

Facing Idea Engineering Roadblocks

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Abstract

This exploratory paper discusses some of the challenges facing the creative thinking process leading to technological innovation. It presents various idea engineering approaches that have been successfully implemented in American innovative companies, specifically those that benefit technologists, designers, and engineers.

Introduction

The United State's economy has been in a tail-spin the last several years. The standard of living has decreased because of the loss of jobs, the housing market, and the rising cost of gasoline and food. The United States is faced with the challenge of remaining a competitive global player. The new reality for prosperity is innovation and that is possible with successful idea engineering. In order for the United States to maintain the competitive edge, technology and engineering companies are well aware that employees must be able to think creatively, since this leads to innovation. United States university graduates have been lacking creative thinking skills for many years [1, 24].

In the next decade, 90 percent of an engineer's knowledge will be accessible on the computer [2]. Many technical skillsets will be outsourced. So what will make the future technologist and engineer in the United States valuable? It will be his or her ability to innovate [3]. The attributes of the technologist and engineer of the future include practical ingenuity and creativity. The terms "creative technologist" or "creative engineer" are often viewed by those who are not technologists or engineers as oxymorons. Creative thinking is often ambiguous, and ambiguity is "gray." Technologists and engineers are often viewed as traditionally "black and white" thinkers, because they get too focused on the limitations of design. Innovation and problem solving cannot occur without creative thinking, because "creativity is at the heart of innovation" [4]. Technologists, designers, and engineers invent new products, improve the usefulness of objects, and use product design or technical processes to solve problems, make things faster and more cost effective. The key factor of this research is understanding creative thinking, and exploring how successful companies have challenged the roadblocks that prevent technological innovation.

Methodology

This paper is explorative in nature and uses an investigative study, rather than theory-testing academic research. For this research study, creative thinking and the process of innovation will be the focus. Even though there is plenty of research on how individuals can be taught to think creatively, specific techniques on how to do so are not within the limits of this paper. This creativity research also excludes artistic endeavors, and instead, focuses on the applied process for the target market of technologists, designers, and engineers.

Discussion

Major roadblocks to creative thinking in the innovation cycle

Creative thinking is prone to roadblocks in the Innovation Cycle [1]. This includes the following phases of the Innovation Cycle: (1) definition and preparation, (2) idea generation, (3) idea incubation, and (4) verification and architecture (Refer to Figure 1). These are the phases that need unblocking in order for successful product development to occur.

