QUALITY: WHAT IS IT AND HOW DO WE ACHIEVE IT?

We want quality in our personal, family, community, and professional lives. And we and our organizations – business, government, academic, and volunteer – like to create quality slogans.

What is quality and how do we achieve it as we plan and manage projects and carry out our other student and practice activities? How do we make quality operational in our daily work as we provide services and products to our internal colleagues and to our clients, owners, customers, and stakeholders?

10.1 Quality Defined

What is quality in the consulting business, in government, in academia, and in volunteer organizations?

Quality as Opulence

In the context of professional work or in a general context, the word "quality" may suggest opulence, luxury, "gold-plating," and over-design. Examples of products or results consistent with this opulence concept of quality might be Rolex watches, cashmere sweaters, and safety factors of 5.0. That is, such products and results generally go well beyond what is needed for functional purposes, but not necessarily beyond what may be desired by a few individuals or organizations. In an individual or organizational environment of unlimited or at least great resources, the opulence definition or understanding of quality might be acceptable. The opulent approach to quality, however, is not useful in the vast majority of engineering and business situations.

Quality as Excellence or Superiority

Another approach to quality is the concept of excellence or superiority as suggested by dictionaries which use expressions and words like "degree of excellence" and "superiority" when defining quality. Offering a superior, standard-setting product or service is certainly admirable, but is not likely to be practical for most engineering and business situations. While clients, owners, and customers may want "excellence" and "superiority," they may not want to pay for it. Furthermore, while notions of excellence and superiority may engender positive reactions, they may be too vague, that is, ill-defined.

Phillip Crosby who wrote Quality is Free (1979), one the most influential books about quality, says "The first erroneous assumption is that quality means goodness, or luxury, or shininess, or weight." In the context of professional practice, quality must mean something other than opulence or superiority in kind for the enlightened, progressive, but practical student, young practitioner, or seasoned professional and/or businessperson.

Quality as Meeting All Requirements

In his book, Crosby wrote "We must define quality as conformance to requirements." Snyder (1993) offered this definition of quality: "Quality in engineering is a measure of how well engineering services meet the client's needs and conform to governing criteria and current practice standards." Snyder's definition is useful because it elaborates on Crosby's meeting requirements concept. Certainly, the client, owner, or customer has a major role in defining requirements. However, for the good of all concerned, the definition of requirements must include and go beyond what the clients, owners, or customers need, or believe they need. For example, the engineer must strive to satisfy government requirements and consistency with the standard of care of the profession. The requirements of a potential client, owner, or customer may lie outside what you are willing or able to do. In such situations, personal and corporate ethical standards, possibly augmented with liability exposure concerns, may require that you terminate the relationship.

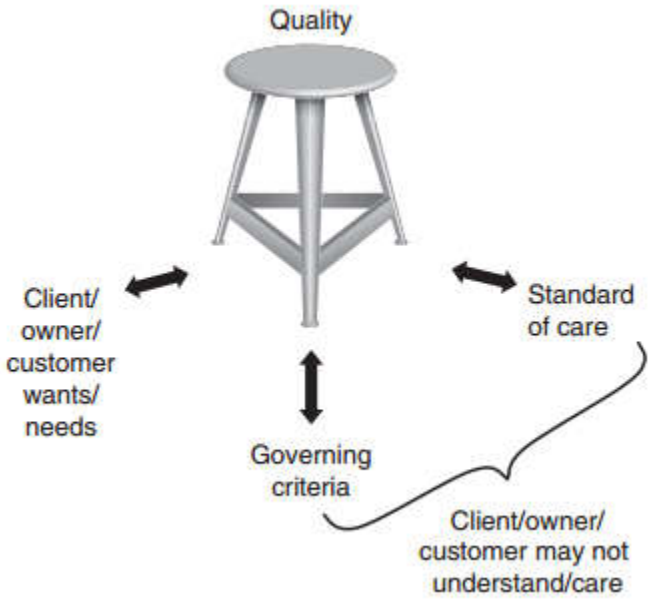

Figure 10.1 Quality stands on three legs.

Consistent with this three-part definition, quality can be seen as a sturdy stool standing on three legs as shown in Figure 10.1. The first leg is client, owner, or customer wants and/or needs. However, meeting each and every client, owner, or customer want or need does not constitute a quality project. More is needed. Governing criteria form the second leg. This leg includes local, state, federal, and other requirements as well as design criteria prescribed by others.

The third leg is the standard of care. What does that mean? J. R. Hawkins (2005) offers this short definition: "The level of competence practitioners in their field customarily expect given the circumstances." Standard of care may also be referred to as "duty of care" (Bachner 2007). Regardless of what you decide to use, standard of care or duty of care, please recognize that you are not expected to be perfect. However, you are expected to do your work as well as others doing similar work under the same circumstances.

Your client, owner, or customer may not, at least initially, understand and/or care about two of the three legs—governing criteria or standard of care. Nevertheless, assuming quality is your goal, you must attend to those legs. If you don't build them now, their absence is likely to have negative impacts later.

Figure 10.2 illustrates unfortunate situations in which quality was not achieved even though wants and needs stated by the client, owner, or customer were met. Assume, for example, your firm designed an air pollution control system for a manufacturing plant. It was built and works well – the first quality leg was satisfied. However, your firm neglected to inform the owner about the required permit and now the owner faces a penalty imposed by the state environmental agency. Therefore, the second leg was missing and a quality project was not achieved.

