

---

## **AC 2012-4979: CREATIVITY GARDEN ANALOGY**

### **Dr. Don L. Dekker, University of South Florida**

Don Dekker has been an Adjunct Professor of mechanical engineering at the University of South Florida since 2002. He is currently teaching the capstone design course. Before his retirement in 2001, Dekker taught at Rose-Hulman Institute of Technology. He first joined ASEE in 1974 and some of his ASEE activities include Zone II Chairman (1986-1988), Chairman of DEED (1989-1990), and General Chair of FIE, 1987. His degrees include a Ph.D., Stanford University, 1973; a M.S.M.E., University of New Mexico, 1963; and a B.S.M.E., Rose Polytechnic Institute, 1961. He became a Fellow of ASEE in 2007.

### **Dr. Rajiv Dubey, University of South Florida**

Rajiv Dubey is a professor and Chair of the Department of Mechanical Engineering and Director of the Center for Assistive, Rehabilitation & Robotics Technologies (CARRT). He received his bachelor's degree from IIT Bombay, and master's and doctoral degrees from Clemson University, all in mechanical engineering. Before coming to USF, Dubey was a professor of mechanical engineering at the University of Tennessee, Knoxville. His research interests include assistive robotics and prosthetics; rehabilitation engineering; and robotics in healthcare, space, undersea, and nuclear waste management. He has published more than 150 refereed articles and directed more than 50 Ph.D. dissertations and M.S. theses. He was an Associate Editor of the IEEE Journal on Robotics and Automation for eight years and has been on numerous organizing committees for major international conferences in robotics. Dubey has received research funding as a PI from various agencies including NSF, NASA, Department of Defense, Department of Energy, Department of Education, and the private sector. He is a Fellow of the American Society of Mechanical Engineers (ASME).

### **Mr. Stephen Sundarrao, University of South Florida**

Stephen Sundarrao is the Associate Director of the USF's Center for Assistive, Rehabilitation Robotics Technologies (CARRT). His undergraduate and graduate education is in mechanical engineering, and he has nearly 20 years experience as a Rehabilitation Engineer and more than 10 years experience managing a statewide program. He is certified by RESNA as an Assistive Technology Practitioner and Rehabilitation Engineer. He served on the Board of Directors of the National Mobility Equipment Dealers Association (NMEDA) for three years, National Health Advisory Board for the Museum of Science & Industry (MOSI), and the Florida Department of Health's Disability Taskforce on Bioterrorism. He currently teaches the capstone design course for senior mechanical engineering students, which develops 10-15 new innovative technologies for individuals with disabilities annually. He regularly presents papers at national and international conferences. His research interests include advanced vehicle modifications, ergonomics and mobility devices for individuals with disabilities. He received the Presidential Award from NMEDA and an award from the University of Miami for course development and recruitment for their online training in AT. He is actively involved with the state VR program to develop policy and training for better integration of rehabilitation technology services. He is on the advisory board for the RERC on Wheelchair Transportation Safety at the University of Michigan. Recent awards include: Engineer of the Year (American Society of Mechanical Engineers), Innovation Research Award (USF), and Florida Governors Point of Light. In 2006, He founded Rehab Ideas, a start-up company that has commercialized three patented products developed at USF.

## **Creativity – Garden Analogy: An Aid to Understanding and Teaching Creativity**

*"Imagination is More Important than Knowledge" Albert Einstein*

The nature of engineering creativity is not well understood. In his book, Design Engineering: Inventiveness, Analysis, & Decision Making, John Dixon<sup>1</sup> states, "Though a great deal is still to be learned about the question, present indications strongly suggest a real conflict between the inventive and analytic roles of modern design engineers. It is important, therefore, that engineers be aware of this conflict and take steps to resolve it." We, as faculty, need to understand how the inventive and analytic roles work together in engineering design so that we can teach our students both analytic skills and creative skills. Some say that creativity cannot be taught, but Dr. Paul MacCready said in a talk at Rose-Hulman Institute of Technology, "Thinking and creativity can be taught as a skill." If creative skills can be taught, then creative skills can also be learned.

