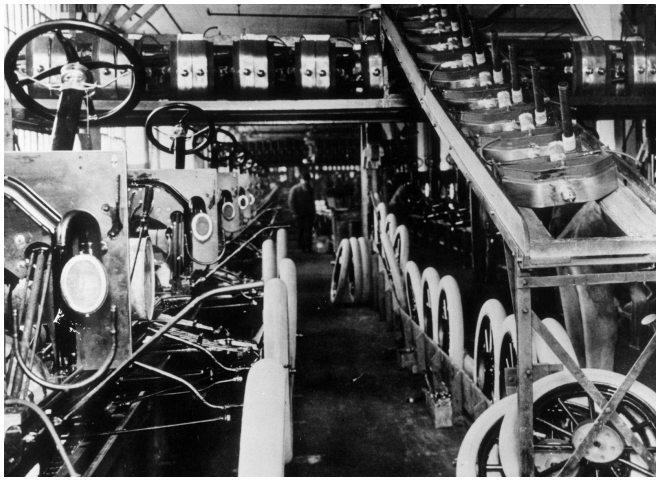

Figure 2: Ford Moving Assembly Line, 1913, Highland Park Michigan [9]

- Edward Deming, Kaoru Ishikawa, Joseph Juran, and Philip Crosby – 1940s–1960s: These Quality Thought Leaders contributed to quality philosophies like Statistical Process Control (SPC) and Total Quality Management (TQM). Their focus on **customer satisfaction** and data-driven improvement influenced modern QA **defect prevention** processes.

  In short, Total Quality Management (TQM) is a comprehensive management approach that focuses on continuous improvement across all areas of an organization, with the ultimate goal of enhancing the quality of products and services. Deming played a particularly influential role in promoting TQM principles in post-war Japan, which promotes the idea that quality is not the responsibility of a single department, but a shared commitment across the organization—from leadership to operations—using a systematic, long-term approach to improve processes, reduce defects, and meet or exceed customer expectations. In the context of modern Agile QA, TQM's influence is clear. Agile shares TQM's emphasis on continuous improvement, cross-functional collaboration, and a customer-centric mindset.

- Toyota Production System (TPS) – 1940s–1970s: Developed by Taiichi Ohno and Eiji Toyoda, TPS synthesized earlier ideas into a comprehensive system [10]. Core principles included:
  - **Elimination of waste** (muda)
  - **Just-In-Time (JIT)** production
  - **Continuous improvement** (kaizen)
  - **Respect for people**

  Toyota Production System inspired many QA methodologies that emphasize **value-driven testing** and team collaboration. The term “Lean” was introduced by James Womack in The Machine That Changed the World (1990) [11], summarizing decades of practice at Toyota. While the term was new, the philosophy had matured over time and found relevance in software development and QA processes.