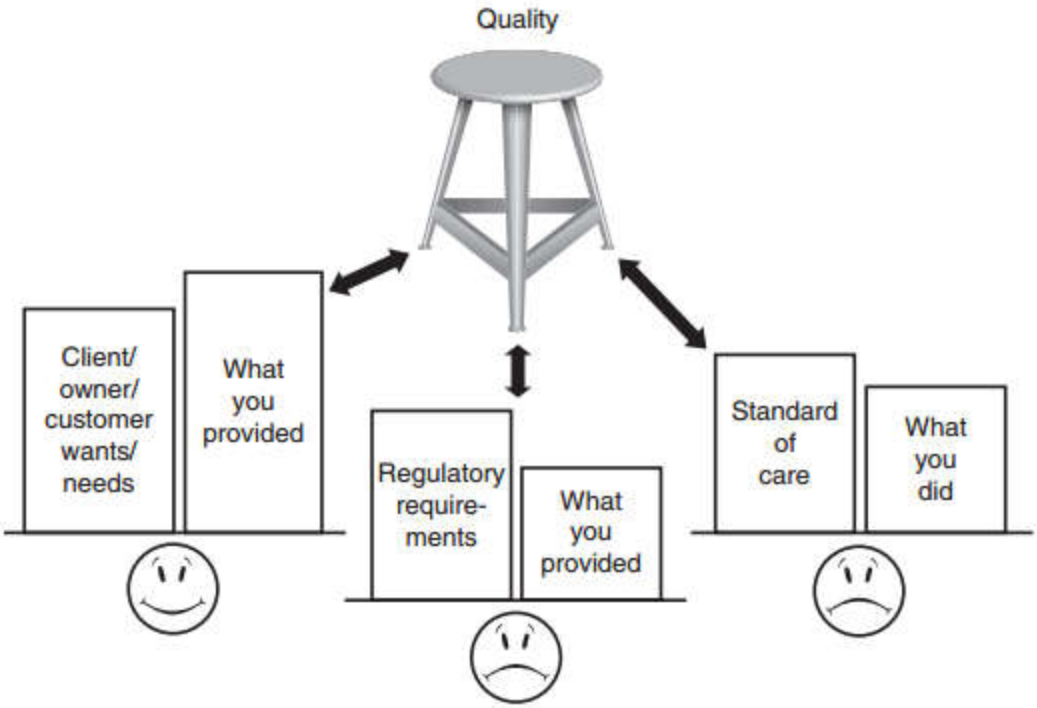

Figure 10.2 Quality requires providing all three legs.

Quality requires all three legs!

10.2 A Caution for Engineers and Other Technical Personnel

Frankly, some engineering students and young technical personnel may have difficulty accepting the idea of quality as meeting, but not significantly exceeding, all of the established requirements. Almost any technical activity or project, such as field investigations, laboratory tests, a planning study, and a design culminating in plans and specifications for a manufactured product or constructed facility, can be done better than expected. After all, technical personnel tend to be bright and usually have access to a variety of sophisticated tools and techniques. They know how to "do it better" such as creating a larger spreadsheet, using a computer program instead of performing manual calculations, or writing a report rather than a memorandum. Furthermore, a young person's education may have encouraged him or her to go well beyond what was needed.

However, in the world of practice and business, going well beyond what is needed tends to increase labor and other costs and cause delays, both of which are ultimately disruptive to budgets and profits and to relationships with clients, owners, and customers. Weigh your personal desire to

produce a superior or even opulent product or service against the best interests of your employer and those individuals or organizations your employer serves.

But you may be thinking, I want to "delight" my clients-owners-customers stakeholders by exceeding their expectations, that is, by giving them more than they expected. That's fine, subject to these three conditions:

- You first meet all requirements which is typically a challenge
- They value the "extras" you are going to "give" them
- You can afford to exceed expectations, to provide the "extras," given budget and schedule constraints.

10.3 Quality Control and Quality Assurance

Quality control (QC) can be defined as "the review of services provided and completed work, together with management and documentation practices, that are geared to ensure that project services and work meet contractual requirements." The "what" might be checks, reviews, inspections, tests, and verifications. Each of the "whats" is carried out against a standard or expectation. For example, "All plan sheets will be reviewed by an experienced engineer not directly involved in the project" or "Digital photographs (close up and vicinity view) will be taken of all survey monuments"

Quality assurance (QA) can be defined as "planned and systematic actions focused on providing the members of the project team with confidence that components are designed and constructed in accordance with applicable standards and as specified by contract." For example, providing initials and dates indicating which experienced engineer, not directly involved with the project, actually reviewed the plan sheets or requiring a sign off when verifying files containing digital photographs of all survey monuments.

The American Society for Quality (2011) uses these definitions (quoted):

QC: The observation techniques and activities used to fulfill requirements for quality
QA: The planned and systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled.

QC refers to those things that are supposed to be done (e.g., tests) to achieve quality and QA is proof or verification that they were done (e.g., observing a test or reviewing the test result) and appropriate action taken.

Regardless of the phase of a project (e.g., design, construction, manufacturing, operations), QC and QA are typically the responsibility of different individuals or entities within and/or among organizations. For example, the QC/QA process may be applied within an engineering firm during the design process. The work product of designers, carried out within the organization's QC requirements (e.g., double checking calculations) might be reviewed as part of the organization's QA requirements by other designers (e.g., to assure that calculation double checking occurred and/or to make general or detailed parallel calculations). A similar two-part QC/QA process could be used in construction and manufacturing.

