


The Rocky Marriage of Technology and Quality



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Technological Innovation

- **Parsing innovation into categories¹:**
 - Incremental innovation: refinement of products and production systems
 - Radical innovation: entirely new product category
 - Architectural innovation: reconfiguration of a product
- **Examples of innovation that will be used in this talk include the computer and lighting**


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Definitions of Quality: Art

- It is said that art mimics life, so finding a definition of quality in art
- **From Zen and the Art of Motorcycle Maintenance:**
 - “The real train of knowledge isn’t a static entity that can be stopped and subdivided. It’s always going somewhere, on a track called Quality².”
- **Not pursuing metaphysical arguments, this interesting quote presages my approach of reaching into several fields tying quality and technology together**


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Definition of Quality: Formal

- **ASQ’s two definitions of quality³:**
 - A subjective term for which each person or sector has its own definition. Two articulations:
 - One common articulation⁴ is customer-defined: “I know it when I see it” such as in a focus group
 - Or quality could be an ideal such as in Plato⁵ who made an analogy of shadows in a cave where the “truth is nothing but shadows of the images” and “you should be hold not an image but the absolute truth”
 - In technical usage, quality can have two meanings:
 1. the characteristics of a product or service that bear on its ability to satisfy stated or implied needs;
 2. a product or service free of deficiencies. According to Joseph Juran, quality means “fitness for use;” according to Philip Crosby, it means “conformance to requirements.”
- **Although flexible, is ASQ’s definition appropriate for new technology?**
 - As my presentation will explain, ASQ’s definitions do not include the temporal (time) required for new technologies that create new markets

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Quality: Management

- **It is no surprise that management literature has struggled marrying quality and innovation**
 - From the Juran Institute:
 - “One of the most frequent questions I hear is whether we can have quality management and creativity at the same time... We need ideas for continuous quality improvement, to continually reinvent our businesses and to create new goods and service⁶.” (viz., continuous improvement)

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Continuous Improvement

- **Continuous improvement is integral to quality management.**
In fact,
 - ASQ holds an annual conference called the ASQ World Conference on Quality and Improvement (May 5-8, 2008 in Houston).
- **Common tools in continuous improvement include control charts and PDCA**

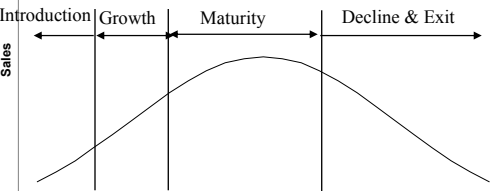
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Exponent  7

Temporal Aspect: The Product Life Cycle

- **The Product Life Cycle⁷ (PLC) describes a product's lifetime as a series of phases, each phase with characteristics**

Maturity Phase features large market with intense competition but with reduced profit margins relative to growth phase. Maturity is often the longest duration phase.



Introduction | Growth | Maturity | Decline & Exit

Sales

- **What is called quality changes in the PLC phases**

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Exponent  8

Quality: Marketing

- **Market segmentation is the process of so designing or featuring a product or service that will make a particularly strong appeal to some identifiable subpart of a total market.⁸**
- **Segmentation is the basis of corporate strategy used in mature markets.**
 - The isles of grocery stores are stocked full with products focused on multiple segments
 - Examples include bottled water, laundry detergents, beer
- **Quality is typically defined within each market segment**
 - Conformance to requirements or fitness for use (ASQ's second definition)
 - Requirements typically originate from focus groups (ASQ's first definition)

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Exponent 9

Time Factors

- Production cost
 - In 1936, the reduction of cost per unit with increasing production was called the learning curve effect⁹.
 - As an example, the reduction in labor cost per unit might reduce by a percentage (determined by technology) for each doubling of production quantity.
 - This concept can be extended from labor to include all variable costs, called the experience curve
 - Each new technologies typically develop characteristic curves.
 - Market performance forms a characteristic curve called the technology life cycle
 - Quality work focuses on mature technology
 - Functional performance forms over time forms an "s curve"¹⁰.
 - As a technology matures, production improvements create a series of s curves that combine to create technology growth of an industry such as Moore's Law for integrated circuits, Kryder's Law for disk drives or Heinz's Law for lighting
 - Technology forecasting is, in large part, based on these relationships

