SAND--87-2801C

DE88 003309

INNOVATION AND CREATIVITY - A CRITICAL LINKAGE

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Abstract

Creativity involves the associating of hitherto unrelated elements to form a new and useful combination. All have the ability but most seldom use it because of some false beliefs and failure to understand the creative process. Deterrents to creativity include fear of criticism, narrowness of education and training, habit, negative attitudes toward problems, lack of motivation, lack of self-confidence, lack of courage and discouragement by failures. The recognition and development of creative ideas requires mental effort, an open mind, searching seemingly unrelated fields and definition of the problem. Brainstorming is widely used to produce alternate ideas. Modifications of it are the Gordon Technique and Synectics. Morphological analysis and the examination of attributes are other aids to creativity. Recognition of a need, or of a new use of an old idea can be helpful. Management should encourage attempts at creativity. If the will exists, creativity can be developed by conscious effort instead of being left to chance.

Creativity is one of the most fruitful of all human abilities, yet it mysteriously remains one of the least utilized. Why? Why, particularly when it can be shown that most of our celebrated scientific and industrial advancements, and even the minute developments that afford us our high standard of living, have resulted primarily from some sort of creativity? Could it be that we do not understand what is meant by or involved in creating?

Creativity, as it is viewed here, concerns the evolvement of ideas, particularly how to do things differently and better; how to develop unique solutions to problems. But how do these ideas evolve -- by chance or by choice?

Many of us believe a worthwhile idea is a stroke of genius. In fact, we startle ourselves when even we come up with a good idea. Perhaps we are startled because we did not realize we had it in us, or because we do not know how or why the idea came to us. All of us have innumerable good ideas floating around in our heads, but we do not recognize them until conditions are just right; then Bang! -- the idea hits. Can we afford to wait for good ideas to hit--accidentally? Must we in industry, rely hopefully on inspiration, as is the case in the creative arts, or can we deliberately generate and recognize creative ideas, and at the time those ideas are needed?

In recent years we have been aware of notable sophistication of management, engineering and scientific techniques. Supporting this progress has been the development of human abilities to implement those techniques. Not so familiar, however, is the progress in the development and identification of techniques that better enable the utilization of human abilities. It has been found that the process or technique of creating is essentially the associating of seemingly unrelated elements to form a new and useful combination. It might also be the beneficial result of the uncommon application of an idea or item. But what about the ability to recognize the benefits of such associations -- the creative ability?

Creativity is an ability all of us have always had. Do you remember those fantastic nightmares when you were about four years old? Remember how you imagined spooks in the dark closet, monsters crawling up the bed? And there was no doubt in your mind that there was something living in the attic or in the cellar. When you were six you probably had a tree house, sniped Indians from behind the fire hydrant, "got" the bad guys with a fast draw. A keen imagination allowed you to create any situation, no matter how fantastic. It was then that you could use an ordinary stick as a trusty sword, or mount it as "Trigger" and charge down the sidewalk, or swing it as a pretty good Louisville Slugger. Your imagination allowed you to use that stick for any purpose you wished to imagine. You did not develop that creative imagination; you merely used what already inherently existed.

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Today, you are still using that creative imagination in trying to solve daily problems, brush fire problems, even in trying to fix things around the house by using whatever you can find to do the job. You resort to your creative imagination but only because there is no other readily available solution. This is what is known as creating by emergency -- unimpressive, yet effective. But because it is unimpressive we unjustly discount the creativity involved. We do possess creative ability, and its use has proven advantageous. Why then do we not use it more?

While some may reason that the environment of many large organizations is responsible for this situation, the void of creative activity actually stems from some false beliefs and from the individual's lack of understanding of the creative process. Let us discuss each in turn.

One such belief is that creativity is the private property of an exclusive fraternity, a fraternity of super intellectuals who enjoy probing the psychological, emotional working of man, or of students who seek a thesis so nebulous as to avoid condemnation of their views (and the thesis). In fact, articles on the subject seem to be a closed circuit, which, to the layperson, might appear as: "Dr. Tyler of the Creative Concepts Society recently stated before the subcommittee on Creative Motivation, of the Association for Creative Education, that he concurs with the theory of Dr. Jacobs of the Psychological Department of the University of Santa Cruz, whereby he takes takes issue with the article by Mr. Kelmer of the Idea Generation League, wherein the substantiates the beliefs of Holmes, Allen and Low as stated in their text, 'The Creative Man,' et cetera, et cetera."
A slight exposure to such sophistry as this tends to make us laypersons hesitate to tread on such hallowed ground.