10.4 Suggestions for Developing a Quality Seeking Culture

Now for some very specific suggestions for developing a quality-seeking culture within your team, department, or other organizational entity. Such a culture shares a common understanding of quality and seeks to provide it to those it serves. In this context, culture means the way things really work around here when serving clients, owners, and customers, especially when faced with problems and challenges. The right kind of quality culture, or underlying system, determines if your team, department, or other organizational entity will thrive, just survive, or die as suggested by growth expert Steven S. Little: "A smart system can work with a little stupidity, but a stupid system can't work with even a lot of smarts."

Before proceeding, consider the International Organization for Standardization. Its short name is ISO which is pronounced "eye so" (ISO 2011). ISO produces standards for just about everything—literally from "nuts and bolts" to, yes, quality management programs. ISO 9000 is a subset of standards—a family of standards—concerned with quality management.

Table 10.1 Eight principles underlie the ISO 9000 Quality Family of Standards.

Principle	Example Benefit
Customer Focus	Increased revenue and market share
Leadership	Personnel understand where the organization is going
Involvement of People	Individuals held accountable for their performance
Process Approach	Focused and prioritized improvement
System Approach to Management	Ability to focus on key processes
Continual Improvement	Improved organizational capabilities
Factual Approach to Decision Making	Increased ability to challenge and change opinions and decisions
Mutually-beneficial Supplier Relationships	Flexibility and speed of joint responses to changing conditions

Strive to Understand Client, Owner, and Customer Wants and Needs

Begin at the beginning. Discover what this person and/or organization really wants and needs. This is ISO 9000 Principle 1, Customer Focus, in action. Study the Request for Qualifications (RFQ) or Request for Proposal (RFP) provided by the organization seeking services. Visit the organization's website. Search for and examine foundational documents such as mission and vision statements and lists of core values.

Review documents such as a city's capital improvement plan, a consulting firm's strategic plan, or a manufacturer's business plan. These are typically more substantive and objective than mission, vision, and core values. Talk to colleagues who have worked with or otherwise know the organization you hope to serve. For example, are personnel in this organization open to new ideas or do they prefer the tried and true?

Ask and Listen

Recognize that RFQ or RFP and the other listed sources are just the "tip of the iceberg" in revealing wants and needs. You need much more data, information, and knowledge in order to understand

wants and needs and the way to accomplish that is to ask many and varied questions. Focus on asking and listening early on. If you feel compelled to do a lot of telling, to talk much, do that later. Skillfully mix two kinds of questions with the being closed-ended questions. These are answered with yes, no, or statements of fact. They typically begin with words like how much, where, what, who, is, are, can, will, and should (Parkinson 2010). For example:

- How much is budgeted for the hospital expansion?
- Where will project implementation funds come from?
- Who will be the principal obstacle to project success?
- What data/information are most suspect?

Engineers and other technical personnel tend to ask all or mostly closed-ended questions to get the facts. While this practice is useful, also ask the second type of question, that is, open-ended which often begins with words like why, how, and what. For example: "Why are you adding on to the existing hospital rather than constructing a new one?" Open-ended questions motivate the other person to elaborate. Robert Half, founder of a staffing firm, said: "Asking the right questions takes as much skill as giving the right answers."

The "5 Whys" is a specific type of open-ended questioning that helps you and others move beyond symptoms to real concerns, causes, wants, and needs (Liker 2004). Diplomatically and persistently ask "why?" or variations on "why?" up to five times. There is nothing "magic" about five, but you will need at least several "whys."

Refer to Table 10.2 for an example of series of "why?" questions being asked of a hypothetical, potential industrial client who expressed interest in having more entrances/exits for the company parking lot. On hearing the answer to Question 1, you might be tempted to stop asking. However, you don't. Instead you ask Question 2 and learn more but still think that more or modified entrances/exits are needed.

You continue to ask. As a result of the answer to Question 3, you begin to think in ways that differ from what you were thinking after the first two "whys." Good, that's why you are using the "5 Whys." So you ask Question 4 and the answer intrigues you if for no other reason than that "always done it that way" often indicates an inability to look at old practices in new ways. There's still

more to learn, so you ask Question 5 and, as the potential client thinks about your question and answers it, the client solves the problem.

Table 10.2 The "5 Whys" is an effective way to discover wants and needs

Question	Answer
1. Why do you need more entrances/exits for your employee parking lot?	Because the lot cannot handle number of vehicles
2. Why does the lot not accommodate the number of vehicles?	We have major congestion and frustration when workers enter and leave the lot
3. Why does this happen?	Because day-shift workers leave the lot at 4:00 PM when night-shift workers are arriving and nightshift workers leave at 4:00 AM when day-shift workers are arriving.
4. Why do all day and night shift workers arrive/leave at the same time?	Because we have always done it that way
5. Why do all workers in a shift need to start and leave at the same time?	They don't—we could stagger start—stop times for subgroups in 15 intervals. That would solve our problems and save us engineering fees and construction costs. I like the way you help us think through a problem.

Speaking of thinking, you may be thinking that as a result of using the "5 Whys," the questioner just talked himself or herself out of a project! That raises another question: What is the service provider's highest priority, that is, is it winning projects or is it gaining or retaining clients, owners, or customers? The answer to that question depends on an organization's marketing philosophy and policies.

English writer Rudyard Kipling offered another method for effective questioning when he said "I had six honest serving men – they taught me all I knew. Their names were Where and What and

When and Why and How and Who." Hard to imagine a potential client, owner, or customer and/or a project that does not embody Kipling's six elements. Imagine you are sitting across the desk from a representative of an organization you want to serve. You can recall Kipling's "six" and use them to guide your questions.

Mixing closed and open-ended questions, using the "5 Whys?" technique, applying Kipling's six honest serving men, or any persistent questioning, enables you to "drill down" – to get to the bottom of things – to move past symptoms and get to causes.