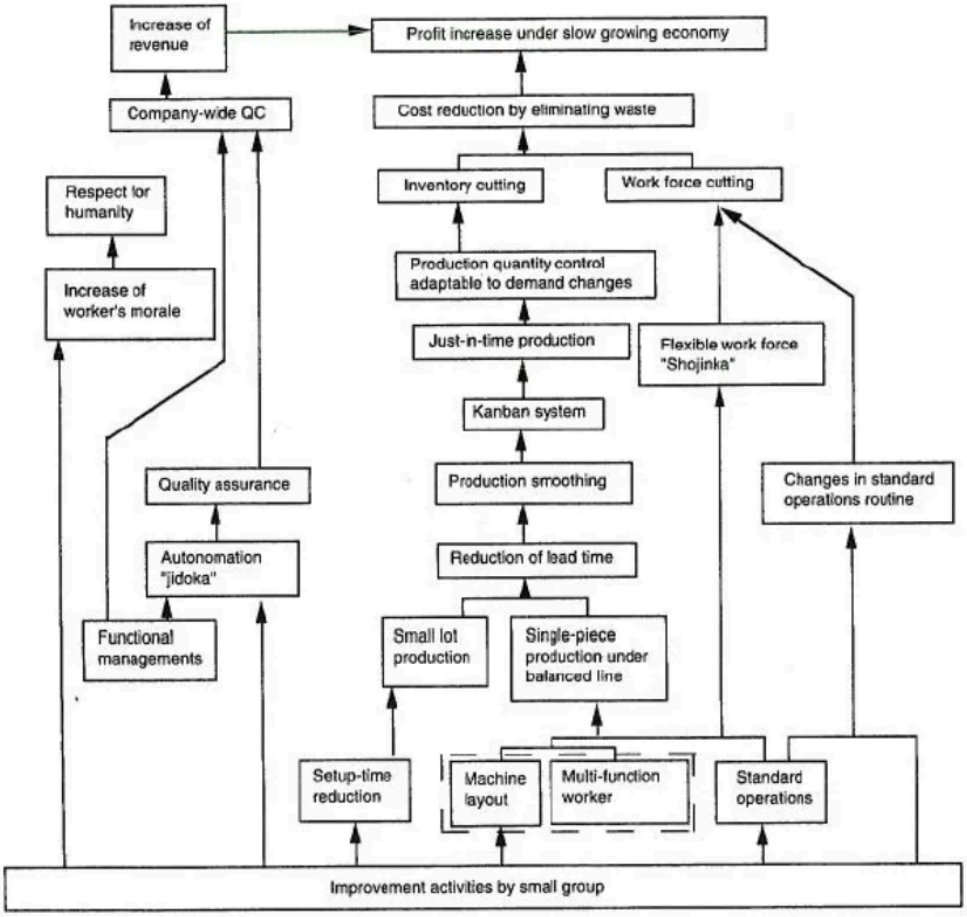

Figure 3: Depiction of TPS [12]

2.1.1 Reflections on Today

Eli Whitney's use of interchangeable parts sounds familiar in terms of today's landscape since we similarly try to avoid implementing the same solutions from scratch and instead encourage **reusability**, **modularity**, scalability, and consistency. Building a standard is the key for the use of interchangeable units because custom implementation would not integrate into external systems. Before developing short term solutions, planning a well-structured standard approach takes some time, but it will save time in the long term. This approach totally aligns with the Lean mindset by removing duplication.

Frederick Taylor's scientific approach to improve efficiency is again one of our biggest goals nowadays as release deadlines are the tightest ever and resources are limited. Gilbreth' s theory had the same goals of identifying root causes and removing them. If we understand and follow this mindset which analyzes the improvement rooms and bottlenecks in the process, this will help us conduct the releases more smoothly.

Henry Ford's moving assembly lines are still inspiring because we also try to automate stages in development pipelines and get rid of manual verification steps. For me, "push-on-green" practices are a modern reflection of Ford's moving lines. ***How I try to adapt it into an actionable item is by figuring out whether we can automate the verification steps we currently perform manually at each pipeline stop, and then adding the relevant ticket to our backlog.***

One of the popular quality assurance mottos nowadays is "We are all on the same boat". The idea follows the TQM principles which encourages teamwork and taking responsibility to improve quality. While TPS has similar principles, the focus is value-driven testing. Contemporary testing approaches like risk based testing or test suite prioritization methods are based on the same philosophy.

2.2 Prioritization & Value Mapping

One specific practice originated within TPS was **Value Stream Mapping.** It is used to **visualize, analyze, and optimize the flow of materials and information** required to deliver a product or service to a customer. The primary goal of VSM is to **identify value-added and non-value-added steps** in a process, uncover **waste**, and improve **overall efficiency and flow**.

2.2.1 Pareto Principle

Another approach, The **Pareto Principle (80/20 Rule)** is also frequently applied in the areas of quality and process improvement. The principle was first introduced by Italian economist Vilfredo Pareto [13] in 1896 and it was used to describe the unequal distribution of wealth, observing that 80% of land in Italy was owned by 20% of the population. Over time, it has become a general rule of thumb for prioritization, highlighting that a small number of causes are often responsible for the majority of outcomes.