There are also those who look on creativity as a talent possessed only by a gifted few; the geniuses. Those who practice creativity are indeed gifted and, depending on the magnitude of their creations, could even be classified as geniuses. But this by no means excludes any of us from the ranks of the creative. When someone is recognized for his outstanding development, he then is looked upon as a genius. If he had any identity at all up to that point, he was probably considered a screwball or some kind of a nut.

Another false belief is that to be creative one must possess a high degree of intelligence. But studies have indicated that intelligence actually has very little relation to one's ability to create -- a conclusion some of us may find to be rather encouraging.

Extensive education or specialized training in one's vocation is also thought to be a requisite for creativity. The fallacy in this belief is exposed in recalling that Ely Whitney, of cotton gin fame, was a school teacher; Morse was an artist when he developed the telegraph; Fulton was a portrait painter; and even Alexander Graham Bell had almost no knowledge of electricity when he developed the telephone. A man named Strowger was a professional undertaker when he conceived the idea of automatic telephone switching equipment. Of course, there are those who have made creative advancements in their vocations, but it should be recognized that these developments are, for the most part, the result of their creativity rather than their specialized education. The late Charles Kettering[2] is an excellent example of this. Even Albert Einstein professed that "Imagination is more important than knowledge." Actually, as is explained later in this article, specialized and extensive education tends to destroy creativity.

Recognizable creativity seldom comes naturally. It emerges only when factors detrimental to creating are identified and overcome, when a proper attitude is assumed, and when a deliberate effort is made.

In Figure 1, some of the factors detrimental to creativity can be seen. It shows what has happened to our inherent creativity over the years.

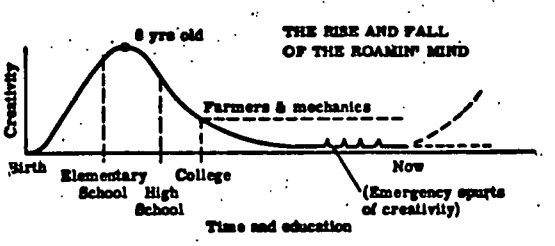

Figure 1

Earlier we recognized the presence of an active and creative imagination in our early years. Do you remember what happened when you were about eight years old? All of a sudden you became very conscious of people and their opinions and of the conventions of society. No longer could you use that stick as a trusty steed for fear of being called the village idiot. And when one of the older boys sarcastically informed you that baseball is played with a baseball and baseball bat -- not a stick and tennis ball -- your creative imagination bowed to criticism and left you believing that things are exactly as they are -- they cannot be anything else or used for anything else.

This was a lesson we never forgot, as was demonstrated in an experiment by Dr. Sidney Parnes.[3] A group of students was asked to

retrieve a ping pong ball from the bottom of a pipe which was fastened upright to the floor. Tools and aids furnished were a hammer, pliers, rulers, soda straws, string, bent pins and an old bucket of dirty wash water. After fishing vainly with the various tools, most of the students finally saw the solution: They poured the dirty wash water into the pipe to float the ball to the top. A second group of students was given the same problem, with one exception. Instead of the dirty wash water, on a nearby table was placed a crystal pitcher of ice water, surrounded by shiny goblets on a white linen cloth. Not one student associated the drinking water in the beautiful pitcher with the problem. They recognized the ice water for what it was, but did not recognize that it could be used for something else -- to float a ping pong ball out of a rusty pipe.

As we proceed through levels of education, particularly through college, the situation worsens. Our education provides training mainly in analytical, evaluative and deductive thinking while synthetic and creative thought is often neglected. We develop the "ability" to evaluate spontaneously each and every thought, even as that thought is being generated. While this is desirable in situations requiring immediate decisions, it does inhibit positive development and maturity of ideas. That is why many good ideas have been permanently discarded.