You go up the learning curve and gain a better understand client, owner, or customer wants and needs. Such understanding is the "secret" of quality.

Consider the following possible consequences of not asking lots of questions and, as a result, not understanding wants and needs:

- You and your team correctly solve the wrong problem, or only part the actual problem, and then you see the wisdom of this comment by humorist Josh Billings: "It ain't so much the things we don't know that gets us into trouble. It's the things we know that just ain't so."
- Then you dissipate a lot of energy justifying what you did. Author Don Miguel Ruiz explains it this way: "Because we are afraid to ask for clarification, we make assumptions, and believe we are right about the assumptions; then we defend our assumptions and try to make someone else wrong."

Distinguish Between Wants and Needs

As you learn about wants and needs, try to distinguish between them. Modifying "wants" to become realistic "needs" is one way you show concern and reveal your expertise. And, sometimes, as a result of your effort, the client, owner, or customer will realize an economic benefit.

In contrast, sometimes caring and competent asking leads to a situation in which your organization's judgment indicates that the cost of what is needed to solve a problem exceeds the cost of what the client, owner, or customer wants. Now what? My advice is to perform the trusted advisor role and tell the prospective client, owner, or customer that their "needs" will cost more than their "wants." My advice assumes that your overall goal is quality, that is, conformance to all requirements.

Define the Other Project Requirements

Recall that the first leg on which quality stands, as illustrated in Figure 7.1, is client, owner, or customer wants/needs. Presumably you now understand that leg. Therefore, turn attention to the other two legs. The second leg is governing criteria, that is, local, state, federal, and other requirements as well as design criteria prescribed by others. You or your organization know the governing criteria or can find them. Furthermore, you are "keeping up" and are competent, that is, you know the applicable standard of care, which is the third and last leg supporting quality.

Assess and Manage Risk

Now that client or stakeholder wants and needs and other project requirements are defined, what risks will the project team encounter in meeting those requirements? The likelihood of meeting all requirements is inversely proportional to the team's ability to assess and manage risk.

Think Upstream, Not Downstream

Focus on the process used to create the deliverable, not the deliverable itself. Study the production process, identifying the tasks and their interrelationships, determining the effectiveness of each task, and improving each task. The process referred to might be all the tasks completed by a project team in designing a manufacturing process, constructing a bridge, and writing software.

With the upstream approach, the organization first commits to understanding all the tasks in its production process and their interrelationships. Then the focus shifts to improving each task. This goes beyond doing each task right to continuously striving to do each task better.

In contrast, the downstream approach recognizes the production process but does not consistently delve into it. Instead, heavy reliance is placed on inspecting deliverables and, if they do not meet requirements, "fixing" them. Sometimes when an organization experiences quality problems, they apply the downstream approach even more energetically by doing more checking. Or they blame individuals or search for scapegoats.

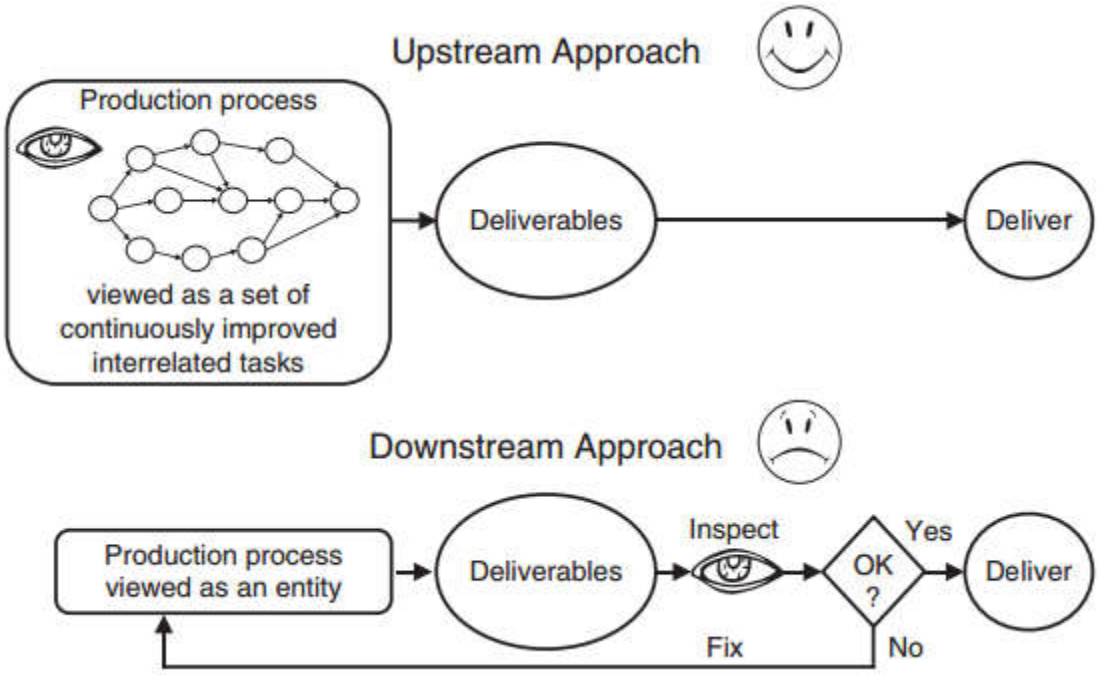

Figure 10.3 The upstream approach, with its emphasis on continuous process improvement, is more likely to achieve quality than the downstream approach with its emphasis on inspection and fixing.