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Exponent 10

Example of Current Technological Change and the Learning Curve

Year	Cost (\$/Mimhr)
1800	10000
1850	1000
1900	100
1950	10
2000	1
2050	0.1

- Lighting technology follows a learning curve. The cost of lighting has reduced by 10 times every 50 years, since fire¹¹.

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Exponent 11

Haitz's Law

Year	Lumens
1965	0.001
1970	0.002
1975	0.004
1980	0.008
1985	0.016
1990	0.032
1995	0.064
2000	0.128
2005	0.256

- Analogous to Moore's Law for integrated circuits, Haitz's Law says light emitting diode (LED) luminous flux doubles every 18 to 24 months¹²

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Exponent 12

Quality Focuses on Mature products

- Therefore, the ASQ definition of Quality is focused on the mature phase of the product life cycle
 - As shown by both the definition of quality and the mechanisms of continuous improvement and incremental innovation
- Quality tools to address new products known as Quality Function Deployment
 - The house of quality is market segmentation
- But how does the Quality professional approach new technologies, technologies that replace existing product families?

House of Quality

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Exponent 13

Technology Life Cycle

- **The Technology Life Cycle¹³ is an approach that is a generalization of the Product Life Cycle to include all firms making a similar product**
 - The previous learning curve example included more than one lighting technology.
 - As an example in the “History of Light” graph, the firms who produced high quality whale oil succumbed to electric bulb technology.

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Exponent 14

Economic Technology Diffusion

- **Economists call the rate at which technology becomes widely used, adopted, “technology diffusion”.**
 - Also described as an epidemic, a legitimization process, or rational process¹⁴
- **An example of technology diffusion is the adoption of the personal computer (PC). The following chart shows PC adoption by metropolitan area.¹⁵**

Computer use by metropolitan area
Number of PCs per 100 employees relative to San Francisco
(after controlling for industry composition)

2002

1990

Hickory, NC
El Paso
Fresno, CA
Austin
NYC
Boston
Madison
DC
SI

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Exponent 15

Marketing Description of Technology Diffusion

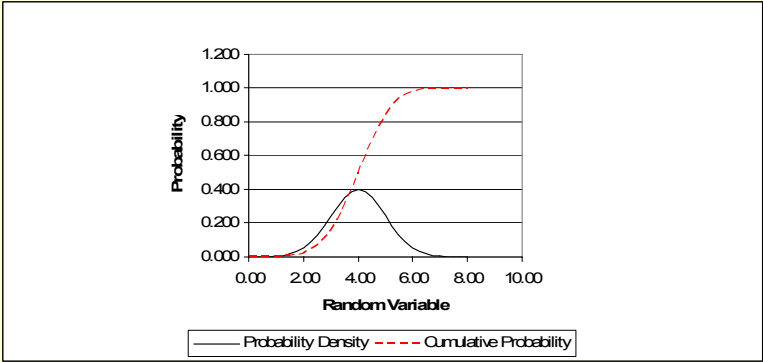
- When selling a new product category, one might seek a more useful view of diffusion than the one on the previous slide
- A generalization of the PLC¹⁶ concept to explain buying behavior, subdividing the market into rationalized behavior
 - This may be an attribution bias, but useful sales perspective nevertheless



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Exponent 16

Introduction of a Technology forms an S-Curve



- The integral of the probability density (such as the PLC) is the cumulative probability, and it forms an s-curve
- The s curve is used to represent technology change adoption¹⁷ and Haitz's Law is the combination of many s-curves