We are also taught to use textbooks and handbooks extensively, but we go too far. Books should be used to show how to do a specific task once the course of action is selected. Too often, however, we rely on such sources to delineate the course of action; consequently, no thought is given to other ways a function may be fulfilled. It is well to remember that books relate only what is known, but there is more that we do not know and could know than we do know. As Ethel Barrymore phrased it, "It's what we learn after we know all the answers that counts." Charles Kettering would not allow his employees to use textbooks or the library to solve problems until all creative thought had been exhausted. The reasoning behind his preference is illustrated in one of his favorite stores which involved the drive between Detroit, where he worked, and Dayton, where he lived. A friend who also drove between Dayton and Detroit approached Kettering one day with the statement, "I understand you drive from here to Dayton in four and one-half hours." Kettering replied that he was sometimes able to do this, depending on traffic. "I don't believe it," his friend charged, "I'm a much better driver than you are, and I can't do it."

The following Friday, the friend rode along. Here is the account in Kettering's words:

"So we rode into Dayton in about four and one-half hours, or a little more, and he said, . . . 'No wonder you do it. You don't stay on Route 25.'

"Now Route 25 is a red line that is marked on all the maps between Detroit and Dayton. If you are a stranger, that is the road you should take. It never occurred to my colleague that you could take any other road on either side of Route 25. There's a lot of country on either side of it; in fact, half the earth is on each side of it."

By the time we complete college we have learned to utilize immediately the customary solution or approach to problems without giving due consideration to other, perhaps more creative approaches. It has been observed that if a person has an engineering or scientific education, the probability of his producing an invention is only about half as great as if he does not have that specialized training.

Two notable groups of people do not fall into this education trap. Most farmers and mechanics never went past high school; they did not have the opportunity to "learn" that things must be done in a specific or conventional way. As a result, they are extremely creative people; they can and must improvise or create solutions to their daily problems; using bailing wire to repair a part that "must" be welded, using a broom handle to replace the broken spoke, using a pipe to hammer a part into place, or using a cow to mow (and feed) the lawn.

The rest of us know the "right" way to do the job, and except for sporadic flares of forced or emergency creativity, we follow this relatively uncreative path the rest of our lives; that is, unless we recognize what has happened to our creative imaginations and overcome these deterrents.

Habit seems to be another deterrent to the creative process. Over the year we have developed easily recognizable habits, some good--some bad, such as taking the keys out of the ignition, bringing your security badge to work, helping your wife with her coat, smoking, smiling. There are, however, other habits which are seldom recognized. Do you every wonder how to put on your shoes, or do you do it without thought--through habit? We like to develop habits because we are basically lazy and want to do repetitive tasks without much thought. Sometimes habits are essential, such as in assembly line production where repetitive tasks should be performed habitually. Sometimes, however, habits can be a hindrance. What do you think of first when you need something to conduct electrical current? Wire? And when you have to provide in your design a way to ease the friction of rubbing surfaces--grease? Oil? This is habit-controlled thinking -- the lazy way to solve a problem -- the way it has

always been solved, through habit. Habits are nothing more than what we have done before. They keep us where we were yesterday. Habit-controlled thinking also keeps us there by inhibiting our search for other, new ways to do a job. And it keeps us from accepting new ways and new products. For instance, titanium was developed in 1790 but ignored until duPont made sponge metal in 1948. Synthetic rubber was produced before the turn of the century but not used industrially until we were forced to use it in the 1940's.

Samuel Walter Foss, as far back as 1895, recognized this habit hindrance in the following poem:

Path of the Calf

"One day through the primeval wood
A calf walked home as good calves should;
But made a trail all but bent askew,
A crooked trail as all calves do.
Since then three hundred years have fled,
And I infer the calf is dead.
But still he left behind his trail,
And thereby hangs my moral tale.
The trail was taken up next day
By a lone dog that passed that way;
And then a wise bell wether sheep
Pursued the trail o'er vale and steep,
And drew the flock behind him, too,
As good bell wethers always do.
And from that day o'er hill and glade
Through those old woods a path was made.