It has become a widely adopted tool not only within Lean but also across other quality management frameworks like Six Sigma, Total Quality Management (TQM), and Agile QA.

2.2.2 Kano Model

The Kano Model [14], developed in the 1980s by Professor Noriaki Kano, is a framework for understanding and categorizing customer preferences and how they relate to product satisfaction. Unlike traditional models that treat all product features as equally important, the Kano Model distinguishes between different types of customer needs: basic needs (expected features that cause dissatisfaction when missing), performance needs (features that cause satisfaction when fulfilled and dissatisfaction when not), and excitement needs (unexpected features that delight customers but don't cause dissatisfaction when absent).

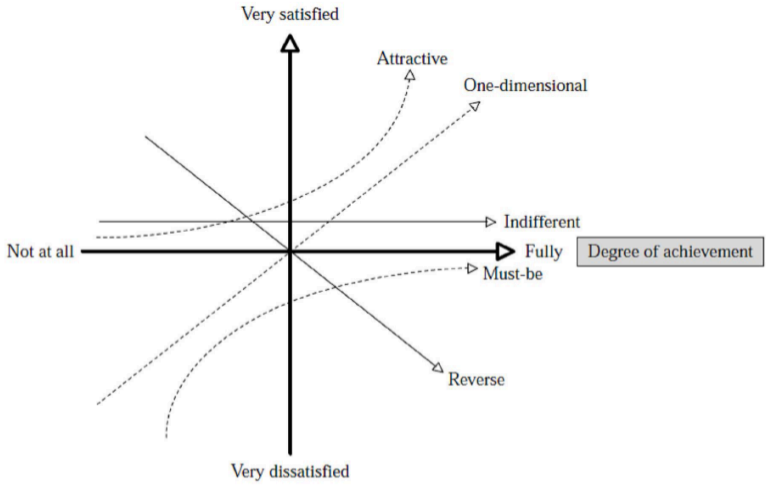

Figure 4: Kano Model [14]

2.2.3 Reflections on Today

Value Mapping principles help teams focus their limited time and resources on the most impactful areas. Agile projects operate under short iterations and tight timelines, so exhaustive testing is not feasible. By applying the 80/20 rule, QA teams can identify the 20% of components, user flows, or modules that tend to produce 80% of the defects or carry the highest risk. This insight is often gained through historical defect data, exploratory testing insights, or collaboration with developers and product owners. ***In all my projects, the first thing I do is discuss with Product Owners to clarify whether there are features that are not being used or needed, yet are still being maintained to reduce the technical debt.***

2.3 Continuous Improvement

The PDCA Cycle (Plan-Do-Check-Act) [4] is a method for continuous improvement, which was originally developed in the 1920s by Walter A. Shewhart, and later popularized by W. Edwards Deming. The PDCA cycle provides a structured, cyclical approach to problem-solving and improvement: first by planning a change or experiment, then doing (executing) the plan on a small scale, checking the results against expectations, and finally acting based on what was learned—either standardizing the improvement or adjusting the plan and iterating again.

Statistical Process Control (SPC), is a frequently used technique during Check stage, which introduces the use of **statistical techniques** to monitor, control, and improve process performance by identifying and addressing variations. Using statistical tools like **control charts**, SPC enables teams to detect issues early, make data-driven decisions, and prevent defects before they reach the customer.

2.3.1 Reflections on Today

The PDCA cycle is deeply aligned with the mindset and practices of **Agile Quality Assurance**. In Agile environments, teams continuously adapt their processes and products in short, iterative cycles—mirroring the PDCA model. In **modern Agile QA**, SPC principles remain highly relevant in terms of **fast feedback**, **metrics-driven improvement**, and **early detection of issues**. The underlying mindset of **monitoring trends**, identifying abnormal patterns, and making decisions based on measurable data is central to many Agile QA activities.