The Creativity-Garden analogy discussed below compares the attitudes and skills necessary for creativity with the essentials for successful gardening. This comparison provides a framework or a map for understanding and guiding the creative processes. This understanding can be used to help us improve our own creativity, and we will then be able to teach our students how to enhance their creative skills. We may not become a Michelangelo or daVinci, but we can become more creative. This is good news! With this in mind, we can look forward to improving our creative skills as we travel through life.

### **The Garden**

Suppose that you decide to plant a garden. You need a location. Then you must decide what type of garden you want to plant. Do you want to produce flowers or vegetables?

If you decide to plant flowers, what varieties of flowers will be considered? Are you or your family allergic to any of them? What time of year do you want the flowers to bloom? How much tender loving care are you planning to spend? How hardy does the variety have to be? Do you want annual plants or perennials?

If you choose vegetables, what kinds do you like to eat? How much tender, loving care are you planning to spend? Do you want to use herbicides and pesticides, or do you want to garden organically?

Although the list of questions is long, people do get through it and plant gardens. The following is a list of things that are necessary for the successful production of vegetables or flowers: (1) fertile ground, (2) sunshine, (3) tools, (4) weed control, and (5) water and fertilizer. Many people plant and grow successful gardens every year.

As with gardening, creativity needs certain factors to help it exist. Creativity needs (1) an environment, (2) appropriate language, (3) creative enhancement techniques, (4) quit interfering with natural creativity, and (5) develop a creative attitude. All of these factors can help us be more creative.

<b><u>Gardening</u></b>	- = -	<b><u>Creativity</u></b>
Fertile Ground	- = -	Environment
Sunshine	- = -	Appropriate Language
Tools	- = -	Creative Enhancement Techniques
Weed Control	- = -	Quit Interfering with Natural Creativity
Water and Fertilizer	- = -	Develop a Creative Attitude

Each part of this Gardening = Creativity analogy is discussed in the following sections.

### **Fertile Ground = Environment**

For the creative process to flourish, there must be a receptive environment. Although the perfect creative environment may differ in degree in various situations, the creative environment should include the following five factors:

- (1) Challenge
- (2) Exposure
- (3) Inputs
- (4) Experiment
- (5) Time

Challenge is needed for motivation, and it must also be worthwhile. The engineer and the company must be willing to spend time and/or money to rise to the challenge. The adage, "Necessity is the mother of invention" says this very well. If there is nothing that you have to do, either externally or internally, you probably won't even begin the "design" processes, let alone finish them.

Exposure means that all aspects of the problem are studied, and that the problem might be re-defined, broadened, or restricted. This also includes gathering information from many different sources.

Inputs must come from all members of the team and also from the persons or groups who will be affected by the solution. It is also a good idea to get different ideas from different disciplines, other societies, special interest groups. The list goes on and on. Sometimes different ideas can easily be seen by reading different magazines.

The opportunity to experiment is a necessary part of a creative environment. Think of Edison in his laboratory at Menlo Park, New Jersey. He certainly tried out more than a few different ideas and performed numerous experiments before he successfully developed electric lights, for example.

Time is essential. Creativity is not an analytical process. The mind needs time to consider all of the inputs, exposures and experiments. This "incubation period" lets the mind work on all the information, combining it with the experimental results, recognizing our past experiences and then producing unexpected, creative results. A Readers Digest<sup>2</sup> article puts it this way. "Next time when you're working on a complex problem, whether it be a calculus proof or choosing the right car for your family, it really pays to 'sleep on it.'" Researchers at Harvard Medical School have looked at the conditions under which people come up with creative solutions. In a study involving math problems, they found that a good night's rest doubled participants' chances of finding a creative

solution to the problem. The sleeping brain, they theorize, is capable of synthesizing complex information.