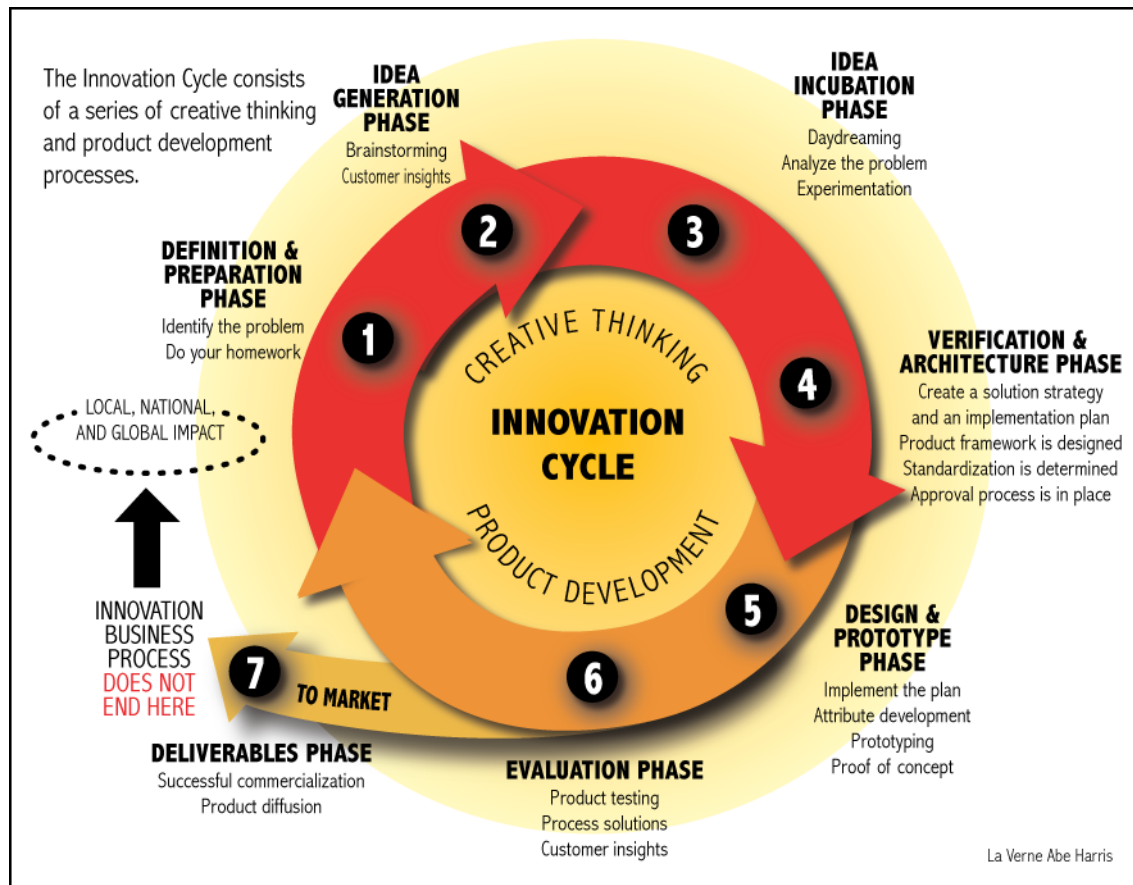


Figure 1. Innovation Cycle

It is important to identify the roadblocks that prevent the engineering of ideas in a company, because these roadblocks lead to restrained thinking and jeopardize the creative process that leads to innovation. There are several roadblocks to creative thinking that center around

negative attitude. How to change these attitudes that block creativity in individual employees is not within the limitations of this study. This research is based on the bigger picture of researching the creative thinking process in innovative companies. These negative attitudes, however, can apply to the organizational culture. After researching case studies of organizational cultures that support innovations, such as 3M, Hewlett Packard, Intel, Apple, Canon, General Electric, Google, Johnson & Johnson, and IDEO, a design consultancy, a number of challenges to roadblocks were found that will be presented.

Challenges to Roadblock #1: Lack of visionary leadership

Technology and engineering companies lacking organizational vision, have heavy workloads, reward crisis management instead of crisis prevention, and do not typically foster creative thinking [5]. Dean L. Kamen, an American entrepreneur and inventor from New Hampshire, states that “innovation requires leadership, but management kills it” [8]. 3M believes that if you want people to be innovative, the one thing you do not want to do as a visionary leader is to micromanage your employees [6].

After examining case studies of innovative companies, the most important challenges to Roadblock #1: Lack of visionary leadership is the hiring of the right people. This in turn sets up an environment conducive to creative thinking and balances creativity and efficiency.

Challenges to this roadblock begin at the top — the hiring of the Chief Executive Officer (CEO), who takes on the role of the “innovation champion” and who inspires every senior manager in the company to commit to the vision. This allows the creative thinking process to take root [8]. Companies are successful at being innovative when the organizational culture is receptive to creativity and “... shaping corporate culture is an executive responsibility” [7].

The innovative companies in this study overcame this roadblock by selecting a CEO who is a visionary leader. They also have team leaders, who are visionaries in the creative thinking process or someone else to champion their cause. Marissa Mayer, the director of consumer Web products at Google, says that it is imperative for company leaders to “act like a venture capitalist” if you want to be successful [8]. A visionary leader is a technical champion who knows how to get things done informally, understands the working dynamics of the organization, is not afraid to put his or her career on the line once in a while, is passionate about the projects and what is being done, and can deal with the constraints of bureaucracy. This person’s charismatic personality inspires loyalty.