2.4 Bug Analysis & Failure Prevention

2.4.1 FMEA

Failure Modes and Effects Analysis (FMEA) [15] is a structured, proactive tool developed in the 1940s by the U.S. military to improve the reliability of complex systems. It was later adopted by industries such as aerospace, automotive, and manufacturing — and is now used widely in software and Agile QA practices as well. The core idea behind FMEA is to anticipate potential failure points in a system, process, or product before they occur, evaluate their impact, and prioritize mitigation strategies accordingly. It aligns with the Lean and Agile philosophy of preventing defects rather than reacting to them.

2.4.2 The Fishbone Diagram

The **Fishbone Diagram**, also known as the **Ishikawa Diagram** or **Cause-and-Effect Diagram**, was developed in the 1960s by Japanese quality management expert **Kaoru Ishikawa [16]**. It is a visual problem-solving tool designed to systematically identify, explore, and display the possible causes of a specific problem or effect. The goal is to uncover root causes rather than just symptoms, promoting a deeper understanding of issues impacting quality.

2.4.3 SWOT Analysis

SWOT Analysis [17] is a planning tool that was initiated in the **1960s**, primarily developed by business consultants such as **Albert Humphrey** at the Stanford Research Institute. It is used to evaluate an organization's internal **Strengths** and **Weaknesses**, alongside external **Opportunities** and **Threats**. The goal of SWOT is to support informed decision-making, strategic alignment, and risk mitigation by encouraging a holistic view of internal capabilities and external conditions.QA teams might use it during retrospectives or planning sessions to identify gaps in test coverage (weakness), emerging tools or automation practices (opportunities), or potential risks in deployment pipelines (threats).

2.4.4 Taguchi Model

The Taguchi Model [18], developed by Genichi Taguchi, is a quality engineering practice that focuses on designing quality into the process from the start instead of only detecting and fixing post-production defects. The main idea is that quality should be measured not just by defects, but by the total loss a product causes to society, including inconsistencies in performance and customer dissatisfaction. Taguchi introduced key tools such as **orthogonal arrays** to streamline experimental design, allowing for the analysis of multiple variables with minimal testing effort.

2.4.5 Six Sigma

Six Sigma [19] is a data-driven quality management methodology that emerged in the **1980s**, initially developed by **engineers at Motorola**, with key contributions from **Bill Smith** and later popularized by **Jack Welch** at General Electric. The primary goal of Six Sigma is to reduce process variation and eliminate defects to improve overall quality and efficiency.

2.4.6 Reflections on Today

Bug analysis and failure prevention is one of the most important practices today as we always say “Fixing bugs is great, but how about avoiding them in the first place?” FMEA helps teams proactively identify test risks before new features are released, evaluate weak spots in automated test coverage or CI/CD pipelines, mitigate production failures by reviewing likely failure points during sprint planning or retrospectives and collaborate cross-functionally between QA, developers, and product owners to build more robust systems.

Similarly, In modern Agile QA, the Fishbone Diagram is, just like SWOT analysis, commonly used during retrospectives, defect analysis, and root cause investigations to collaboratively diagnose recurring bugs, process inefficiencies, or test coverage gaps. Taguchi’s methods are used for optimizing automated test cases, tuning performance under varied environments, and ensuring software behaves consistently across unpredictable real-world conditions.

Looking at Six Sigma, its structured problem-solving techniques are used to bring discipline and measurement into Agile environments. While Agile emphasizes rapid iteration and adaptability, Six Sigma offers tools to dig deep into quality issues, identify root causes, and validate improvements with data—making it especially useful in Agile teams working in regulated or high-stakes industries like finance, healthcare, or aerospace.