### Environment in the Classroom

If we are to encourage creativity in engineering classrooms and cultivate the creativity of our students, we must consider the factors which will help us nurture this environment.

Students are aware of many of the factors which inhibit and encourage creativity. A course, at Rose-Hulman, which emphasizes creativity and creative problem-solving techniques asked the students to develop a list of things that encourage and discourage creativity. These lists are reproduced below.

#### Classroom Things That Encourage Creativity

- \* Projects - grading details unclear, more subjective
- \* Final exam was partially graded on creativity-subjective
- \* Seating variety - more flexible things, less done by habit
- \* Projects - ping pong ball mover, mouse trap powered vehicle, etc
- \* New ideas discussed in class
- \* Interact with different classmates
- \* Meet in different places
- \* Have people lecture who appreciate creativity
- \* Thermo II - creativity graded as part of the design project
- \* "Gallagher" type devices
- \* Competition
- \* Need

#### Classroom Things That Discourage Creativity

- \* Criticism and making fun of people
- \* Derivations
- \* Cut and paste and fill in the blanks type of assignments
- \* Set ways to do everything - structure
- \* Grading - marks to reproduce certain things
- \* Too serious
- \* Deadlines, schedules
- \* Lack of enthusiasm
- \* "Plug & Chug" mentality
- \* Lack of time
- \* Subjects that haven't kept up with technology

An effective design engineer must also have some "creative courage." As soon as a new idea is born, the person who originated the idea becomes its ONLY advocate---a minority consisting of one. That person must then face others who have contracted the Not Invented Here (NIH) syndrome and who are trying to discredit the idea. In fact, we may sometimes defeat ourselves when we first have an idea enter our mind and then immediately think, "That's a dumb idea!" This certainly kills the promising idea, before it has a chance to develop.

Action:

Add a project or two to your courses. This creates an element of excitement to the course. The project can be scored as a competition to add more interest and enthusiasm. This also gives the students an opportunity to work on a team and interact with different classmates. Creativity can be used as part of the score, and a lecture or two about creativity can be added to your class.

### **Sunshine – Appropriate Language**

Creativity must have many languages to express itself. These "languages" include, but are not limited to, mathematical, analytical, visual, oral and written communication, computer, musical, and foreign languages (e.g. French and German).

The engineer certainly has mathematical, scientific, and analytical skills. In fact, it has been estimated that 80% to 90% of the engineer's curriculum consists of analytical courses. Is it any wonder that A. D. Moore<sup>3</sup> says; "In fact, I suspect that the taking of a degree in engineering or science may, in many cases, do more to stifle creativity than stimulate it." He goes on: "... most faculty members have little interest in creativity, and know even less about it."

If we are poor at visualizing in three dimensions, it will be very difficult to fit things together "in the mind's eye". 3D visualization is a very valuable skill for the design engineer. As well as spatial relationships, this includes sketches, engineering drawings, poster presentations, and data presentation (graphs).

Our industrial friends have observed that many engineering graduates do not have adequate oral and written communication skills.

Many engineers have well developed computer skills, but there may be engineers who do not have adequate computer skills.

Knowing the language of music may be useful in some design challenges. Likewise, if you are working in another country, knowledge of the native language may help, or in fact, be essential.

Of course, the ability to work in teams is extremely important. This requires knowledge of what good teams are like, the vocabulary of high-performing teams, and the attitude to make it work.

Depending upon the area of specialty, or the job assignment, an engineer may have to develop skills in many of these "languages" to be effective.

Action:

When the students are working in teams on a project, have them share their skills and abilities with their teammates. This provides an opportunity to learn about each other.. The team could also develop a list of skills and abilities necessary for the completion of this project.