It is not just the correct selection of the top management that makes a company innovative. Intel says that you need to go a step further and also select the right people to solve the problem — the “transformative employees” [9].

Research has found that creative thinking and innovation can be nurtured by believing in people and expecting success. This empowers employees, opens up communication, gives people freedom, and accommodates their needs. This is what a visionary leader at all levels does. So in summary, it is the people who are central to the creative process [1]. Innovation begins with understanding human beings, especially during the creative process.

Another way to confront creative thinking obstacles is to balance creativity and efficiency, since there is an internal struggle between efficiency and creativity in many companies [11]. It is a balance that is reached by innovative companies, such as Apple Computer, who approach creativity and efficiency as symbiotic entities. The successful creative process makes the entire company more efficient [12].

Steve Jobs, CEO of Apple Computer, focuses on making “insanely great” products (Burrows, 2005). Apple Computer’s philosophy on innovation is to have the vision of making great products, not on making a profit or becoming the biggest company [12].

The goal of Hewlett Packard’s (HP’s) Innovation Program Office is the business impact – getting the product into the hands of the customer. They understand that it cannot be done without creative thinking, so Phil McKinney, the Chief Technology Officer (CTO) of HP’s Personal Systems Group, runs an incubation program to analyze and experiment with solutions to problems [13].

Being open to associating unrelated ideas and visualizing new relationships between concepts sets a creative environment. Intel likes to establish an environment that gives researchers both “freedom and direction” [9]. Other innovative companies, such as 3M, have a deliberate creative environment which enabled the invention of the Post-It note. In spite of the fact that this particular invention was labeled “accidental,” it could not have happened without the proper creative setting [11].

Another way to unblock the roadblock is to follow 3M’s “15% rule” in which technologists and engineers spend 15% of their company time initiating and developing their own pet projects. This rule resulted in over 60,000 products in 3M by the early 1990s [11]. Google also adopted this rule in their organizational culture; however, they allocate one day a week for the pet projects [8]. This is also a way of rewarding employees.

Challenges to Roadblock #2: Resistance to change or to the idea

An environment that resists change, is bureaucratic, hierarchial, and cautious, is most likely not to be conducive to creative thinking. Unsuccessful initiatives that have been funded and staffed continue in environments that do not foster creativity. The status quo is maintained, which in turn supports the political agendas [5].

Innovation is about embracing new ways of thinking. It is not “pie-in-the-sky.” It is about survival for a company in today’s post-industrial world. Innovation begins from the top down. It begins by getting rid of those who are resistant to change.

Three challenges to Roadblock #2 are: (1) identifying the correct problem to be solved, (2) not always settling on the first solution, and (3) being open to ideas with a systematic incubation period and experimentation.

A problem to be solved is identified when one can discriminate between what exists now and what you want that is better [15]. Intel says that many times creative activity is wasted on trying to solve the wrong problem [9]. Jobs of Apple says that his company is successful at innovation

because they focus on select problems to be solved and “say no to 1,000 things” [12].

Part of what makes innovation so intriguing is that the solution to the problem may be only the beginning of many more improvements. Just because something works, does not mean it cannot work better. Often noteworthy changes occur by associating unrelated ideas and visualizing new relationships between concepts during the incubation period. Product improvements in cost, quality, and time-to-market are not only incremental steps, but also significant steps of innovation.

Phil McKinney, Vice President and Chief Operating Officer at Hewlett Packard (HP), fosters innovative ideas by being receptive to anyone’s ideas in the company who has a sponsor and an advocate. Innovation does not just happen in R&D. It must be a companywide process. HP approaches resistance to the idea by having systematic goals and milestones during the incubation period of the idea [13].