Create, Use, and Continuously Improve Written Guidance for Repetitive Tasks and Processes

While each of your organization's projects, whether internal or for others, is likely to be unique, many of the tasks and processes (series of tasks) included in a project are repetitive. Examples are delineating watersheds, designing a circuit, sizing members of a truss, or preparing next year's budget. Consider documenting how you and your organization currently do each repetitive task or series of task. One reason: Don't "reinvent the wheel" each time. Instead, make existing wheels roll even better (Weiss 2003). My admonition to develop, use, and continuously improve written guidance is supported by ISO 9000 Principle 4, Process Approach, and ISO Principle 6, Continual Improvement.

What do we mean by written guidance? Written guidance has many names and comes in many forms. Examples of other terms are best practices, bulletins, checklists, guidelines, mini-manuals (Galler 2009), standards, tips, and templates. The label or format aside, the intent of written guidelines is to capture the current cumulative knowledge and experience of an organization's

personnel. Write it down and widely share it and then, once understood and applied, continuously improve it.

As a result of creating, using, and continuously improving written guidance, an organization and its members will derive the following nine long-term benefits:

1. Eliminate Valueless or Marginal Activities: Unnecessary, redundant, outdated, and other marginal or valueless tasks and steps are likely to be identified and then updated or removed. The process of thinking about, discussing, and then describing, in writing, possibly with graphics, steps to be taken in doing a task or tasks to be completed in a process inevitably identifies valueless or marginal activities. Finding and eliminating tasks reduces expenses and frees up staff for more productive tasks.

2. Increase Efficiency: More efficient approaches typically arise as a result of thinking through steps that comprise a process. For example, some tasks previously done in series may subsequently be done in parallel, thereby reducing elapsed time. Tasks formerly done by personnel with high hourly rates may subsequently be accomplished just as effectively by personnel with lower hourly rates, thus reducing costs. Delegating tasks is simplified because ready reference can be made to written descriptions. Tasks previously done manually may, as a result of the insight gained by analyzing a process, subsequently be executed with software thereby reducing costs and saving time.

3. Avoid "Reinventing the Wheel": Knowledge acquired and experience gained by an organization's personnel, assuming it is reflected in the written guidance, can be readily shared with other personnel. As a result, much less time is wasted in redeveloping methods.

4. Facilitate Interdiscipline and Interoffice Projects: The multidiscipline, multi office organization should be structured and operated to provide its clients, owners, and customers with the optimum mix of personnel and other resources regardless of the physical and organizational "homes" of personnel. Written guidance that captures best practices applicable across discipline and office lines facilitates the desired corporate team approach. The lack of guidance frustrates interdiscipline and interoffice cooperation even when personnel want to work as a team.

5. Train New or Transferred Personnel: New personnel and personnel transferred from one office, division, or unit to another can receive the appropriate written guidance as part of their on-

the-job education and training. This approach requires less supervisor and colleague time than relying on verbal descriptions and the shared ideas and information are more likely to be understood because they are written.

6. Invoke the Novice Effect: When new or transferred individuals use written guidance to do a task that is new to them, and are asked to suggest ways to improve those guidelines, the novice effect that was introduced in Chapter 2 is likely to occur. They read the guidance and think of better ways to explain what is to be done or improved ways to do it.

7. Reduce Liability: Negligence, the principal cause of liability claims in the consulting engineering business, is reduced. Errors and omissions are less likely to occur when work is influenced by tested, written guidance.

8. Mitigate Negative Impact of Personnel Turnover: Some personnel turnover is inevitable, even in the best-managed and led organizations. Contributions that departed personnel made to an organization are more likely to remain with the organization if some of those contributions were captured and documented in the form of written guidance prepared by the now-departed personnel. In his book about the growing importance of intellectual capital, Stewart (1997) defines such capital as having three components: knowledge embedded in an organization's processes, knowledge emanating from its clients or customers, and knowledge held by the organization's employees. The last portion of intellectual capital can go down the elevator and out the door at any time.

Accordingly, proactive organizations try to capture some of the knowledge held by their personnel. Written guidance is one way to do this.

9. Support Marketing: External and internal clients, owners, and customers are increasingly concerned about the quality of the services and products they receive. The test is: do or will these services or products meet their wants and needs? Using written guidance is one way of demonstrating a unit or organization's commitment to quality and especially a desire to do things right the first time.

Expect Each Person to Check His or Her Work

One danger of the QC/QA aspect of a quality program is that it becomes the rationale for not being responsible for one's work. The argument goes like this: "Well, I don't have to be that careful with

my calculations, someone else is going to check them anyway." Adopt a quality policy that requires double checking. Push work back to people who make errors, don't correct their work. Personally exemplify responsibility for the accuracy and completeness of your work products. Expecting everyone to check their work is supported by ISO 9000 Principle 3, Involvement of People.

Arrange for External Reviews

The idea of external reviews is to leverage knowledge and experience assets within your organization. Build external reviews into your project plan by identifying experts outside of the project team, assigning hours to them, defining when their help will be needed, and indicating what you want them to do. Early input by "high-priced," experienced personnel might result in great savings later on by diminishing rework, additional work, or unnecessary work. Focused participation by experts could help you achieve quality and do it within the budget.

Reduce Cycle Time

Cycle time is the total elapsed time needed to complete a process, typically a process that includes many repetitive—you've done them before—tasks. Cycle time is measured in hours, days, weeks, and months. It is not the absolute time, for example, person-hours invested in the process. Examples of processes are preparing a proposal, designing a manufacturing process, preparing a capital improvement plan (CIP), obtaining soil borings, and constructing a bridge.