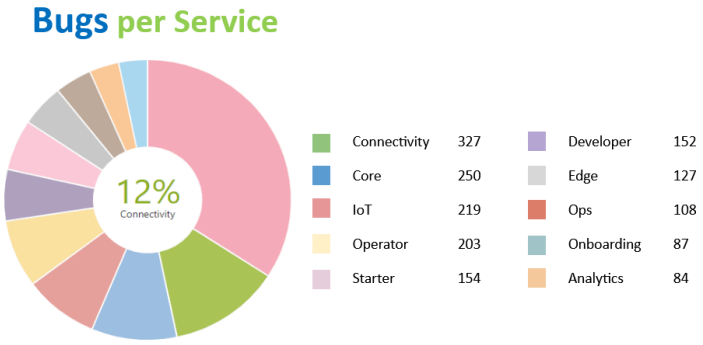

Figure 5: One dashboard I created on Jira to show the modules on which bugs were found.

3 Conclusion

Over the past century, the field of quality assurance has evolved through the convergence of foundational principles and industrial innovations. Early contributions from figures like Frederick Taylor, Frank and Lillian Gilbreth, and Henry Ford laid the groundwork for systematized processes and efficiency—values that resonate in today's software engineering pipelines. The mid-20th century saw the emergence of quality thought leaders such as Deming, Ishikawa, Juran, and Crosby, who emphasized statistical control, customer focus, and organization-wide quality ownership. Their ideas culminated in frameworks like Total Quality Management (TQM), which later influenced modern Agile QA with its emphasis on collaboration, data-driven improvement, and continuous feedback loops. The Toyota Production System (TPS), a hallmark of Lean Manufacturing, integrated these philosophies into a holistic model emphasizing waste reduction, flow, and respect for people. As a result, it paved the way for Agile practices centered around efficiency and value delivery.

Modern QA also draws from prioritization and analytical techniques like the Pareto Principle and Value Stream Mapping, which help teams focus on the most critical issues and optimize testing efforts. Frameworks such as the PDCA Cycle, Statistical Process Control, and Failure Modes and Effects Analysis (FMEA) continue to inform root cause analysis, risk prevention, and performance monitoring. Visual and diagnostic tools like the Fishbone Diagram, SWOT Analysis, and the Kano Model offer structured ways to identify quality gaps, evaluate customer needs, and guide decision-making under uncertainty. Meanwhile, the Taguchi Model and Six Sigma contribute robust, data-oriented methodologies for improving process consistency and reducing variability—supporting even fast-moving Agile teams in maintaining high reliability.

Altogether, this century-long lineage of quality practices continues to shape and enrich Agile Quality Assurance, demonstrating that while tools and environments evolve, the fundamental goals—consistency, efficiency, customer satisfaction, and continuous improvement—remain timeless. From Eli Whitney's interchangeable parts in the 1800s to Agile retrospectives and CI pipelines today, the pursuit of quality has never stood still. While the tools and terminologies have changed, **the underlying goals**—repeatability, predictability, efficiency, and continuous improvement—**have remained strikingly consistent**. This historical continuity reminds us that **modern Agile QA is not a break from the past but a refinement of it.** Techniques like Test Automation, Shift-Left Testing, and fast feedback loops don't just emerge from Agile values—they echo the same principles that drove Total Quality Management, Lean Manufacturing, and the scientific management of production lines. Each generation simply adapts these ideas to fit its technological and organizational context.

Understanding this lineage gives us **more than just appreciation for history**. It challenges us to reexamine our current practices: Are we applying test automation merely for speed, or as a way to ensure repeatability like Shewhart's control charts? Are retrospectives just rituals, or a modern echo of Deming's PDCA cycle aimed at real improvement? If we treat Agile QA not just as a set of practices, but as our era's response to an enduring quality problem, we unlock new ways to be intentional, impactful, and innovative.

3.1 Personal Experiences in Actual Projects

I personally respect those old-but-gold fundamental quality assurance approaches. I've observed that they significantly boost the efficiency of my outcomes in real-world projects.

Starting with Eli Whitney's use of interchangeable parts, I've realized—especially in large organizations—that many teams or individuals often attempt to solve problems that have already been solved before, sometimes in different forms, and sometimes even in exactly the same way. After adopting this mindset, I began consistently approaching problems from this perspective: even before starting implementation, I first check whether a similar module already exists elsewhere. Then, I always try to move repeated steps in spec files to helper classes or util files from where it can be called by several different modules.