### **Tools -- Creative Enhancement Techniques**

There are many books available on enhancing both individual and group creativity. Dr. Edward

deBono's<sup>4</sup> book, Serious Creativity: Using the Power of Lateral Thinking to Create New Ideas, is an excellent practical guide. Dr. deBono discusses seventeen different tools and techniques to produce creative new ideas on demand. This is very helpful because it means we no longer have to think of creativity as an "ah-ah" major breakthrough. We can dispel the notions that if we remove our conceptual blocks we will be creative, or that the goal of creativity is to produce many ideas (as with Brainstorming). The "Serious Creativity" concept also implies that we can be creative about any topic at any time.

Doug Hall<sup>5</sup> also lists many tools which will aid and encourage creativity in his book, Jump Start Your Brain. Through his research, and consulting, he has developed the following formula for being creative.

$$Eureka \text{ (AnInvention)} = (STIMULUS + BrainOperatingSystem) FUN$$

According to this equation you need multiple stimuli. Doug suggests catalogs, magazines, talking to others. Several of his "Brain Programs" are activities to help you increase the stimuli. Then there is the Brain Operating System. This is similar to the MBTI and Herrmann Brain Dominance Instrument, which both provide an insight to our preferred brain operating system. Hall has his own personality test, which will result your being a Realist, a Builder, or a Dreamer. He even has a listing of which Brain Program people with a particular Brain Operating System will like. In summary, you need a lot of different stimuli, plus to a "Brain Operating System" and then have a lot of FUN! Unfortunately, sometimes having fun on the job, is difficult for engineers to do.

Many creative enhancement techniques are useful in repressing negative habits that don't encourage a natural, creative climate. These techniques force us to expand the number of ideas and combinations that are produced. They apply to both individual and group ideation. A partial list of these creative enhancement tools is found below.

- deBono – Lateral Thinking
- Hall's Activities Plus FUN
- Brainstorming
- Synectics
- Nominal Group Process
- Morphological Analysis
- Attribute Listing
- List Making

Action:

Read Dr. deBono's book, "Serious Creativity: Using the Power of Lateral Thinking to Create New Ideas" and Doug Hall's book, "Jump Start Your Brain" for a good beginning. These two books should give you a good foundation for learning about creativity. Many other books are available for future reading.

### **Weed Control – Quit Interfering with Natural Creativity**

"We do not have to teach people to be creative;  
we just have to quit interfering with their being creative."  
Ross L. Mooney<sup>6</sup>

If we quit interfering, we have taken the first step in nurturing the student's natural creativity. However, as educators, we must do more than this. We must teach the use of creative enhancement techniques and tools, and we must eliminate premature judgment. In most of our schooling and life in general, judgment is thought of as something necessary and even good. Jim Adams<sup>7</sup> states that, "In the university, much scholarship is devoted to judgment rather than creativity."

Another stumbling block to nurturing creativity is a negative attitude. If you say "I can't do this," it probably won't get done -- at least not by you. Someone else will probably do it instead. Negativity does not fit well with creativity. Mark Twain had an opinion on negativity when he said, "It is easy to find fault, if one has that disposition. There was once a man who, not being able to find any other fault with his coal, complained that there were too many prehistoric toads in it."

Eliminating negativity and premature judgment during creative processes is very necessary. Blocking this negativity and creating a positive, receptive climate for new ideas is important. It is important because just as you cannot simultaneously get hot and cold water from a faucet, you cannot create and criticize at the same time.

Finally, conceptual blocks need to be eliminated.

"Conceptual blocks are mental walls which block the problem-solver  
from correctly perceiving a problem or conceiving its solution."  
James Adams<sup>7</sup>

These conceptual blocks can come from cultural, environmental, perceptual, emotional, intellectual, and expressive influences. These are the things we don't consider because it is taboo, not done that way, or because we don't see the problem correctly.

Action:

When you start to say something negative about an idea, STOP! Say three (or more) positive comments about the idea. Only after stating the positives are negative statements allowed.