Tools and Techniques for Stimulating Creative and Innovative Thinking

Create and Innovate Defined

Create: Originate, make, or cause to come into existence an entirely new concept, principle, outcome, or object.

Innovate: Make something new by purposefully combining different existing principles, ideas, and knowledge. Johannes Gutenberg's reusable type printing press, which he first used in about 1439, is an example of innovation. In designing it, he borrowed from woodblock printing, weapon and coin forging, and the screw press process used by winemakers and olive oil producers.

Brainstorming

This is a great place to start whether trying to determine the cause of a problem, find a solution to one, or explore ways to pursue an opportunity. Invite a wide variety of participants. For example, if the problem at hand is how to reduce the drag on an automobile component invite representative engineers, scientists, technologists, technicians, and administrative personnel – seek representatives of all functions that are involved in any aspect of automobile design and manufacture.

Create a non-threatening environment so that all participants feel free to say what they think. Provide background and pose the problem and then invite, in fact, expect everyone to offer ideas being careful not to evaluate any ideas during the brainstorming session. Great ideas often appear because of:

- Widely varied knowledge, skills, and attitudes represented by the participants.
- Some participants are very close to problem causes—but no one ever asked for their views.
- Contributed ideas stimulate the thinking and creation of more ideas by others.

Go for quantity, not quality (Byrne, 2005) and, remember, absolutely no evaluation of ideas during the brainstorming session. As noted by poet and critic Mark Van Doren, "Bring ideas in and entertain them royally, for one of them may be the king." Or, as observed by scientist Linus Pauling, "the best way to have a good idea is to have lots of ideas."

Strengths-Weaknesses-Opportunities-Threats

To apply SWOT, assemble a heterogeneous group—certainly don't clone yourself.

Provide background and pose the problem. Assume it is a poorly performing service line in a professional services firm.

The SWOT approach is valuable partly because it cannot degenerate into a complaining or whining session. While Weaknesses and Threats are unpleasant or negative, Strengths and Opportunities are uplifting and, therefore, positive. While opportunities and threats are external and largely out of the group's control, strengths and weaknesses are internal and can be addressed by the group. SWOT can be used in a variety of ways. For example, Milosevic (2010) describes use of SWOT to determine how investors and contractors view a particular construction project.

Stakeholder Input

Your or your organization's stakeholders are those internal or external individuals or organizations that have a significant interest in what you and your organization do. Your actions or inactions affect them. The best way to find out how well you and/or your organization are doing in meeting wants and needs is to go to the source—ask your stakeholders. Your organization could do this informally or use formal surveys. As a student or entry-level technical person, you can informally query your stakeholders—fellow students, professors, colleagues, supervisors—to determine how you are doing and how you can improve.

Process Diagramming

Process diagramming, which is also called flow charting or network diagramming, is useful in helping a team or group more fully understand the entire system, the big picture. The premise is that most repeated processes involve individuals from various departments, offices, and specialties. While each knows his or her job, few, if any, may see the big picture. They can't see the "forest," only their "tree," and therefore process improvements are less likely to occur.

Assume selection of a process that involves individuals from various departments, offices, specialties, and/or other characteristics. The process might be preparing a proposal, conducting laboratory experiments, designing and implementing a manufacturing process, or conducting field reconnaissance.

Collaboratively identify the steps or tasks in the process, and their interrelationships, as currently practiced. This may be the first time anyone in the group "sees" and fully understands the process. Assemble the tasks and their interrelationships into a process diagram or flow chart or network diagram as illustrated in the upper part of *Figure 10.4*. This is the "as is. Study the result. Look for unnecessary steps/tasks or steps/tasks that could be combined. Search for others that could be done in parallel to reduce the process duration. Then create the new process diagram. As shown in lower part *of Figure 10.4, this is the "could be," "should be," or "will be." Note that in the hypothetical case that the original ten tasks are reduced to eight tasks and the elapsed time is shortened.*

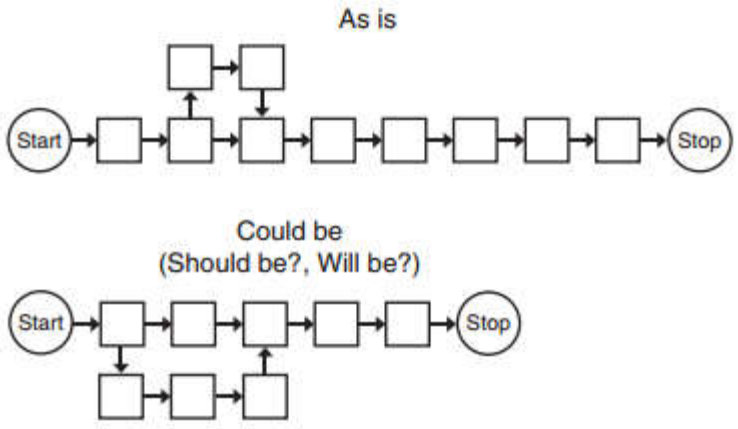

Figure 10.4 Process diagramming seeks to improve a process by actions such as eliminating useless tasks and doing more tasks in parallel.

Fishbone Diagramming

This method, which is also called a cause and effect analysis or the Ishikawa analysis (Black and Kohser 2008, Hensey 1993, Rose 2005), provides a systematic way to thoroughly identify widely-varying possible causes of a problem. Once again, assemble a diverse group, provide background, pose the problem, and construct the fishbone diagram.