Next, I would choose Henry Ford's moving assembly lines to continue with. Automation is definitely very critical for QA processes. But furthermore, in-sprint automation is critical since otherwise the pipeline is stopped for manual verification and there is a significant waste of time. Even if the verification itself takes some certain time, there is additional unseen waste stemming from the context switch. As Ford assists operations with moving lines, in a similar fashion, when we assist pipelines with automation, it will facilitate the smoothness of the deliveries.

Thirdly, in various projects I experienced that individual efforts do not work in terms of quality assurance. QA is one ring in the whole chain. Even if early feedback is given, important observations are done and all the other good practices are applied, there would be no outcome without support from development and product management teams. To solve testability issues, a strong communication is a must between all teams. Similarly, to ensure robustness and sustainability of quality assurance, teams and team members should continuously maintain a close relationship and support each other. This holistic approach is mainly encouraged by TQM and I can easily say that it improved my work a lot.

One of the most crucial terms in modern product development and delivery practices is "Focusing on Value". An initiative I started recently boosted the efficiency in a significant level, which was discussing the features with the product managers. After figuring out the features which are not a real need for the customers, we removed them from our test suite and in this way we had a chance to reserve more time on more critical features.

Finally, to wrap up, measuring quality is very difficult. There might be various metrics we can track and monitor for this purpose, but bugs are perhaps one of the most direct indicators of product quality. Again, it is not only the number of reported bugs, but the content of the issues. That being said, as bugs are the direct indicators of quality, how can we minimize the number of critical bugs? Solving them as soon as possible is of course a good way to do it, but a better approach is finding root causes in advance and trying to avoid having them in the first place. By embracing the mindset, I try to perform root cause analysis and bug monitoring activities to identify repeating issues. After figuring out root causes and more importantly developing solutions and preventive measures, we will observe that the number of escaped critical bugs will significantly reduce.

As a final thought, we don't always need to build everything from scratch. Quality assurance is a long-standing, evolving discipline with a rich heritage rooted in traditional methods dating back to the 1800s. By embracing this legacy of quality advocacy, it is entirely possible to deliver high-quality products with limited resources—and still achieve strong user engagement.

3.2 Summary Table

Quality Principles	Matching Modern QA Practices
Interchangeable Parts (Eli Whitney, 1800s)	Test standardization, modular architecture, reusable test components
Pareto Principle (1890s)	Bug prioritization, defect clustering, focusing QA efforts on top issues
Scientific Management (Taylor, early 1900s)	Process metrics, test coverage analysis, automation strategy
Gilbreths' Motion Studies (1910s)	Test execution optimization, CI/CD efficiency
Ford's Assembly Line (1913)	Pipeline orchestration (CI/CD), repeatable automated deployments
PDCA Cycle (1920s)	Iterative testing cycles, sprint-based QA planning and retrospectives
Statistical Process Control - SPC (1920s)	Test result monitoring, performance regression tracking, trend analysis
Total Quality Management - TQM (1950s)	Team ownership of quality, cross-functional QA involvement, continuous improvement
Toyota Production System / Lean (1940s–50s)	Agile QA principles, waste elimination in testing, focus on value delivery
FMEA (1940s)	Risk-based testing, failure impact analysis
Fishbone Diagram / Ishikawa (1960)	Root cause analysis for bugs, exploratory testing strategy
SWOT Analysis (1960s)	QA strategy design, evaluating product risks and opportunities
Taguchi Model (1960s)	Robustness testing, test environment tuning, performance testing under variation
Six Sigma (1980s)	Test process improvement, defect rate reduction, quality metrics
Capability Maturity Model - CMM (1980s)	QA process maturity models, structured test lifecycle practices
Kano Model (1980s)	Usability testing, prioritizing features based on customer satisfaction
Value Stream Mapping	Test process visualization, identifying bottlenecks in QA workflows

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