### **Water and Fertilizer -- Develop a Creative Attitude**

If we are going to improve our creative capacity we must "think about our thinking." This is very difficult to do. It's easier, for example, to improve our tennis or golf games if we try some of these suggestions.

- \* Buy an instructional video
- \* Video tape ourselves while playing
- \* Buy a more expensive racquet, shoes, or outfit
- \* Take lessons
- \* Play with someone who is better
- \* Practice
- \* Practice in front of a mirror
- \* Buy an instructional book
- \* Read an instructional book

- \* Join a tennis (golf) club
- \* Watch the professionals
- \* Buy audio tapes
- \* Meditate about tennis (golf)

Now suppose we want to improve our creative capacity. Which of the things from the above list would work? Not very many! Where would we go for lessons? Practice creative thinking in front of a mirror? Not helpful! Books, audio tapes, classes, and videos are the main aids available that would be helpful. However, after we read Serious Creativity<sup>4</sup>, we discover the need to practice the tools and techniques of producing creative, new ideas so that they become comfortable to use. We need to "break-in" our thought processes so the creative enhancement techniques and tools can be used often and easily.

Action:

Reading the two books, as suggested earlier, will provide a good start. Now read additional books, take a creativity class, and practice the three creative guidelines discussed next.

### Three Creative Guidelines

Three guidelines, which help to develop a receptive environment for creative ideas, are:

(1) Ask, "What's good about it?" (2) Defer judgment (3) Speculate, ask, "What if ... ?"

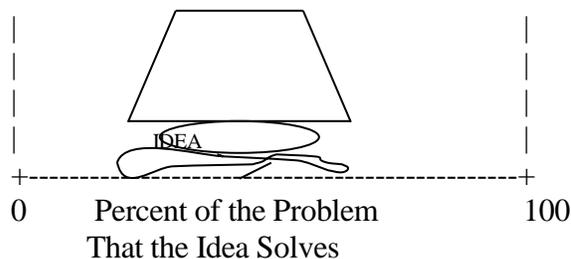
Asking what's good about an idea first means listing four or five positive aspects of it. By doing this first, the best parts of the ideas are salvaged. If we list the negatives first, usually the ideas will be destroyed and the positive aspects will be lost forever.

Most of us have been trained to judge ideas very quickly. When trying to create, it is helpful to build-on or build-up an idea before knocking it down with judgment.

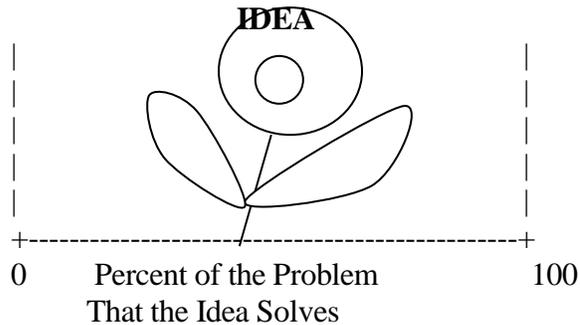
Asking "What if ...??" encourages us get out of the rut, to throw off our blinders, and to "blue-sky" for awhile. After we do this we must, of course, come back to reality and evaluate the options that have been created. Nothing can be analyzed before it has been conceived.

### Idea Nurturing

When negative attitudes and premature judgments get hold of a new idea too soon, the result looks like the following sketch. The idea is "squashed" instead of nurtured.



When a new idea or concept arises from some creative process, it must be nurtured and developed. The seedling idea will seldom totally solve the problem. It will not be 100% successful. The positive aspects must be saved and the negative characteristics must then be overcome. The young, vulnerable flower must be nurtured and protected so that it will grow into a beautiful plant that is part of a beautiful garden. The goal with new, tender ideas is to encourage them and take care of them. Combine them with other ideas, and prune away the dead parts, until the idea (flower) becomes 100% of the solution.