Pareto Analysis

The approach introduced here is called Pareto Analysis after Vilfredo Pareto, an Italian sociologist and economist, who is credited as the source (Kuprenas et al 1999, Rose 2005). When agreed-upon quality is not being achieved, Pareto Analysis can be used to identify the most influential causes of substandard performance so these causes can be addressed first. Pareto Analysis was used to reduce defects in the manufacturing of spacecraft electronic components.

Problems-First Meetings

Project and other management meetings are often devoted primarily to reporting on progress. Instead, report progress in writing and start meetings with and focus on problems (Liker 2004). Go around the room and ask each person to share a problem they are facing and then expect others to offer initial ideas to solve the problem. The expectation to offer ideas coupled with the group's diversity is likely to lead to synergistic interaction and generation of creative and innovative ideas. Such short, intense collaborative efforts also plant problems and the need to solve them in the

subconscious minds of participants. Some of this "planting" may lead to later unexpected "growth" of creative or innovative ideas.

Mind Mapping

When faced with the need, either individually or as a group, to "get started," to generate ideas consider mind mapping, which is also called clustering (Arciszewski 2009, Gelb 2004, Gross 1991, Rico 2000). It offers a simple, quick, and powerful means for assembling a set of connected ideas.

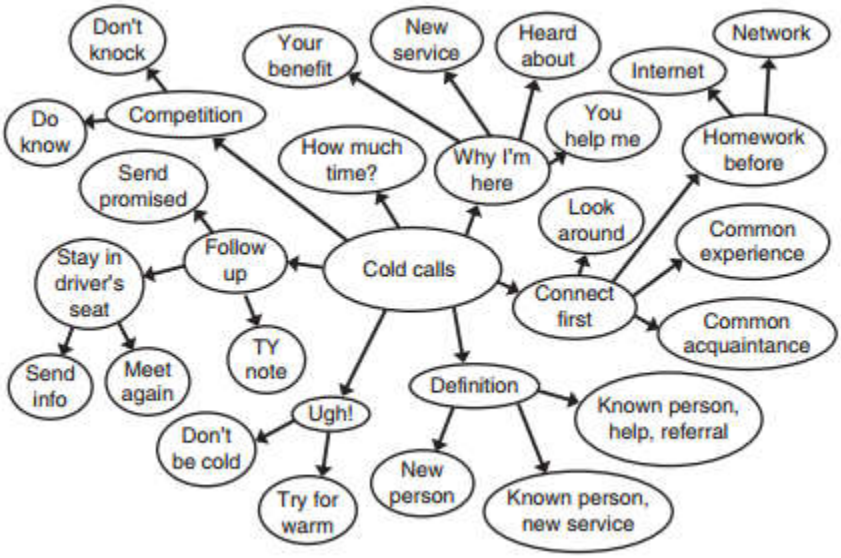

Figure 10.5 An example mind map that suggests the manner in which this process can generate ideas

Why Mind Mapping?

Mind mapping is an effective means for generating ideas, whether performed individually or by a group, because:

1. It can be done quickly in real time by simply drawing on your knowledge and experience, or the combined knowledge and experience of members of a group.
2. No preparation is required other than to select the topic and perhaps the participants in that they should be diverse in terms of characteristics such as knowledge, skills, attitudes, and experiences.
3. Once the highly-visual process starts, ideas flow in that one idea leads to another. The process is all about generating ideas for later consideration.

4. The process is non-linear, that is, it does not require one item to logically follow another in step-by-step fashion, and, as a result, many and highly-varied ideas are generated. Stated differently, the process, whether done by one individual or a group, engages both hemispheres of participant's brains.

With respect to the last item, most of us typically rely on left-brain thinking which is verbal, analytic, symbolic, abstract, temporal, rational, digital, logical, and linear (Edwards 1999, Walesh 2011a). For example, the left side of our brain likes to think Step 1, Step 2, Step 3, etc. Left-brain thinking is powerful. However, we have another kind of mental ability and it is draws on the brain's right hemisphere.

Mind mapping is a tool to engage more right-brain thinking which is nonverbal, synthetic, actual, analogical, non-temporal, non-rational, spatial, intuitive, and holistic. For example, the right side of our brain tends to see the big picture and new possibilities. We should strive to supplement our valuable left-brain abilities, the development of which is typically stressed in our formal education, with equally valuable right-brain abilities. As a result of mind mapping, you or a group are better equipped to take more creative, innovative approaches to identifying and solving problems, seeing and pursuing opportunities, and addressing issues. A half brain is good, a whole brain is better! (Edwards 1999).

Ohno Circle

Named after Taiichi Ohno, an early innovator of the Toyota Production System, the technique is "used to make deep observations of a process or scene with the goal of improving what you see" (Wilson, 2011). This method differs from the others in that it is done by an individual, not a group or team. However, it is intended to enable an individual to find ways to improve group or team efforts to effectively and efficiently meet requirements.

Taking 30 minutes, finding a quiet, unobtrusive place in one of your classes, meetings, offices, or laboratories, or in the field at a project site, and simply observe. More specifically, in the spirit of continuous improvement, look for wasteful or otherwise undesirable situations like these.

- Underutilized resources – Capital, equipment, or personnel that are not being fully deployed or utilized.

- Excess motion – Unnecessary movements
- Defects – Production that does not meet standards and needs fixing
- Excess inventory – Retention and storage of production which is not needed now
- Non-value added processing – Performing work for which clients/owners aren't willing to pay
- Transportation – Using excessive resources to move materials, equipment, or personnel
- Waiting – Not having the materials, information, or resources at the right place or time Safety and health hazards

Metrics

Metrics, the art and science of measuring and using the results to guide future action, helps us understand how things are going in an absolute sense and in terms of historic trends as we strive to achieve quality, and stimulate us to think more creatively and innovatively about issues, problems, and opportunities illuminated by the data.