Jim Collins and Jerry I. Porras, authors of the book “Built to Last,” stress the importance of experimentation and “purposeful accidents” in the creative thinking process [16]. They believe that in the success of a visionary organization, it has a priority higher than strategic planning. 3M suggests that successful ideation revolves around the persistence of new and unique ideas, and implementation of many inexpensive and small experiments [6]. The experimental part of the incubation phase focuses on the goal of solving problems, not implementing a specific solution. Keep shifting solution paths until one works means that in order for innovation to occur, one must not make the mistake of being overly committed to one solution.

One technique that Michael Lopp, senior engineering manager at Apple, uses is to require their designers to produce 10 design mock-ups in comparison to the typical three produced in other design departments. The designer selects the top three and commits months on the three in order to reduce the choice to one. Lopp states that there is more time spent on the initial design time, but this saves time in the production phase, because less time is spent making revisions and figuring out ambiguity [17].

Challenges to Roadblock #3: Fear of failure and anxiety

One of the major roadblocks to creative thinking and problem solving is fear of failure and the anxiety that accompanies it. Failure should be expected as a part of the process and should be viewed as educational, as well as evidence of action. Two challenges to Roadblock #3 are: (1) establishing a risk-free organizational culture, and (2) teaching people how to think differently.

Elimination of fear is how creative breakthrough thinking occurs. Not being afraid to make mistakes opens one up to creativity and innovation. This cannot be accomplished without a risk-free organizational culture. “Failure is our most important product,” states R. W. Johnson, Jr., former CEO of Johnson & Johnson [18]. In its 107-year history, this company has never posted a loss. It is not afraid to make mistakes and has many failed ventures; however, the ones that are successful are highly successful.

Just like Johnson & Johnson, 3M understands that failure is part of the creative process. They advise companies to accept their mistakes, learn from them, and move on [21].

Research indicates that when people face huge and complex problems, they habitually gravitate in their thinking to familiar and narrow potential solutions [34, 35, 36]. This results in failing to notice up to 80 percent of potential solutions. What is more surprising is that they are totally unaware of their behavior [37, 38]. People can learn to think differently through learning creative thinking techniques. Higher education is in the business of teaching people how to think, so the responsibility of teaching creative thinking for future technologists, designers, and engineers should rest with universities [3].

Challenges to Roadblock #4: Difficulty dealing with criticism

Another roadblock to creative thinking is difficulty dealing with criticism. Ideas are often criticized because they appear childish or not feasible. In order to deal with criticism, all members of a critique must harvest an open attitude that may link a viable solution to the most outlandish idea. Remember that constructive discontent is necessary to challenge the status quo. Five challenges to Roadblock #4 are: (1) cultivating creativity, (2) changing the way brainstorming is implemented with energy and rigor, (3) brainwriting, (4) concept mapping, and (5) synetics.

“It is easy to destroy creativity through discouragement and other means; cultivating creativity requires a significant, disproportionately higher degree of effort” [25]. For an organization to be innovative it would have to undergo a cultural transformation by having an avenue to express ideas without rejection or consequences. Always following the rules, selecting the first idea that comes into our head, being quiet for fear of failing or believing there is only one best answer are sure ways to fail at creative thinking.

IDEO is a design firm based in Palo Alto, California. IDEO’s ideation sessions begin with homework. Participants are asked to research the problem to be discussed the night before. They often begin by playing a zippy word game to set the stage for creative thinking. An ideation facilitator is used to guide the discussion and know when to change the focus. The focus is on one problem to be solved at a time. They come up with “wild ideas” and plenty of them [26]. When “wild ideas” are being presented in a brainstorming session, one person speaks at a time, judgment is deferred, and ideas are presented visually and physically, as well as verbally. The goal is to come up with 100 ideas per hour. Many ideas are built upon others. White boards, Post-It notes, foam core, tubing, duct tape, hot glue guns, and other tools are on hand at IDEO to sketch, diagram, and make rough prototype models [26].