"The years passed on in swiftness fleet,
The road became a village street;
And this, before men were aware,
A city's crowded thoroughfare.
And soon the central street was this
Of a renowned metropolis;
And men two centuries and a half
Trod in the footsteps of that calf.
Each day a hundred thousand rout
Followed this calf about
And o'er his crooked journey went
The traffic of a continent,
A hundred thousand men were led
By one calf near three centuries dead.
They followed still his crooked way,
And lost one hundred years a day;
For thus such reference is lent
To well established precedent.

"For men are prone to go it blind
Along the calf-paths of the mind,
And work away from sun to sun
To do what other men have done."

This brings us to the point of attitude. How do you view a problem -- with consternation, frustration, despair, worry? Not so of creative people. They view problems as only temporary inconveniences; they know there is a solution someplace. Problems are only those things for which we have not yet found a solution. For instance, there is no such thing as an incurable disease -- we just have not found the cure yet. At one time, crossing the Atlantic was a problem; now the only question is which method of transportation to use. Problems are really only challenges. A few years ago we had a problem of getting to the moon -- or was it really only a challenge? There are solutions to all problems; we just have to find them. After all, as Kettering mused, "The problem once solved will be simple." Haven't you said, "Why didn't I think of that?" when the solution turned out to be quite simple?

Creating is the process of thinking of something new, something that has not been thought of before. The creator knows that that something can and will be thought of; he is a positive thinker. He is a real believer, an optimist in the purest sense, who is convinced there are better ways to do a job, who knows everything can be improved, who knows there are answers to every question and solutions to every problem, and who knows those answers are somewhere. He must unfalteringly believe these things, without a doubt, even to the point of being obsessed with these beliefs. For it is only though this attitude of positive thinking and courage of conviction that he will find, develop and create the better way or better product. While it may be true that all the answers might not be found today, skepticism can never be allowed to compromise the positive search for improvement. The Wright brothers knew man could fly--they did it; Thomas Edison knew there could be a better light than gaslight--he developed it; a short time ago going to the moon was popularly thought impossible but a few people knew it could be done--they got there. When it is known that there are better ways, those better ways will become known.

In itself, the philosophy of believing in better ways does not produce results. There must also be motivation, a sincere desire to want to find a better way. The motivation may vary, from the profit-motivated executive to the performance-conscious manager to the schedule-minded supervisor to the success-seeking engineer. It matters little what the motivation be, but is is important that a motivation be recognized. "Where there's a will, there's a way," may be a worn-out phrase, but it is certainly applicable here, and it is this driving force that provides encouragement for initiating and sustained pursuit of a better way.

When you believe you can do something, you can do it. One of our biggest problems is lack of self-confidence in what we can do. A few years ago there was a news release about a mother who lifted her car off her child whom she had just run over. We know this is impossible, but she did it. Our problem is that we need emergencies to convince us that we have capabilities beyond

what we believe. We also lack confidence in what we know, but seldom are there emergencies to develop this confidence. As an example, try this: If you are a birdwatcher or member of the Audubon Society, this little test may not prove anything. See whether you can list ten varieties of birds you can identify by name. Go ahead; try it before reading further. Now did you think of the common birds, such as chickens, turkeys, ducks? You know about these birds, but for some reason they usually do not come to mind (at least not at first). Why? The point is that we probably know more about almost anything than we think we know, but we too often restrict our thinking within self-imposed, imagined boundaries which consequently restrict the use of our vast knowledge. In this case, mention of the Audubon Society may have triggered a self-imposed restriction to consider only exotic or wild birds. We may also prefer to say, "I can't think of ten varieties of birds," rather than try to figure out the answer. Like your ability to think, you have more creative ability than you think you have. The main need is to avoid self-imposed restrictions and apply enough effort to utilize that potential more fully.

Ideas are really valueless until put to use and this requires considerable courage. Alex Osborn[4] reminds us that most of the world's great ideas were laughed at when first suggested. And we all recognize that each new invention is made under the stress of the attitude that it cannot be done. In fact, almost any idea can be shown to be wrong, immediately and logically. Sometimes the proof is so convincing that one is tempted to discard further thought about the new proposal. Promoting an idea is a hard task, and it may take a long time. It has been said, "You can send a message around the world in a seventh of a second but it may take years to force a simple idea through a quarter inch of human skull." The world resists change, yet progress has always been dependent on change.