Metrics are useful in any project management or other management effort committed to achieving quality. The idea is to determine the set of requirements that define quality, select those that can be quantified, and then implement a metrics program to track them and, of course, act on what is learned. Metrics is based on recognizing an element of human nature – what gets measured gets done.

- Consider, for example, a manufacturing organization that has defined and is striving to achieve quality. The organization might use the following metrics, maybe on a quarterly or annual basis:
- Time required to respond to a request for a price quote
- Time required to design and test a new product or a major modification to an existing product
- Number of products manufactured per shift
- Percent of each component rejected per shift
- Cost per manufactured product
- Warranty claims on each product per year
- Market share

Similarly, a consulting engineering business committed to quality might use the following metrics, perhaps on an annual basis:

- Percent of projects completed early, on-time, and late
- Percent of projects completed under budget, on budget, and over budget
- Number and percent of new clients served compared to total clients served
- Number and percent of contracts signed by state, province, or country of origin
- of the client; monetary size of contract could also be used
- Number and/or dollar amount of liability claims and statistics and how they were resolved
- Chargeable hours as a percent of total hours worked, expense ratio, and multiplier

Freehand Drawing

Freehand drawing is another means of assisting individuals and groups to more fully use their mental resources and thus be more creative and innovative. Drawing, which might be defined as converting "a mental image into a visually-recognizable form" (Beakley et al 1986), has been used for over two millennia by the predecessors of what are now engineers, architects, and other similar technical professionals.

Seeing, Not Just Looking

A principle guiding freehand drawing is to draw what we see contrasted with drawing something the way we think it should look. For example, before taking pencil drawing lessons, if I were asked to draw a boat, tree, dog, or other object, I would have been thinking mainly about what such an object should look like and try to draw it in that preconceived manner. Now, having benefited from drawing lessons, I draw what I see, that is, composition, shapes, and values. Artists first carefully examine the object or thing to be drawn and then, and only then, draw what they see. While each of us has his or her own style of converting what we see into pencil strokes on paper, the process is driven by careful observation.

Increased Awareness of the Right Hemisphere's Powerful Functions

As a result of learning and applying freehand drawing principles, or studying and doing other visual arts, an engineering student, researcher, or practitioner is likely to become more aware of the different and valuable functions of the brain's right hemisphere relative to the left hemisphere. This enhanced awareness may be implicit as in increasingly viewing issues, problems, and opportunities more intuitively and holistically.

A Tool for Group Collaboration

Taking improved seeing further, the enhanced seeing that can enable an engineer, or an engineering team, to more fully define an issue, problem, or opportunity can also, through continued enhanced visualization, help him or her resolve the issue, solve the problem, or pursue the opportunity. Dan Roan (2008) refers to this process as visual thinking which he defines as "an extraordinarily powerful way to solve problems" and explains it as consisting of four steps, mainly, look, see, imagine, and show. In application, each step in visual thinking involves drawing.

To elaborate, simple freehand drawing enhances a person's and/or group's ability to perform the first two steps, that is, to look and then see, really see at least the physical aspects of issues, problems, and opportunities. Then more "art," in the form of simple shapes, lines, arrows, stick people, and things, facilitates the remaining imagining and showing steps. The idea is to engage both of the brain's hemispheres because, as noted earlier, a whole brain is better.

Take a Break

You, as a students or practitioner and whether working individually or within a group, sometimes get bogged down when intensely studying, researching, analyzing, designing, writing, or engaging in some other challenging endeavor. You hit a wall, draw a blank, or experience writer's block. Take a break! Changing from one kind of activity to another stimulates creativity. This is especially true when transitioning from work to leisure, exercise, or a hobby. Perhaps by resting our conscious mind we engage or release our subconscious mind.

Rollo May (1976) tells the story of Albert Einstein asking a friend "Why is it I get my best ideas in the morning while shaving." The friend's answer was "often the mind needs the relaxation of inner controls—needs to be freed in reverie or daydreaming—for the unaccustomed ideas to emerge." Expanding on the take a break suggestion, May recognizes that, what he refers to as "the insight [that] comes at a moment of transition between work and relaxation," is common. He goes

on to suggest that these vivid breakthroughs of the subconscious mind to the conscious mind are preceded by "intense, conscious work." Recognize that while creative-innovative breakthroughs occur during relaxation or exercise, the insight instance is preceded by intense work. Our conscious mind must make an intense effort before resting and hopefully engaging the subconscious mind. Apparently we cannot relax our way into creativity and innovation.

Final Word: COMMIT TO QUALITY

Quality means meeting all requirements of those we serve, whether within or outside of our organization. Defining and then satisfying those requirements is challenging. You can rise to that challenge if you:

- Are aware of and respond to individuals and organizations—internal and external stakeholders—who have an interest in the products or services you produce
- Ask, listen, study, and work to provide those individuals with quality products and services
- Continuously improve the tasks and processes you use, or contribute to, as you do your work
- Apply appropriate tools and techniques, both individually and in groups, to stimulate creativity and innovation
- Expect and enable, to the extent of your ability, everyone to contribute to your organization's efforts to achieve quality

Care and quality are internal and external aspects
of the same thing.
A person who sees quality and feels it as he works
is a person who cares.
A person who cares about what he sees and does
is a person who's bound to have some
characteristics of quality.
(Robert M. Pirsig, in Zen and the Art of Motorcycle Maintenance)