CREATIVE THINKING IS VITAL IN PROCESS SAFETY MANAGEMENT

Paul Baybutt
Primatech Inc., Columbus, Ohio, USA
paulb@primatech.com

A version of this article has been published:

P. Baybutt, Get creative with process safety management, Chemical and Engineering Progress, pages 56 - 60, Vol. 113, No. 4, April, 2017.

Abstract

Creative thinking is needed when addressing many process safety elements. It is essential in process hazard analysis studies where people brainstorm what can go wrong. Also, it is important for other elements such as incident investigation, procedure writing, management of change reviews, and developing emergency response plans. Formal education usually discourages creative thinking and most people don't need to be creative for much of what they do in daily life. Consequently, the ability to think creatively is not common. However, creative thinking is a skill that can be learnt and guidance can be provided for ways in which creative thinking can be approached by anyone when the need arises. This article provides guidelines for creative thinking that can be used to address the challenges of process safety.

Key words: Creative thinking, process safety.

1.0 Introduction

Creative thinking taps into human imagination to generate new ideas.

Imagination involves being able to see something in a new light and having the capacity to conceive of something new. People are born with imagination but it can languish and atrophy, often because it is not emphasized in education but rather is replaced with analysis. This situation certainly is true of the education that is received by engineers and it is unfortunate for process safety where creative thinking is needed in various areas, for example:

- Identifying hazard scenarios
- Performing change reviews
- Identifying risk reduction measures
- Improving process safety practices
- Identifying ways in which processes may be mis-operated
- Investigating the causes of incidents
- Planning for emergencies

While empirical evidence suggests that some people may be more gifted or predisposed to think creatively, the prevailing view is that creative thinking can be learnt. The literature on creative thinking can be used to extract guidance appropriate for process safety applications. While there are no rules for creative thinking, there are suggestions, guidelines, and strategies that can be gleaned from the literature. This information has been used in this article to provide guidelines and a framework for creative thinking that can be used to address the challenges of process safety.

2.0 Nature Of Creative Thinking

Creative thinking uses inventiveness to generate ideas and possibilities that have

not been thought of before. It requires original and imaginative thinking that is associated with divergent, lateral, out-of-the box, and out-of-the rut thinking. Creative thinking involves:

- Perceiving layers of detail
- Asking many kinds of thoughtful questions
- Identifying relationships and grouping and linking them
- Noticing links with prior knowledge and experience
- Developing interpretations based on observations
- Reflecting, assessing, and revising

Creative thinkers ask questions of themselves and others including:

- What if?
- Why?
- Why not?
- How?
- How else?

“What if” questions are particularly important because they allow the suspension of assumptions that may be held by people. Also, they encourage an imaginative frame of mind. Some examples of questions asked by creative thinkers are:

- How else can I view or consider this issue?
- What alternatives might there be?
- Is there anything I / we haven’t yet considered?
- What other ways might there be to do that?
- Where else can we get more information?

- Who else has a suggestion?
- How can something happen? (Rather than whether it can)

The kinds of questions asked are important. Good questions encourage exploration, open minds to possibilities, enliven curiosity, and excite imaginations. Good questions probe getting to the heart of an issue, are provocative causing others to think differently, and are open-ended allowing more than one answer. Also, they jump start thinking by stimulating and engaging others, generate other productive questions, and produce good answers. The ability to ask such questions is a goal for all creative thinkers.

Some examples of good questions are:

- Why consider a safety instrumented system failure to be a near miss?
- How can we avoid a runway reaction?
- To what extent do personal safety and process safety overlap?
- Why not allow senior operators to train new operators?
- What if we invited LEPC members to participate in our hazard analysis studies?

Some characteristics of creative thinkers are provided in Table 1 and some dispositions and attitudes that foster creative thinking are given in Table 2.

3.0 Overcoming Obstacles to Creative Thinking

Various obstacles may need to be overcome to allow creative thinking to thrive. Common obstacles are described here together with suggestions for overcoming them.

3.1 Searching for the “right” answer

Educational systems are geared to teaching people to find the correct answer. This is a universal experience for engineers and it becomes deeply ingrained in our

thinking. The approach is fine for problems that have only one correct answer but many real-world problems have many “right” answers. Unfortunately, if people believe there is only one correct answer, they will stop looking as soon as they have found one because most people don’t like facing problems and usually take the first way out. However, there may be other, more promising solutions to the problem that are missed.

One way to address this obstacle is to set a quota for alternatives when thinking creatively about an issue and to keep looking for ideas until the quota has been reached. This process may generate less-than-promising ideas that are impractical or improbable. However, their value lies in where they lead our thinking. They can be stepping stones to better ideas. For example, when investigating incidents there can be a temptation for investigators to jump to a conclusion regarding the cause of an incident because of a strong desire to know what went wrong. However, the temptation must be resisted and all possible causes identified before conclusions are drawn.