Can you stand failure. Most of us cannot. We have grown to look at failure as something very shameful, something to be avoided at all cost. Mr. Kettering observed, "From the time he enters kindergarten, or maybe a little further up, (the child) is examined two or three times a year and, of course, if he flunks, that's awful. Well now, an inventor flunks all the time and if he succeeds once, he's in, you see, instead of being out. By the time this boy graduates from college, he is so afraid of the world 'failure" that he doesn't want to enter into any zone where there's even an atmosphere of failure.' But it is a rare occasion when a new idea does not meet first with failure; the two seem to go hand in hand. After failing 1,000 times to find a solution to a problem, one of Kettering's employees became completely discouraged. Kettering told him not to look at failure as failure . . . "Actually you have progressed wonderfully; you have found 1,000 ways it won't work."

Thomas Edison believed likewise. His people tried 6,000 different plant fibers before they found one suitable as a filament in Edison's light. He told them to try everything -- even cheese. Certainly, if we hope to create something new we must try new things, many of which will fail. We must have the courage to accept failure and try again, and again, and again.

Up to this point we have been concerned with the requisite philosophy toward creativity, the false beliefs that hinder it, and the state of mind necessary for it. How, actually, do we recognize and develop creative ideas? Count the number of square in the design in Figure 2.

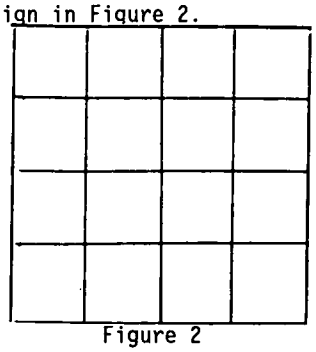

Figure 2

How many, 16? Perhaps you can see the 17th--the perimeter square. There are actually 30 squares. Along the top line from the left corner go right two squares. This line forms a side of another square. Continue. Finally, along the top line from the left corner go right three squares. This forms the sides of one of the last four squares. Now can you see all the squares? There are no more squares than when you first looked at the design, but now you can see all the squares. The point is that we are basically lazy; we see what is easy to see, what is familiar. Actually, we do not see with our eyes, we see with our minds, and using the mind is hard work. It is amazing how we can look at something and not see all there is to see. A creative answer to a problem or a creative idea can lie before us, yet not be seen.

Often, too, ideas are spontaneously rejected because they appear to have no bearing on the problem. But creativity, we must remember, is the association of seemingly unrelated elements. We therefore must have an open mind, ready to accept any and all ideas for consideration. During the early days of World War II, an artillery shell manufacturer assigned one of his engineers the task of developing a better way to handle clumsy shells during production activities. Though the engineer designed some pretty unique modifications of existing

handling equipment, his fruitful solution stemmed from a Chinese handcuff toy with which his young son was playing. The handcuff is woven straw, tubular in shape. It is inserted over the finger and grips tight when an effort is made to retract the finger. Having an open mind, ready to consider any idea, the engineer recognized another application of this handcuff principle. A similar shaped "handcuff" made of woven metal fabric proved to be a very successful solution to the problem.

Most of us are trained in one profession and have a specialized talent we rely on for our livelihood. Consequently, and quite naturally, we rely on that specialized knowledge to solve our problems. The best and the most creative solution, however, may be found in a seemingly unrelated field. But it will not be found unless we look there, unless we are flexible in our thinking. A chemist or a biologist or a plumber cannot help you with your problem unless he knows of your problem and you solicit his ideas. Do you realize that anti-knock in gasoline stemmed from an analysis of a red plant that popped through the snow in early spring. A problem was solved through consideration of an item in a complete unrelated field -- seemingly unrelated, that is.

The underlying key to knowing where creativity can be applied is in not being satisfied with things as they are, in recognizing that almost anything can be improved. Without assuming this attitude, chances are very slight that you will ever recognize opportunities to be creative. But by inquisitively challenging what exists, why it exists and why it exists in its present form, often our minds are triggered to wonder what else will do the job. Consider the time-consuming shoring of merchandise in freight cars by the usual means of timbers. What else will do the job ? Somebody thought of an inflatable dunnage bag, similar to a life raft. The bag is placed between the stacks of freight, then inflated. A substantial saving of time and cost, and a better way of shoring resulted. The bag is also used in cargo airplanes.