The early stages of ideation, often referred to as the “fuzzy front end,” involve decision making associated with ambiguity [14]. Revolutionary thinking stems from believing that in the brainstorming session, no idea is a bad idea, because brilliant solutions are often discovered in the oddest ways. Creative thinking sees beyond the obvious and uses the imagination to repurpose an idea. Taking two good ideas and combining them into one is another method for creative thinking. Being open to changing directions is important, so that there is no overcommitment to a particular solution, when the focus should be on finding the best solution to the problem.

Successful ideation in innovative companies is rigorous and disciplined, as well as creative. Energy expenditure is high in cultivating creativity. Richard P. Carlton, Former CEO, 3M Corporation, states that 3M has “stumbled onto some of its new products. But never forget that you can only stumble if you're moving” [11].

For example, Google has eight brainstorming sessions each year with 100 engineers. Six top concepts are pitched for 10 minutes each. The goal is to have one idea per minute built upon the idea [8]. Some companies have Yes! Meetings in which every idea is greeted with an encouraging “Yes!” to let the ideas flow freely [10]. Apple Computer has paired design meetings (production and brainstorming), and management meetings (pony meetings) each week, and produces more than three times the idea mock-ups than other design departments. IDEO’s brainstorming session has the goal of 100 ideas for the hour session.

A brainstorming technique called “brain-writing” is a successful option to an open verbal forum. It is often referred to as the “6-3-5 method” (six participants, three ideas each, and five times around the table). It has been proven successful, especially with introverted technologists and engineers. Ideas are sketched out or written on a worksheet, Post-It notes or index cards and passed out to a team of six participants. The papers are passed around about five times and additional drawings and notes are added to the idea sketches. Usually a feasible design will result from this session [4].

Concept mapping, which was developed by Joseph D. Novak and his Cornell University research team in the 1970’s, is another visualization technique to generate and organize ideas. It is based upon the learning movement of constructionism and the cognitive theory of assimilation, which builds upon prior knowledge. The main concept is placed on the blank map and other related ideas are linked as nodes by lines [27].

In the 1960s an alternative to the unstructured chaos that resulted from traditional brainstorming was founded – “synetics.” Because it is set up as “controlled brainstorming,” it eliminates the discomfort that often arises for the technologists and engineers, when placed in a typical spontaneous brainstorming setting. It also controls the dominance of some people, and formalizes the recording of idea generation. The creative thinking process begins with the client asking a specific problem to be addressed. The team comes up with over a dozen “I wish” or “What if” statements that are read out loud with no criticism. Each member is asked how he or she originated the idea, what will be accomplished, the feasibility of the idea, and questions about the target market. The ideas that are not feasible are eliminated and the list is downsized. The ideas are then organized in categories. The client has the choice to take notes and select any feasible idea.

Challenges to Roadblock #5: Running a company with no reward system

Only 16% of companies give some type of incentive to employees who offer ideas for improvement of company products [28]. Establishing an incentive plan is a management responsibility. When employees do not receive some type of reward for their ideas, they lack initiative and do their job and nothing more. Rewards for innovative behavior and

“disincentives for lack of results” should be in place in an innovative company. Compensation structured to reward innovation would create an organization of employees who are motivated [3]. Incentives such as recognition, empowering employees to do the things they enjoy, and money, will inspire loyalty, increase morale, and increase profits. Things get done that are rewarded, so it is important that management makes sure they are truly rewarding the behavior they want repeated.

Jack Welch, past CEO of General Electric, overcame this roadblock by putting a compensation plan in place that were not only “rewards for the soul,” but were “rewards for the wallet.” Intel overcomes this roadblock by linking rewards to performance. More than 70% of employees can purchase stock options. In addition to stock options and bonus plans, Canon offers recognition, promotions, and non-monetary rewards, such as thank yous and vacations.