3.2 Assuming limitations that are not there

Sometimes people make invalid assumptions about a situation and proceed to address a problem with constraints that actually do not exist. As a result, they may not develop an optimum solution to the problem. For example, when faced with the prospect of reducing the risk from a runway reaction in a vessel, it may be assumed that no amount of pressure relief on the vessel will be adequate and, consequently, a reaction kill system is needed. However, while the assumption may be valid in many cases, it is possible that the reaction kinetics and heat and mass balances in the particular case invalidate the assumption and make pressure relief viable. Creative thinkers must always look for assumptions in their thinking, stated or unstated, and

challenge them.

3.3 Following rules

There is considerable societal pressure to follow rules, including ones that are unwritten. This practice is encouraged by the educational system and people feel more comfortable following rules than challenging them. However, this inclination on the part of people encourages thinking about things as they are, not as they could be.

Creative thinkers must identify and challenge rules that control a situation. A creative solution may be found by successfully breaking rules or escaping from obsolete rules. Of course, rule breaking must not be illegal, immoral, or unethical.

The author once encountered a process where the operators were transferring material from one tank to another, allowing it to sit for an hour, and then transferring it back. This operation was creating difficulties and a solution to the problem was needed. After some investigation, it emerged that this unwritten rule originated when different materials had been used in the process some years before but a change had been made and the requirement for the transfer operation was no longer needed.

3.4 Emotional blocks

Emotional blocks to creative thinking occur when feelings inhibit clear thinking, such as anger and fear. Anger must dissipate before creative thinking is possible. For example, if PHA team discussions become heated, it is a good idea to call a break. The fear of being wrong also may impact PHA studies. One experienced PHA facilitator once stated that he always had a recent graduate engineer on his study teams because they could be relied upon to ask the “stupid” questions that more experienced team members would not ask and often it was the “stupid” questions that led to the discovery

of serious hazards. If these recent graduates had been informed that their questions were stupid, it is unlikely they would have continued to ask them. PHA studies should be conducted in an environment in which every question is considered seriously, even though some may lead to dead ends. Addressing the fear of being wrong ideally requires an attitude of confidence and willingness to be seen to be wrong as well as a safe and secure thinking environment that does not punish creative thinking.

Creative thinkers must get out of their comfort zone and be willing to risk failure and view it positively. Failures should be viewed as learning experiences that are necessary to improve the ability to think creatively. Similarly, creative thinkers must be comfortable with errors. Most people are inclined to try to avoid errors. However, such an inclination produces conservative thinking that impairs creative thinking. To err is not wrong in the context of creative thinking. It is acceptable to err intelligently.

People must avoid falling in love with ideas. Becoming enamored of a particular idea can be a problem. The person then is unable to see the merits of alternative ideas. It is important for people to challenge their own ideas. They should not be immune from self-criticism.

3.5 Polarizing blocks

Polarizing blocks cause people to see matters in terms of opposites. It is black and white, either / or thinking. Different types of polarization are possible, for example, us versus them, for or against, and right or wrong.

Polarizing blocks can be addressed by asking “to what extent is …” or stating “yes, but …” or “no, but …”. For example, a finding that a proposed process change may increase risk should not be met with insistence by management that the change

must proceed for operational reasons. Rather, an appropriate response is “to what extent is the risk increased and what can we do about it” or “yes, but isn’t there something we can do to manage the increased risk”.

3.6 Cognitive biases

Cognitive biases are unconscious, automatic influences on human judgment and decision making that can interfere with clear thinking and cause reasoning errors. They occur commonly and can impair creative thinking.

For example, habits of thought involve the unconscious tendency to limit ideas to common, familiar, habitual responses. Uncommon or unfamiliar ideas are blocked out. Habits of thought can be addressed by forcing oneself to keep thinking of ideas to address a problem or issue so that the habitual ideas are flushed out and creative ones can emerge.

A number of separate oil spill incidents occurred in Alaska involving storage tanks with drain valves that were inexplicably opened. Various explanations were considered, such as mechanical failure and vandalism. However, eventually it was discovered that pieces of ice resulting from snow freezing had fallen from the top of the tanks and hit the horizontal handles of the valves. Identification of such unusual release mechanisms certainly requires habits of thought to be overcome.

Many other cognitive biases exist. For example, groupthink involves people sharing common but possibly false beliefs, or causes members of a group to be more concerned about the approval of other group members than trying to come up with new ideas. Individuals may be affected by mindsets where they hold assumptions that are so established they do not recognize they exist. Such cognitive biases impair creative

thinking.