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Exponent 17



Innovation and Quality: Conclusion and Issue

- **Quality efforts focus on incremental innovation for mature products (PLC)**
- **Technology adoption follows a diffusion process**
 - Technical innovation is inherent to quality, but the focus of technology in quality is incremental innovation such as process improvement
 - Technological process can be described by a s curve
- **That said, how does the quality professional approach new technologies, technologies that replace existing product families?**

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Exponent 18

Radical Technology Innovation Example: Electronic Computer vs. the Slide Rule



- The computer replaced the slide rule (17th century¹⁸)
- Replica of the Atanasoff-Berry computer at Iowa State University, the first electronic computer (1939)^{19,20}

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Technological Innovation: Economics

- **Creative Destruction is a theoretical explanation of the creation of new markets (i.e., electronic computers) and destruction of old markets (i.e., slide rules)**
- **The economist Joseph Schumpeter (1883-1950)²¹**
 - Contrary to the definition of quality, Schumpeter said “Capitalism is by nature a method of economic change and never can be stationary.”
 - He further coined the expression “Creative Destruction” to describe replacing existing product categories with new product technologies
- **Though poetic, this description does not provide an adequate description of the economic results of innovation. New theories have developed that explain the mechanisms of new markets.**

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Technological Innovation: Biography

- **An example is provided in a new book by Steve Wozniak about why HP did not adopt his Apple I computer design²²**
 - “I believed it was my duty to tell HP about what I had designed while working for them... I told my boss, that I had designed an inexpensive desktop computer that could sell for under \$800 and would run BASIC.”
 - Response: “HP keeps a close eye on quality control, he told me. ... So he turned me down... I received a note from HP’s legal department saying they claimed no right to my design.”
 - “I was disappointed.. But looking back, I see he was right. How could HP do it? It couldn’t.”

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Exponent 21

Technological Innovation: Strategy

The graph plots Performance on the vertical axis and Time on the horizontal axis. Two dashed lines, labeled 'Sustaining Technologies', represent performance trajectories at the high and low ends of the market. A solid line, labeled 'Disruptive technical innovation', starts at the low end and moves upward over time. Two dashed circles are drawn: one at the top right labeled 'Region in which old technology over-performs' and one at the bottom right labeled 'Region in which new technology underperforms (low Quality)'. A red dashed arrow points from the low end of the market towards the disruptive innovation line.

- Prof. Christensen's²³ chart describing sustaining vs. disruptive technologies as trajectories and consequences
- His question: why do leading firms fail in face of technical change


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Technological Innovation: Strategy

- Christensen's dilemma is attributed to his basis of predictive rationality by Dew & Saravathy²⁴ who answer with a Pirsigesque invention they call "effectuation"
 - Causation processes focus on generating and selecting means to create an effect
 - Example: market segmentation-targeting-positioning
 - Effectuation processes take means as given and focus on selecting between the possible effects that can be created with those means (such as social networks)
 - The success of silicon valley has been much studied as attributed to groups of skilled workers in an industrial center²⁵
 - Predictive vs. effectual: 1. planning dinner, shopping for diner ingredients, cooking vs. 2. looking at what is available, planning menu, cooking
- What does this mean?
 - To the extent you can predict the future, you can control it.
 - To the extent that you can control the future, you need not predict it.

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Conclusions

- **The quality function has been built to benefit mature products in the technology life cycle, products differentiated by incremental innovation**
 - Silicon valley has provided revolutionary innovations, innovations where application of quality tools has led to industry growth
- **I did not tell you a motivation of this talk. I think technology is at an inflection point. I think a new wave of innovation is about the break over us**
 - Hence, the importance of this presentation (maybe I can come talk about why in the future).
- **Quality professionals confronted with revolutionary technology should consider the entrepreneurial effectual process (described by Dew and Sarasvathy in response to Christensen's description of technology markets) rather than the traditional methods based on quality for products based on mature technologies**

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