You might then ask another creative question: Where else could this bag be used? Experiments are currently being performed to determine how the principal can be used with people in airplanes. Could "balloons" be inflated in front of passengers to hold them and everything firmly in place in case of emergency? Can this same idea be used in automobiles to replace seat belts? Can it be used in small boats to provide immediate buoyancy in case of capsizing? What about the opposite use -- deflatable or collapsible containers. The British Navy now uses them in place of copper rum casks. American industry is using them now to transport fluids in boxcars, on flat cars, on flat bed trucks. When the tank has served its purpose, it is folded into a small bundle, enabling the vehicle to carry other merchandise on the back haul. A substantial savings and convenience all around.

And what about the development in wet strength treated paperboard? Humble Oil Company dramatically demonstrated its capability by cruising 800 miles in an outboard motor boat made of this paperboard. What does this boat idea suggest? Inexpensive, disposable boats for wilderness country fishermen, boats for kids, family runabouts without needing a trailer? Floating freight in rivers in boxes containing merchandise lashed together as rafts -- similar to the way logs are floated to the mill?

Keep your eyes open for a need, then fill it. Some fellow watched his wife chip her teeth and puncture her scalp when using bobby pins. He dipped the ends of the bobby pins in lacquer -- problem eliminated through creativity. Some person got tired of the sheets coming out at the bottom of the bed -- voila! -- contour sheets (ironing eliminated, too). Diapers are a nuisance on trips -- make them disposable. Telephone cords get into a tangled mess -- stretch cord; can't get the Kleenex out of the box -- pop-up interfold. Ever hammer your finger instead of the nail? There must be a better way.

It was mentioned that the environment of some organizations is responsible for the lack of creative activity. I am speaking of you and me and what we do to kill the enthusiasm and ideas of others. Too often we unthinkingly laugh at a new idea, not because it sounds funny, but because we want to disassociate ourselves from something that others may consider ridiculous or which might fail. People who generate ideas need encouragement; they need support from you and me and everybody else. The manager of a very successful and creative engineering depart-department recognized this. He never belittles a man's ideas, and he never tells that man that the idea won't work -- even if the manager believes it won't work or that it was tried before. The employee is permitted to try the idea. Either the idea does work, possibly because of some small change from the earlier idea that failed, or the employee will himself discover why it won't work. Next time he will give more thought to his ideas before proposing them. And there will be a next time -- nobody discouraged the man with an idea; rather, he was encouraged to try again.

And then the real payoff comes when we run into situations like the Apollo 13 space explosion which prevented the purification and reuse of the life sustaining air in the spaceship. The problem was resolved not through the use of the multi-million dollar array of computers, nor with scientific knowledge, rather it was the creativity of a few scientists that enabled the concoction of a makeshift contraction that facilitated the

use of lithium hydroxide canisters to purify the carbon dioxide from the air. Today those astronauts are with us, thanks to that creativity to invent and innovate - NOW - when it was, in fact, a matter of life or death.

Today, the Gramm-Rudman-Hollings diet encourages many of us to eliminate the "fat." Where is the fat? Ask the questions: What else will do the job? What else can be used? Who else can do it?, etc. -- All questions that call upon the creative imagination for answers. Great opportunities to trim the fat creatively.

Creativity is not something we generate only by chance happening. We can deliberately develop our creativeness and make substantial contributions to the betterment of our society. The choice is yours. Good luck, Genius!

1 This paper is based on material used in training activities of Sandia National Laboratories. This work was supported by the U.S. Department of Energy.

2. Charles Kettering, Deceased; Vice President of General Motors Corporation and head of General Motors Research Laboratories.
3. Sidney Parnes, Ph.D.; Director of Creative Education, New York State University at Buffalo, N.Y.
4. Alex Osborn, Deceased, L.L.D.; Founder and chairman of Creative Education Foundation; Co-founder of Batten, Barton, Durstine and Osborn; author of "Applied Imagination;" creator of the brainstorm technique.