Cognitive biases are difficult to detect and override because they occur unconsciously and automatically. The first step in addressing them it to be aware of their existence. In a team environment, awareness permits team members to recognize their influence on other team members which provides an opportunity to address them. People should always look at situations from a different viewpoint when thinking creatively. A devil's advocate can be employed to challenge the position taken by a person and help them to recognize the influence of cognitive biases.

3.7 Objections to new ideas

People tend to be critical when looking at new ideas. Unfortunately, some common attitudes can kill ideas. For example, creative thinkers may be admonished to be practical or realistic. Unfortunately, the logic that is used in judging ideas may stifle the creative process. Consequently, a better response to an initial idea that is viewed as impractical is to inquire where it might lead in order to identify ideas of greater practicality. For example, a process safety incident that involves piping failure may prompt a recommendation to perform non-destructive testing for all piping in a process. However, further discussion may recognize that the failure arose from external corrosion and an alternative recommendation to employ visual inspection may be sufficient. Use of the "creative no" can be useful wherein if someone objects to an idea they have to come up with another one. When creative thinkers are told their idea won't work or they can't do it that way, an appropriate response is to ask, "why not?" followed by "what if ...?".

Judgment should be withheld when generating ideas. Nothing should be done to

stop the flow of ideas when people are thinking creatively. Critical evaluation of ideas as they are generated will shut down creative thinking. The ideas can be evaluated once they have all been generated.

Further examples of negative attitudes that kill ideas are provided in Table 3. Such attitudes must be strongly discouraged within a company for creative thinking to flourish. It is important to focus initially on the merits of a new idea rather than its demerits. Creative thinking functions best in a collaborative and collegial environment.

4.0 Guidelines For Creative Thinking

Various practices have been found to be beneficial for creative thinking. They are described in this section.

Make time and eliminate distractions

Quiet time is needed to think, imagine, and reflect and a conducive environment is required.

Use lateral thinking

Lateral thinking focuses on breaking out of the constraints and patterns of entrenched ways of thinking. It is nonsequential and nonselective in contrast to vertical thinking which is sequential and selective. Lateral thinking involves various techniques such as pausing in a deliberate proactive effort to think creatively for a set period of time and focusing on a particular aspect of an issue. Also, included is creatively challenging why something exists as it does or is done the way it is to push thinking beyond blind acceptance and towards thoughtful consideration so that other ways of doing things can be considered.

Pose questions with some ambiguity

Many questions are posed during creative thinking. Care should be exercised not to ask questions that are highly specific as they can stifle imagination.

Maintain focus on the issue while generating ideas

It is easy to become distracted when thinking creatively about an issue and digress into thinking about other issues. A focus should be maintained on the issue at hand while avoiding constraining the generation of ideas relating to the issue.

Don't overlook the value of the intuitive hunch

The human mind constantly records, connects, and stores knowledge, experiences, and feelings. The brain can synthesize this information without conscious effort and present it as an idea that emerges from the subconscious. The person feels intuitively that the idea may be a good one but cannot immediately justify it. The idea is viewed as a hunch and the person is not sure where it came from. However, hunches derive from a lifetime of experience and should not be ignored.

Be alert for fringe thoughts

When trying to think creatively about an issue, human cognitive processes sometimes present a thought that seems elusive and on the edge of consciousness. It is worth expending cognitive effort to pin down the thought as the brain is trying to help address the issue by taking advantage of the information that has been accumulated over the lifetime of the person and distilling it into something relevant.

Be alert to kernels of ideas expressed by others

Brainstorming in a team involves people offering up their ideas. One person may not believe an offered solution to a problem will work but sometimes there is an aspect

of the proposal that triggers the thought of a more promising alternative. Creative thinking can be jump started in this way.

Look for cross-fertilization of ideas

An idea from one situation may be applicable to another so that thinking by analogy can be valuable. Ideas have to be original only in their adaptation to a new situation. For example, knowledge of incidents in other companies can be used to identify ways to prevent incidents in your own company.

Shift attention from one aspect of an issue to another

Difficulty may be experienced in working one aspect of an issue. Another aspect may be more amenable to solution. For example, when exploring how to reduce risks for a process, a PHA team may apply the hierarchy of controls and focus initially on inherently safer technologies but none may be workable. Shifting attention to the use of other approaches such as engineered safeguards may prove more fruitful.

Look at an issue from other points of view

Adoption of a different perspective or considering the issue in a different context can generate new ideas. Reversing the initial viewpoint taken also can be valuable, otherwise solutions outside your focus may be missed. For example, shifting the focus from how to mitigate a runway chemical reaction to how to prevent it may allow the problem of managing the risk of a runway chemical reaction to be replaced by the better solution of changing the reaction chemistry to avoid a runway should that prove possible.