Challenges to Roadblock #6: Lack of resources

Organizational roadblocks limit a company’s ability to initiate design and apply new value-added ideas. A lack of resources is one of the roadblocks to creative thinking. Resources in a company are time, space, human capital, and money.

Openers to Roadblock #6: Lack of resources are: (1) commitment by visionary leaders to commit to investing in time, space, human capital, and money, and (2) commitment to research and development.

3M overcame this obstacle by committing to resources, because they value experimentation. Just like 3M, companies wanting to be innovative need to commit to investing in resources for experimentation, because creativity and innovation do not happen by accident [6].

Hewlett Packard (HP) has resources, but their policy is to remain selectively lean. In HP, the decision on whether to continue an idea to the next phase – the Go/No Go milestone – is a final decision. Once the decision is accepted, the process moves quickly to completion, because it is then that resources are dedicated to the project [13]. The faster to “Go/No Go,” the better.

If you look closely enough in organizational cultures who do not foster creativity, you will see that the entire responsibility of innovation is given to Research and Development and taken out of the hands of the other employees [5]. Buxton [7] states that innovation cannot be “ghettoized” in R&D, since it should be an organizational culture issue.

In a prior study that was conducted by the author with industry leaders from Motorola, Intel, Boeing, and Honeywell [3], participants stated that the research and development department needs innovation training the most. The majority of the participants see the need for employees to learn to think more inventively in their organization.

Apple Computer believes in the importance of not cutting R&D resources; however, Intel suggests that confronting the problems between R&D and manufacturing is a key to innovation success [9].

Challenges to Roadblock #7: Poor internal communication

Companies with poor internal communication lack in decision making and effective creative thinking. One of the top ways to address poor internal communication is to focus on conducting efficient and effective meetings.

Industry leaders suggest there is a need to run more efficient and effective meetings in most companies in order to expedite the creative process. The biggest problems with meetings are that they are not well facilitated, not well planned, and there are too many of them with no purpose. The successful companies have “short meetings that are to the point” [3].

The Six Thinking Hats process, introduced by Edward deBono, is a technique used in the workplace in order to conduct efficient meetings [29, 30, 31, 32, 33, 34, 35, 36]. Wearing one hat at a time when considering solutions to a problem allows the problem to be approached through six different perspectives — logic, emotion, cautiousness, speculative-positive, creative thinking, and control. IBM reported a reduction of meeting times to one quarter of what they were once they applied this technique [30].

Apple Computer conducts two types of meetings each week — a “paired design meeting” and a “pony meeting.” The paired design meeting — a production meeting and a brainstorming meeting — are opposite in nature and are conducted for designers and engineers. In the production meeting, idea logistics are determined and clarified. The “blue sky” brainstorming meeting is for discussing all possible ideas [17].

Michael Lopp, senior engineering manager at Apple, believes that even if company leaders say “I want a pony,” they need to be heard, since they are the ones funding the projects. Lopp incorporates management input in the design process through the pony meeting in which the best ideas from the paired design meetings are presented to the company leaders. He reserves the right to either accept or block their input. In either case, this enables him to get an understanding of what they are thinking and prevents “nasty mistakes down the line” [17].

Challenges to Roadblock #8: Anxiety of external global partners

General Motors (GM) and IBM paved the way for outsourcing to India and other countries (McDougall, 2007). Outsourcing should not be something that American workers fear; however, outsourcing is often perceived as a practice of cutting American operations in lieu of less expensive labor in other countries. Many American workers fear having their company collaborating with external global partners because of outsourcing. What this translates to many American workers is the fear of losing their jobs with their jobs going overseas. How can this roadblock be turned around? Research suggests that openers to “Roadblock #8” are: (1) selective outsourcing, and (2) collaboration.