When a garden is planted, the team never plants only one seed. Multiple seeds of each variety of flower or vegetable are planted. The gardening team may consist of two people or a landscape architect, the foremen, and the laborers. They plant multiple seeds and of many varieties. This creates a balanced, beautiful scene.

In the same way, a design team does not stop with only one idea. The team thinks of and develops many ideas. Some may only satisfy 10% of the problem, others 5%, and some maybe 25%. By combining the ideas and consciously practicing creative enhancement techniques, a working solution is developed.

In the flower garden analogy, this would be like picking several of the individual flowers to create a beautiful bouquet! In a vegetable garden analogy, there would be a variety of vegetables to eat and prepare in different delicious ways.

"This elusive thing called creativity somehow relates to that rare moment when a new combination of existing concepts is related to an existing problem in a unique way."  
Rem Stokes (Bell Labs)

The idea behind developing creative thought patterns is so that the "rare moment" that Rem mentions becomes commonplace.

"Unfortunately for the occurrence of creative thought, higher education often seems to encourage an attitude - which may become habitual - of rejection - rather than receptivity - toward the creative thoughts of others."  
Peter McKellar<sup>8</sup>

By using these guidelines, we can break the creativity destroying habits of the past and replace them with new, creative enhancing habits.

Creativity can and must be used to enhance all of the design processes. In fact, some say that being creative is essential to living a satisfying life, and enhancing our own lives.

### **Final Thoughts from the Master – Leonardo da Vinci**

Leonardo da Vinci has been called “undoubtedly the most curious man who ever lived”<sup>9</sup>. The word “curious” and “creative” are similar. If you are curious you will be creative. Fortunately, for us, many of Leonardo’s drawings and writings are available to us. da Vinci’s own instructions for becoming more “Curiosita” are shown in his following Self-Assessment list, and there are many more suggestions to help you become more “curious” or creative<sup>10</sup>.

I keep a journal or notebook to record my insights and questions.  
I take adequate time for contemplation and reflection.  
I am always learning something new.  
When I am faced with an important decision, I actively seek out different perspectives.  
I am a voracious reader.  
I learn from little children.  
I am skilled at identifying and solving problems.  
My friends would describe me as open-minded and curious.  
When I hear or read a new word or phrase, I look it up and make a note of it.  
I know a lot about other cultures and am always learning more.  
I know or am involved in learning a language other than my native one.  
I solicit feedback from my friends, relations, and colleagues.  
I love learning.

Many of Leonardo’s instructions, if followed, would enhance our creativity and our lives! Note that many of Leonardo’s ideas follow the ones presented in this paper.

#### Bibliography:

1. Dixon, John, “Design Engineering: Inventiveness, Analysis, & Decision Making” McGraw Hill, New York, 1966, (USF Library, TA174.D5)
2. William Speed Weed, “Mind Games: Seven ways to make your brain better, faster, smarter”, Readers Digest, August 2006
3. Moore, A. D. “Invention, Discovery, and Creativity”, Doubleday & Co., Garden City, NY, 1969 (USF Library, T19.M67)
4. de Bono, E., “SERIOUS CREATIVITY: Using the Power of Lateral Thinking to Create New Ideas”, HarperCollins Publishers, Inc., New York, NY, 1992
5. Hall, Doug, & Wecker, David, “Jump Start Your Brain”, Warner Books, 1995
6. Mooney, Ross, & Razik, Taher, “Explorations in Creativity”, Harper & Row, New York 1967

7. Adams, James L., "Conceptual Blockbusting. A Guide to Better Ideas", Addison-Wesley Publishing Company, 1986
8. McKellar, Peter, "Imagination and Thinking: A Psychological Analysis", Basic Books, New York, 1957
9. Clark, Kenneth, "Leonardo da Vinci", Penguin Books, London 1993
10. Gelb, Michel, "How to Think Like Leonardo da Vinci: Seven Steps to Genius Every Day", Dell Publishing, New York, NY 1998