Be aware that the need to satisfy constraints can spark creativity

Time or other resource limitations can provide a stimulus and force thinking

beyond conventional solutions. Of course, such constraints can also impair thinking so care must be exercised when constraints exist. A case in point is during process hazard analysis where time limitations may constrain brainstorming and result in a poor quality study.

Allow time for the incubation of ideas

Stepping back from a problem allows the big picture to be seen. Ideas can germinate, assumptions can be queried, and more information can be developed.

Pay attention to anomalies in situations

An aspect of a situation may have been overlooked, perhaps because the aspect was a minor one and there was no obvious explanation for it. However, careful examination of such anomalies may lead to new ideas that have been overlooked by others.

Don't let the obvious escape your attention

Anything we take for granted may evade our attention. One way to address this matter is to explain a problem or issue to someone who knows nothing about it when unrecognized ideas may become obvious.

Foster enjoyment of problem solving

A playful approach to critical thinking lowers people's defences making them more inclined to experimentation and the exploration of issues. Also, it provides a license to try different approaches without fear of penalty and makes for a more productive thinking environment.

Recognize that humor facilitates creative thinking

Humor puts people in a frame of mind conducive to thinking about issues. Also,

humor allows matters to be taken less seriously which makes it easier to challenge rules.

Comedians take a different perspective on a topic, often by combining ideas not usually associated with each other, and they play the role of an outside observer looking in. Also, comedians question authority and challenge assumptions. These various aspects of humor are valuable for thinking creatively.

Recognize that the hand stimulates the brain

Studies have shown that activating basic motor functions can improve mental performance. Consequently, some creative thinkers manipulate a ball or other object when thinking.

Employ a devil's advocate

A devil's advocate constructively challenges the thinking of others. They help to put issues in a fresh light and stimulate thinking. Devil's advocates try to think of different interpretations, question what others take for granted, reverse assumptions, and ask the apparently stupid questions that no one else will ask but that yield good ideas.

5.0 Ways to Develop Creative Thinking Skills

Critical thinkers can practice mental exercises to help develop cognitive flexibility. Also, they should practice thinking in terms of alternatives and possibilities. Counterfactual thinking can be employed to stimulate critical faculties and develop imaginations. It applies "What if" questions to past history and examines alternatives to what actually happened, e.g. what if the company had adopted the IEC 61511 standard

on safety instrumented systems when it was issued?

6.0 Conclusions

Creative thinking is deeper than routine thinking. It is believed that most people are born with a capacity for creative thought but it atrophies as a result of formal education that discourages it, particularly for engineers. Creative thinking is needed in various elements of process safety, such as process hazard analysis. Fortunately, the prevailing view is that creative thinking can be learnt. The literature on creative thinking was used to compile guidelines that can be applied in process safety.

Additional Reading

1. R. DiYanni, *Critical and Creative Thinking*, Pearson, Boston, MA, 2015.
2. V. R. Ruggiero, *The Art of Thinking: A Guide to Critical and Creative Thought*, Pearson, Saddle River, NJ, 2015.
3. R. E. Nisbett, *Mindware: Tools for Smart Thinking*, Macmillan, New York, NY, 2015.
4. R. Von Oech, *A Whack on the Side of the Head: How You Can Be More Creative*, Hachette, New York, NY, 2008.
5. M. Michalko, Thinkertoys, *A Handbook of Creative Thinking Techniques*, Random House, New York NY, 2006.
6. M. Michalko, *Cracking Creativity*, Random House, New York, NY, 2001.
7. R. J. Sternberg, (editor), *Handbook of Creativity*, Cambridge, New York, NY, 1999.

Table 1. Characteristics Of Creative Thinkers.

Think imaginatively
View issues as challenges
Engage with challenges
Open to new ideas
Believe alternatives exist
Wonder and speculate about what could or might be
Look at issues from different perspectives
Stimulated by the ideas of others
Able to defer judgment on an issue
Display an open mind
Exhibit fluency and flexibility of thought
Use metaphor, analogy, and visualization to make connections and explore ideas from varied perspectives
Able to live with ambiguity
Self-confident
Able to tolerate a degree of chaos in thinking
Know how to ask good questions

Table 2. Dispositions and Attitudes That Foster Creative Thinking.

Patience
Perseverance
Curiosity
Positive frame of mind
See mistakes as opportunities to learn
Welcome challenges
Willing to follow intuition and instinct
Desire to explore rather than prove
Desire to consider rather than argue

Table 3. Attitudes That Kill Ideas.

That’s not how we do things here
If it isn’t broken, don’t fix it
What we have (or do) now is good enough
We tried that before and it didn’t work
That’s not my / your / his / her / our job
That sounds ridiculous
That’s impossible
My mind is made up
It would cost too much
It would take too much time and/or effort
Maybe next year