Seven Basic Quality Tools



The Seven Basic Tools

- Checklists (Checksheets)
- Pareto Diagrams
- Histograms
- Run Charts
- Scatter Diagrams (Scatter Plots)
- Control Charts
- Cause-and-Effect (Fishbone) Diagrams



What Are These Tools?

- Simple techniques to:
 - Track quality performance and trends.
 - Identify the existence of quality problems.
 - Analyze and gain insights into the causes and sources of quality problems.
 - Figure out which problems to address.
 - Help eliminate quality problems.
 - Defect prevention, not just detection and correction.
- Basic knowledge for anyone interested in quality, engineering problem solving & systems design.
 - Probably already familiar with most of these.



Why Exactly Seven Tools?

- Ishikawa promoted the notion of 7 basic tools that could be used to address quality.
 - Designed for manufacturing environments, but applicable to engineering & management.
- There are other very useful tools:
 - Templates, workflow automation.
 - Pie charts and other graphical representations.
 - Relationship diagrams, tree diagrams etc. ("7 new quality tools").
 - System dynamics diagrams (influence diagrams).
- We learn a basic subset here, others left to "lifelong learning".
 - Corporate training often introduces/uses quality tools & techniques.



What to Learn About Each Tool

- What is the tool?
- How is it used?
- For what purposes is it useful?
- What value does it add?
- What are its limitations?
- How can it be used effectively?



Histogram

- A bar graph showing frequency counts.
- X axis often a nominal or ordinal scale.
- Use/value: Easy to see relative magnitudes / frequencies.
 - Sometimes low frequency items are of interest e.g. dissatisfied customers: histogram may "minimize" these.
 - Can use different color or other ways to highlight these.
- Sometimes multiple bars for each item (e.g. last year / this year), to show trends and changes.
- Pie chart representation useful if these are parts of a whole.
 - Not very good if there are several low-frequency items of interest.
- Sometimes cumulative frequency line added to show "total at or below this level" – useful if X axis is ordinal scale.



Histogram Example





From http://www.freequality.org SE 450 Software Processes & Product Metrics

Run Charts

- Plot of some measurement/metric vs. (usually) time.
 - Use this when X axis is interval or ratio scale e.g. "team size".
- Shows trends over time.
 - Easier to spot overall upward or downward trend, or even cyclical variations.
- Visually separate random from significant variation.
 - Major spikes / valleys triggers for explanation / investigation / action.
- Value: Identification of problems, trends, unexpected good results (may learn a lot from these).



Run Charts





Cause-And-Effect (Fishbone) Diagram

- Diagram showing hierarchical structure of causes that contribute to a problem or outcome:
 - Problem of interest forms the backbone.
 - Spines are causes that contribute to the problem.
 - Spines may have bones that represent its contributory factors and so on.
- Used in brainstorming to diagram and identify various possible factors contributing to a problem, and to identify causal sequences (A causes B causes C).
 - Very simple but extraordinarily useful tool.
- Initially both minor factors (that occur rarely or contribute very little) and major causes may all get listed.



Example Fishbone Diagram

• Ex. : High Inventory Shrinkage at local Drug Store



Pareto Diagram

- Histogram arranged by decreasing frequency.
- Used to identify causes that contribute most to the problem.
- After fishbone analysis, may do data gathering to figure out the frequency with which each cause contributes to the problem.
 - In software, review reports are good data sources.
- Plot histogram, identify the major causes easily.
- Based on 80/20 rule.
 - "20% of the causes contribute to 80% of the effects".
 - Indicates general principle that some causes likely to be a lot more significant than others.
- Highest cost-benefit from addressing the most significant problems.
 - Less significant problems may barely be worth addressing.



Pizza Example (Part 2)

• The completed Pareto Analysis results in the following graph:



From http://www.freequality.org



Slices of Pizza SE 450 Software Processes & Product Metrics

Checklists

- Once we identify the causes of problems, how do we eliminate them?
 - Checklists are simple and incredibly effective at preventing & eliminating defects on repetitive tasks e.g. To Do lists, "did you"s on bill payment envelopes, etc.
- Capture knowledge about common problems & how to avoid them.
- Can be used in review processes to identify problems.
- Lightweight: low additional effort to use (not zero!)
- Checklists that become too long lose value (use pareto analysis!)



Flowcharts (Processes)

- Flowcharts show sequencing of activities & decisions.
 - Depiction of processes for doing things.
- Streamline the flow of activities.
- Capture knowledge about how to perform activity (effectively).
- Eliminate problems due to missed activities and badly sequenced activities.
- Can be used to analyze and implement improvement ideas:
 - Good processes can save work and avoid problems.
 - Less than zero cost for improving quality.
 - Should always be the goal of process design.



Flowchart Example

From http://www.freequality.org



Templates

- Templates are another zero-cost defect elimination mechanism.
 - Pre-created document structure.
 - Often pre-populated with "boilerplate" stuff: standard explanations, disclaimers etc.
 - Avoids problems due to missing information, incompleteness.
 - Avoids problems in activity for which the document is the output.
 - Need to fill in form, so get the data / do the activity!
- Problem with templates: not all sections are always applicable, may sometimes want different structure.
- Can constrain people from doing what they need to.
- Can lead to "automaton" mode where people just fill in form without thinking if that's the most appropriate thing to do.
 - Make templates as guidelines, not "set in stone" forms.



Workflow Automation

- Creation of computerized tools that streamline activities e.g. online registration, myCourses testing!
 - Implements process, templates.
 - Eliminates many kinds of defects.
 - Saves effort.
- Flexibility is often a major problem.
 - If the needs are different from what tool supports, can't do it at all!
 - Designing flexible tools which automate workflow is a major technical challenge!



Four Basic Defect Elimination Tools

- Checklists
- Templates
- Processes
- Workflow automation



Scatter Diagram

- Used to determine whether there is really a relationship between two variables.
 - Fishbone identifies possible causes.
 - Doing a scatterplot can show whether the two are correlated.
 - Visual plot can show degree of correlation, non-linear correlations.
 - Linear correlations if most points along a straight line.
 - Poor (linear) correlation if points scattered all over.
- Remember: correlation does not imply a causal relationship!



Scatter Diagrams

Measuring Relationships Between Variables

Negative Correlation Positive Correlation 5 4.5 3.5 3.5 **No Correlation** 150 400 650 400 650 150 5 An increase in y may depend An decrease in y may depend upon an increase in x. 4.5 upon an increase in x. E.g. 4 3.5 150 650 **Negative Correlation? Positive Correlation?** There is no demonstrated connection between x and y. 4.5 4.5 3.5 3.5 400 650 400 150 150 650 If X is increased, y may also If X is increased, y may decrease. increase.

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Control Charts

- Plot of a metric with control limits defined.
 - Upper control limit: If value of metric exceeds this, take action.
 - Lower control limit: If value goes below this, take action.
 - Warning levels: If value outside this, check if all is well.
- Control limits may be derived statistically or less formally (based on "reasonable" values / other impacts).
 - Formal statistical process control has formulae for deriving limits: often 3 sigma deviation from desired outcome.
- Useful to flag "outlier" values e.g. components with very high defect rates, projects that have parameters outside "normal levels" etc.
 - Formal statistical process control not used much in software.



Control Charts Pizza Example



Summary

- The quality tools together form a suite:
 - Histograms, run charts, control charts can identify problems.
 - Fishbone is used to brainstorm possible causes.
 - Scatterplots can be used to analyze whether relationships exist.
 - Pareto analysis identifies which causes are most worth addressing.
 - Checklists, templates, process definition and workflow automation can eliminate problems.