Companies such as Apple, HP, and Google address this roadblock through selective outsourcing. Steve Jobs depends on outsourced design manufacturers (ODMs) for Apple product manufacturing, but unlike many of his competitors, the key design decisions are not outsourced. He keeps the software engineers, the industrial designers, and the mechanical engineers in-house in California. Yes it is more costly initially, but the cost-savings of outsourcing design decisions are not worth what is lost in the creative process [37].

HP reduces operating costs associated with technology management by taking a collaborative approach to global outsourcing. HP spends less time on everyday information technology (IT) operation issues by outsourcing it. This allows them to concentrate on innovative projects and core competencies [38].

Several years ago Google outsourced their billing, collections, and credit evaluations for webmasters, individuals, and other corporations [39]. This enabled them to allocate their resources to what they do best.

Hewlett Packard addresses this roadblock through internal collaboration. Critiques are open to all at different levels [40]. For an organization to follow this model, it would have to undergo a cultural transformation by encouraging collaboration, and form cross-functional, interdisciplinary teams.

Vint Cerf, the chief Internet evangelist at Google since 2005, says that “the Internet’s ability to enable collaboration will be the key to breakthrough innovation” [41]. The answer is to embrace scientific research, business, and education on a global scale and use it to your company’s advantage.

Conclusions

The goal of this study was to identify roadblocks that stand in the way of the creative thinking process leading to technological innovation, and discuss ideas that can improve the process. Eight roadblocks have been identified: (1) Lack of visionary leadership, (2) Resistance to change or to the idea, (3) Fear of failure and anxiety, (4) Difficulty dealing with criticism, (5) Running a company with no reward system, (6) Lack of resources, (7) Poor internal communication, and (8) Anxiety of external global partners. Roadblocks, such as resistance to change or to the idea, fear of failure and anxiety, and difficulty dealing with criticism, are centered around negative attitude. Those that focus on organizational culture include roadblocks such as lack of visionary leadership, running a company with no reward system, lack of resources, poor communication, and outsourcing. Research of case studies of organizational cultures that support innovations, such as 3M, Hewlett Packard, Intel, Apple, Canon, General Electric, Google, Johnson & Johnson, and IDEO, have lead to findings about people, the creative thinking process, the creative environment, and product innovation.

People

Creative thinking starts with human capital. Higher education should have the responsibility to develop visionary leaders in technology and engineering, along with visionary technologists, and engineers. This begins by teaching people how to think. Teaching people how to think is the role of the university.

Creative thinking process

The balance between efficiency and creative thinking is a tenuous tightrope, but it is the very balance that leads to innovation. With a focus primarily on efficiency, products get delivered, but it is status quo and usually slight modifications of the old. With a focus primarily on creativity, the process gets out of control and nothing feasible gets done.

Creative environment

The creative process cannot be changed without having a receptive environment. A creative environment cannot be formed without creative people working for the company. Without a visionary leader, creative people cannot be free to innovate. With the people, process, and environment in place, the products will become more innovative. Then creative thinking will lead to technological innovation.

Product innovation

Some ideas lead to big inventions and breakthroughs, while some lead to incremental improvements on original products or finding a new approach to doing old processes. The successful ideas of technologists, designers, and engineers are the result of creative thinking and innovation.

In summary, non-visionary companies who are stagnant, centralized, bureaucratic, autocratic, who commit to policies that discourage entrepreneurship, and who have no incentives for successfully engineering ideas, are not innovative. Creative thinking is not unorganized chaos. It is a process that can be systematic and can successfully challenge idea roadblocks. It is not just about finding solutions to problems and producing a product. It is about change in an organization that is transformational. It is change in how people think and how people approach work [6]. The bureaucratic environments of large organizations are not always conducive to out-of-the-box thinking; however, many large companies, as well as smaller companies, have been successful innovators for our society. They need to continue to successfully challenge these idea roadblocks in order to contribute to the sustainable economic growth of American businesses in the 21st century.

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Biography

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